The Art of Artificial Neural Networks:
Emergent Creativity in Artificial Intelligence

by

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Date: November 16, 2018
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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Art, Art History and Visual Studies in the Graduate School of Duke University

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ABSTRACT

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Abstract

This M.A. thesis in Computational Media is an exploration of how artificial neural networks could be used by an artist; it is a transdisciplinary study of topics in computer science, light art and installation art. The study culminates in the design and production of two installations that attempt to respond to the question: how does one draw on high-level Artificial Intelligence algorithms and human aesthetic intuition informed by contemporary and historical research of art history, to generate a new hybrid art form?
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1. Introduction

Recent advances in computational power and an unprecedented wealth of data have sparked a renaissance in artificial neural networks (ANNs) – a branch of statistical machine learning that loosely mimics the structure of mammalian brains. ANNs are complex networks of simple synthetic neurons, constructs implemented in software or hardware. Deep learning algorithms enable these hierarchically structured and richly layered networks to learn to decipher and classify complex new patterns presented to it based on what it has “perceived”, or learned, from patterns it has been exposed to in the past, rather than follow explicit task-specific instructions. This technology is the backbone of many artificial intelligence systems being developed today in fields as diverse as health care, self-driving cars, financial forecasting, environmental conservation and industrial design. This thesis is an exploration of how neural networks could be used by an artist; it is a transdisciplinary study of topics in computer science, light art and installation art. The study culminates in the design and production of two installations that both respond to the question: how can one draw on these high-level algorithms, engaging both the emergent intuition of an A.I. system and human aesthetic intuition informed by contemporary and historical research of art history, to generate a new hybrid art form?

Initial inspiration for this thesis came from a 2016 exhibition and symposium titled *DeepDream: The art of neural networks* presented at the Gray Area Foundation for the Arts in San Francisco. The event, curated by Google, featured visual artworks with imagery generated by artificial neural networks, and was the first art exhibition and auction dedicated to neural network

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1 “ANN”, “artificial neural network” and “neural network” are used in this essay interchangeably except for when explicitly noted as referring to something different (i.e., biological neural network)
art. Imagery featured was generated by two different processes that had produced viral content on the internet: DeepDream and Style Transfer. DeepDream (the technique) generates a unique image by feeding an existing image or random noise to a neural network to be read and interpreted based on the patterns it has learned. The algorithm incrementally morphs the image, enhancing the neural network’s interpretation of the original “seed” image. Style Transfer, a technique to create hybrid images by combining the content of one image with the aesthetic look and feel of another, has been embedded in social media products and popular stand-alone mobile apps (Facebook, Snapchat, Prisma, Artisto). Joshua To, curator of the exhibition, notes that while these examples of neural network generated art had gone viral, “everyone’s experience was seeing the work on their phone or laptop screen…We thought it would be powerful to curate a collection of pieces so that people can experience the work printed large, high quality, and framed professionally.” The exhibition, despite its small scale and narrow scope, reflected a desire shared between the computational artists involved and Google to somehow elevate this type of generative imagery from internet meme to “gallery-worthy” artform – to express the creative potential inherent in a computational tool, the artificial neural network.

The 2016 Google event also launched the Artists with Machine Intelligence (AMI) program, an initiative that brings together artists and engineers to explore the possibilities of machine intelligence in art. The essays and experiments shared publicly through the AMI channels have established an ongoing discourse that have helped inform my own work in relation to others actively engaging with the technological intervention of neural networks in producing art.

3 Ibid.
In an essay titled *Art in the Age of Machine Intelligence*, Blaise Aguera y Arcas, one of the founders of the AMI program, draws parallels to earlier technological interventions in the production of art, such as the inventions of applied pigments, the printing press, the camera, and computers. These earlier technologies all operate symbiotically as extensions of the human being. The camera can be viewed as an extension of the eye; a paintbrush, as an extension of the hand. Each tool is equipped with its own unique affordances that not only augment the biomechanical limitations of the human body but also inform how the technology is assimilated into culture and the way art is perceived by audiences.

The camera, for example, captures an image of a moment frozen in time. Via the mechanics of configured lenses, framing, and the timing of a shutter, the camera not only models the eye, but enhances its capabilities beyond optics. Walter Benjamin, in his 1931 essay *A Little History of Photography*, suggests that “while it is possible to describe the way somebody walks, it is impossible to say anything about the fraction of a second when a person starts to walk.” He describes this as unveiling an “optical unconscious.” Art Historian Christopher Pinney expands on this concept suggesting that “photographic scrutiny [in contrast to natural observation] might be able to reach other domains as yet unexplored.” Camera culture is ubiquitous today, and memories are arguably constructed as much through the simulacra of photographic images as they are by lived experience. As Benjamin and Pinney suggest, the function of the camera extends far beyond being a pencil of nature, engaging the mind beyond the natural and the literal.

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4 The title of Aguera y Arcas’s essay alludes to Walter Benjamin’s seminal 1935 essay, *The Work of Art in the Age of Mechanical Reproduction*, which similarly raises questions about the role of contemporary art in society given the introduction of new technologies, like the camera, that enable the mass production and reproduction of images.
5 Aguera y Arcas is a Distinguished Scientist at Google and leads AI research and development groups.
The photograph produced acts autonomously, independently of the experienced moment, to generate memories, ideas, and realities. Drawing on 20th century media philosopher Vilém Flusser, Aguera y Arcas proposes that while “preindustrial tools, like paintbrushes or pickaxes, extend the biomechanics of the human body…more sophisticated machines extend prosthetically into the realms of information and thought.” Appropriately, perhaps the camera should then be approached not only as a seeing machine, but also perhaps as a thinking machine.

What can be expressed in art produced with technology that not only mimics the eye, but also intentionally attempts to abstract functions of the brain? What does this kind of art look, sound and feel like? How will our human intelligence be informed by machine intelligence when assimilated through art? Should there be a distinction between other technologies that enhance human ability and those that are dubbed as “intelligent”? Exploring the affordances of rapidly evolving technologies like artificial neural networks must move beyond conceptual thinking and require the actualization of ideas through experimentation and production. Aguera y Arcas embraces the kind of art realizable with this generation of machine intelligence as a “neural daguerreotype”, a technology in its most nascent stages yet on the verge of profound influence in media production and creativity. But while some artists will embrace machine intelligence as a creative partner, and others may continue using contemporary modes of production, “any artistic gesture toward machine intelligence – whether negative, positive, both, or neither – seems likelier to withstand the test of time if it’s historically grounded and technically well informed.” This is the challenge of transdisciplinary work. An artist working at the intersection of these fields must

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9 Ibid.
10 Ibid.
have knowledge and understanding of not only the algorithms at play and but also the history of relevant art to create conceptually interesting work.

As of today, few works that experiment with neural networks attract interest beyond the scope of novel computer art. Many artistic endeavors that involve neural networks to produce work that attempts to compete qualitatively with the technical skills of a human artist through mimesis (for example by composing a song in the style of Bach\textsuperscript{11}, or producing an image in the style of Van Gogh’s *Starry Night*\textsuperscript{12}). While some of these projects have achieved incredible success as imitators\textsuperscript{13}, artistically they do little more than flaunt the effectiveness of the A.I. system at hand to complete an otherwise human, even if extra-ordinary, task. The failure of this work is that the compelling aspect is in proving the supposed intelligence of the machine that created it. This demonstrative approach of intelligence is reflective of the open-ended definition Igor Aleksander and Piers Burnett suggest in *Thinking Machines, The Search for Artificial Intelligence*, writing

An intelligent machine [as practitioners of artificial intelligence suggest] is able to do things which, if done by people, would be judged to require intelligence. On this basis, a definition of intelligence becomes unnecessary: The researcher simply choses a task that seems to require intelligence (playing chess say or recognizing visual images) and tries to build a machine that can accomplish it.\textsuperscript{14}

From an artistic standpoint, it should not matter that the creator of a work demonstrates intelligence (it would be perplexing to see a human artist produce work with this same goal in


\textsuperscript{13} *The Next Rembrandt* is notable project that does a very impressive job producing a portrait in the style of Rembrandt and could easily fool any non-expert as being authentic.

mind). More interesting would be to allow the emergence of intelligence to serve as the conceptual basis of the art produced.

Alternately, the machine generated works that have succeeded, for me, are those that express the emergent intuition of their intelligent systems. Emergence is evident when autonomous agents, whether objects, living creatures, ideas, etc., come into contact with each other to generate something new and unexpected. Emergent phenomena reflects the collective behavior of often large, complex systems which cannot be clearly attributed to the behavior of the system’s individual constituent parts. Whether demonstrating intelligence or not, emergence expresses a form of creativity that is naturally occurring, such as the intuition of human beings. Artificial neural networks benefit from hierarchical structures that can be described as being emergent in themselves in generating artificial intelligence. Cybernetic theorists like Heinz von Foerster, see human consciousness as emerging from the sum of an indefinite number of self-organizing elements. 15 Although most artificial neural network models have been abstracted beyond comparison to their biological counterparts, the parallels to natural phenomena found in emergent behavior are compelling. I believe emergent structures yield emergent behavior, and thus an artificial system constructed of non-thinking actors (in this case artificial neurons) too can act as a natural, harmonious and productive collaborator with humans, in addition to other similar networks.

Some of the best examples of emergence in neural network art can be found in the work of AMI creative technologist Ross Goodwin. Using two neural network models developed by Andrej Karpathy, a Stanford PhD, one that captions images and another which recursively

15 von Foerster, Heinz, Albert Müller, Karl H. Müller, and Michael Kasenbacher. The Beginning of Heaven and Earth Has No Name: Seven Days With Second-Order Cybernetics. (Fordham University Press, 2014), 17
generates text, Goodwin built a mobile, manually controlled camera, called *word.camera*, that captures an image and physically prints a few lines of original poetic prose on rolls of receipt paper.\(^{16}\) What is noteworthy here is how *word.camera* emerges generatively from several acting parts enabled by both the neural networks he employs and his own intuition to produce a unified, multi-faceted, and ultimately self-generating artwork.

Goodwin’s 2015 work with the *word.camera* has since extended to several recent collaborations with another artist, Es Devlin, who’s work, coincidentally, served as my personal initial introduction to the light- and space-based installation art that would become the foundation of my own artistic work. Devlin is well known as a contemporary stage designer, having worked with the groups and artists like U2, the Royal Opera House, and Kanye West. Her recent collaborations with Ross Goodwin, that resulted in the interactive kinetic sculptures *Poem Portraits* (2017), *The Singing Tree* (2017) and *Please Feed The Lions* (2018), however, have brought machine learning into the limelight of the artworld.\(^{17}\) These sculptures add a social and performative element to Goodwin’s *word.camera*, taking images and text as input from visitors to generate collective poetry in public spaces, which in these cases include the Serpentine Galleries in Hyde Park, the V&A, and Trafalgar Square. Devlin’s collaborations with Goodwin take elements from her practice in stage design – creatively manipulating sound, light and space to immerse audiences in the world of an emergent ecosystem that the artwork creates.

What fascinates me most about the collaboration between Goodwin and Devlin, however, is the cross disciplinary collaboration itself. I was curious why someone who builds fantastical


worlds on stage and who works primarily in the world of popular culture would want to engage with machine learning techniques. In both her work on stage and in sculpture, Devlin plays with the mechanics of illusion. To understand illusion, she must engage with the mechanics of human perception – an interest shared by artists like Olafur Eliasson and James Turrell, who generate phenomenological illusions by manipulating color, light, and space, who have informed her designs. This interest in perception is paralleled by cyberneticians, like von Foerster, and computer scientists who design artificial seeing and thinking machines with neural networks. The same questions that fuel creative design in the arts are being asked in the world of technology.

The two art installations I have produced as the culmination of this thesis, *in paradiso* and *Strange Loop*, are attempts to further the discourse on the place of artificial intelligence in art. They are also practical exercises in the design and production of multi-media sculptural work. Hence, these projects reflect the development of an artistic intuition which draws upon machine intelligence and appropriate aesthetic traditions to produce work that emerges through this clashing bisociation\(^\text{18}\) of seemingly disparate disciplines.

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2. Emergent Creativity and the Neural Network

2.1 Bio-memetic Computation

A 1943 paper, titled *A Logical Calculus of the Ideas Immanent Nervous Activity*, by neurophysiologist Warren McCulloch and mathematician Pitts, gave birth to the notion of a synthetic neuron – suggesting that the brain could possibly be modeled through neural networks devised of electrical circuits.¹ This paper established a framework of thinking that the biomechanics of a human “could potentially be simplified and abstracted in the service of the creation of machines that might have thinking-like properties.”² In 1958, Frank Rosenblatt, a psychologist at Cornell who was working on understanding the decision systems present in the eye of a fly, implemented the McCulloch-Pitts neuron model in a machine he called the Mark I Perceptron. The McCulloch-Pitts model is a simple input/output system that takes inputs, calculates a weighted sum, and passes it through a threshold gate, returning ‘1’ if the result is above the threshold and ‘0’ if not.³

Meanwhile, in 1960s cyberneticians like W. Ross Ashby, Gordan Pask, Gotthard Gunther, and Heinz von Foerster, inspired by McCulloch, looked to computation as a means to articulate the unexplained entailments of the human mind and body function.⁴ Researchers at the Biological Computer Laboratory at University of Illinois in Urbana-Champaign, led by von Foerster, saw human intelligence as emergent rather than being determined by a set of rules.

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³ Today’s artificial neural networks are in essence multilayer perceptrons, aided by algorithms like backpropagation that make training multi-layer networks feasible and efficient.
⁴ Seaman, Bill. "(Re)Thinking – the Body, Generative Tools and Computational Articulation."., 219.
Consciousness, for example, cannot be determined by a certain number of nerve cells. The issue with defining consciousness, as von Foerster asserts, is that “no one can tell me what ‘consciousness’ is”. He continues,

My position is as follows: emergence is a culture-bound cognitive process. I live in a certain culture in which I can see that certain phenomena “emerge” and others do not. We find emergence where something new comes into being, where one or some or many people or we ourselves suddenly see something differently. The moment I see something differently, something new is there...Emergence is my ability to see newly.  

The Game of Life created by British mathematician John Conway in 1970 popularized the study of emergent behavior through cellular automata. That simple “chicken-brain” rules could result in highly sophisticated self-organized patterns ranging from the flocking of geese in flight to Mandelbrot’s complex fractal patterns became established to the extent that mathematician Stephen Wolfram attempted to explain all natural phenomena in terms of cellular automata in his book titled A New Kind of Science.

Artificial neural networks are built from neurons which are fairly trivial mathematical constructs implemented in software. But unlike cellular automata, neural networks lend themselves to be trained through a learning process that make them highly non-trivial entities. The development of learning algorithms coupled with low-cost, high-performance computational power has led to the development of systems that “learn” (i.e., interpret high-dimensional, non-linear, statistical patterns in data) without being programmed with task-specific rules. This is a powerful emergent phenomenon -- to perceive and adapt behavior based on what the network has learned. Thus, what humans could perceive to be “intelligence” has begun to emerge in neural networks trained to recognize a wide variety of patterns, both stationary and non-stationary.

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2.2 Artificial Intuition

2.2.1 Style Transfer

One of the most exciting contemporary research areas is the application of neural networks trained for one purpose in areas where it is used for entirely different, unrelated purposes. This process, referred to as transfer learning, demonstrates that an emergent, non-deterministic, structure of a neural network shows capacity for both literal and non-literal knowledge comprehension. Style Transfer, for example, shows that in training a neural network to recognize objects in images, the network incidentally learns the mechanics of how to see. Perhaps this “how”, inherently uniquely biased by the data on which it was trained, can be considered a type of artificial intuition.

As popularized through apps like Prisma and Lucid, and more recently as new features on Facebook and Snapchat, Style Transfer computationally generates a pastiche, taking the style from a pre-existing work and applying it to something new. Applying neural networks to style transfer has been an active area of research, particularly since 2015 when the original paper was published by Leon Gatys, Alexander Ecker and Matthias Bethge at the University of Tubingen in Germany. The goal is to take two inputs -- a style image, and a content image -- and generate a third “pastiche” image.

Neural Style Transfer works by taking advantage of an existing, pre-trained neural network, and utilizing its structure and weights for a new, independent task. In this case a Convolutional Neural Network trained for image classification is used to inherit its ability for perceptual comprehension. Convolutional Networks are structured by weighted neurons

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organized in layers -- each layer acting as a (convolutional) filter. High-level layers distill pixel-level information, like color, and the deeper we go, activated neurons detect edges, contours, features, and objects, which are then scored and classified. The process to read and then transfer style is as follows:

First, a pastiche image is initialized as random noise and we feed it through several intermediate layers of the network. The outputs of these layers are used to compute how close the pastiche is in content to the content image and in style the style image. To determine the loss in content, both the content and pastiche images are both passed through the network. The sum of the square difference between corresponding values outputted from several intermediate layers (which are arbitrarily selected).

Style loss is similar, but rather than comparing the raw outputs at various layers, the outputs are compared via a Gram Matrix. A Gram Matrix is the result of a matrix multiplied by its own transpose. By doing this, spatial information from the individual layer outputs is distributed across the Gram matrix so that it contains non-localized information about the image like shape and texture -- thus, style.

Adding content and style losses together yields the total loss between content, style and the generated image. To reduce this loss, one can backpropagate through the network, optimizing and iteratively evolving the generated pastiche image. The weights of these three “loss” values can be adjusted to generate a desirable aesthetic.

2.2.2 DeepDream

Like Style Transfer, DeepDream similarly exploits the structure of a neural network to generate images that would otherwise be impossible to produce without a neural network, with just explicit task-specific instructions. DeepDream enables us to visually evaluate the learning process of artificial neural networks trained on image classification. In fact, when Alex
Mordvintsev developed DeepDream in 2015, this was the intended goal of the software – the dream-like, surreal imagery were unintended and unexpected.\(^8\)

The images that are born from the DeepDream process reflect the emergent visualizations of a machine intelligence trained on an artificial neural network model. The images generated demonstrate algorithmic pareidolia. Just as humans may sometimes see abstract faces and animals in clouds, DeepDream looks for what it may recognize in a scene and reinforces that bias. It follows that the images generated are unique to the patterns the network has been trained to respond to. These patterns are extracted via learning algorithms from the data which the network is fed. Thus, the images DeepDream produces will always be unique to the Deep Learning models and the data which are used to train the neural network.

For both of the art installations I made, I used the original neural network architecture that was used in developing DeepDream. The GoogLeNet (which won the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2014), was trained to classify images into 1000 categories. Images generated from this network, when visualizing the deeper full-connected layers are often populated with textures that resemble dog heads, birds and various reptilian creatures. Most DeepDream images found online reflect these patterns. This is the result of the data on which GoogLeNet was trained. The animal-filled images reflect an aesthetic that emerges from this particular neural network.

When producing my own images with DeepDream, I attempted to steer this externalized aesthetic, embodied in GoogLeNet. By isolating feature channels, experimenting with window sizes (i.e. the scope at which the algorithm would look for patterns in a given image) and

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designating the number of iterations that the process would search through and transform the seed image, I found that I was able to generate imagery that was simultaneously unpredictable and intentional.
3. Aesthetic Intuition: Es Devlin’s Box of Miracles

The following essay is an analysis of Es Devlin’s 2016 installation, Box of Miracles. It gives insight into how she develops an aesthetic intuition through the use of models. Studying this work formed the basis of how I would inform my own aesthetic choices.

3.1 Introduction

Models are very important to Es Devlin. Her use of models informs her aesthetic intuition; they serve as the basis for her creative process. In 2016, when asked to write a retrospective book about her creative process, the stage designer was inspired to provide instead a model of her work, Box of Miracles: a time-based installation featuring a room-scaled revolving cube with various apertures, a light in the center, and image and video-based projections on its exterior.¹ I will discuss the details of the model in its four phases.

Box of Miracles first presents itself as a light, illuminating the apertures, but concealing the form of the cube. External projections of red, green, and blue, then reveal the cube’s 3-Dimensional form. The cube turns paper-white for the third phase and two hands appear on each of the four visible sides of the cube. They are measuring, molding, folding, cutting, etc. In the final phase, images of completed works from Devlin’s portfolio replace the hands and appear to represent the conclusion of a process. The projections go dark and the series repeats itself.

Box of Miracles is a model of the visual and spatial language that threads together Devlin’s body of work. It was originally designed and built for an exhibition at the C-Mine

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gallery in Genk. Box of Miracles was also featured in the Netflix documentary Abstract: The Art of Design, and a scaled down version was presented on stage as part of Devlin’s talk at the Serpentine Sackler gallery for the 2016 Miracle Marathon. The model tells a narrative of model creation, but also refers to an ever-evolving network of models that Devlin uses to engage audiences across disciplines, from opera to pop concerts. Devlin describes humans as “neophiliacs” – with a constant desire for the new. But as Box of Miracles demonstrates, newness, which Devlin expresses through illusions designed by light and motion on stage, is rooted in the behavior of models that she uses which oscillate between weak and strong.

In a 2016 interview at her studio, Devlin says:

We make models of everything…We will process through 20 or 30, perhaps, versions of an idea – because any idea is only part of a continuum of thought. I walk [into the studio] and look at these objects as if they were objects in an art gallery. It’s almost like looking at the stars; and we find the lines that join them.

Devlin’s work spans a broad spectrum of content, audiences, and spaces, and thus, design needs. She simultaneously designs sets for Wagnerian operas and world tours, for bands like U2 for whom a recent tour featured “a walkway flanked by video screens” that Devlin designed, “so that band members sometimes appeared to walk through moving images.” Her venues range from intimate audiences of fewer than 80 people to stadiums of 80,000. “She is widely considered to be the world’s foremost set designer” and continues to explore the mechanics of illusion, pushing the boundaries of what appears possible. Devlin constructed a the seven-story structure on stage that was the central piece of Beyoncé’s 2016 tour. With Kanye West, Devlin

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2 Miracle Marathon 2016: Es Devlin.
5 Miracle Marathon 2016: Es Devlin.
6 O’Hagan, Andrew. "Imaginary Spaces: Es Devlin and the Psychology of the Stage.”
discarded the entire concept of a stage, in favor of a floating platform that allowed the rapper to traverse sold-out stadiums, barely out of the reach of fans below. In a production of Don Giovanni for Royal Opera House in London, she projected 2D and 3D images on a spinning cube fitted with Escher-esque staircases that enhance the manic, deceitful and looping themes of the opera’s narrative. She has staged catwalks for Luis Vuitton and performances at Coachella. The Nether, a 2015 play about characters who escape to virtual worlds to pursue their vices, famously staged both reality and the virtual on the same set with the use of two-way mirrors, effectively blurring the very same lines of reality questioned in the play for audiences themselves.

Each project calls for its own unique design, but Devlin isn’t afraid to steal. She recognizes, that “when you’re telling a story in a live performance environment, you effectively have a congregation…when something is happening, and there is a truth, everybody in the audience gets it”. To effectively communicate (from the Latin communicare, meaning “to share” or “make common”), Es Devlin calls upon a Latourian understanding of models to devise an accessible language. As Latour describes what he calls Actor-Network-Theory, every object is an actor, and no thing can act or be acted on with complete independence from other forces. Devlin’s models do not exist in any defined hierarchy.

Indeed, constellations of stars – the stars, active agents in their own right --, her work recalls from text, history, contemporary art, and architecture. She dives deep into the literature of the performance she is designing to extract its essence. She notes, that just as Elizabethan audiences were well steeped in the wordplay of Shakespeare’s works, contemporary concert-

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7 2016 Design Innovator: Es Devlin.
goers are equally engaged with the layered lyrics of artists like Jay-Z. She then intervenes these texts along with references to predecessors in theater. Austrian designer Erich Wonder, who pioneered image-based design in opera and classical theater has a clear influence on her work. “She’ll use an image or body of work as shorthand in her early thinking on a project”. Artists such as photographer Andreas Gursky, and installation artist Olafur Eliasson, have surfaced as recent references. Devlin most prominently appears to use the work of light and space artist, James Turrell as philosophical models that underlie the design of her work. “She is theatre’s postmodern expert, and has an instinctive sense of how Shakespeare and opera and fashion and pop concerts might draw from the same dark web of psychological information”. The models Devlin uses, whether brought in from external sources, or her own scale models, act and react to each other, and from there her designs are born.

3.2: The Model

3.2.1: Light

Standing in a dark, empty room you see nothing but a floating beam of light. The room appears devoid of both tangible and intangible matter, but for the beam that levitates in darkness. The light stretches vertically from about one or two feet above the ground to about the same margin.

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10 Head Space: Es Devlin at TEDxYouth@Manchester 2012. Produced by TEDxYouth. YouTube. December 03, 2012. http://www.youtube.com/watch?v=h0s6Hmw4S3c.
14 Medford, Sarah. “Es Devlin's Otherworldly Stage Sets.”
from the ceiling. The light is narrow; its bright, white luminance is unnatural in its circumscription.

In a matter of seconds, the light disappears then reappears again to reveal something new. Encapsulating and illuminated by the same light is a circle with a diameter not much greater than the length of the light beam. Now the light radiates more vigorously, as the photons expand into their new-found space. Once again, the light disappears and the room turns dark. The circle doesn’t stay in our view for long; its appearance and disappearance resembles the gradual waxing and waning of the moon. Just as the circle was revealed, next a square is revealed surrounding the vertical beam. Each side is barely longer than the centered beam. The beam disappears and is replaced by a small rectangle of light, offset and less intense than the beam. The rectangle too, soon wanes and fades into nothing. Our beam once again presents itself as it first did: controlled, floating.

Light is the first essential element of Es Devlin’s work. She uses it as a storytelling device – expressing change over time through projections, immersive ambient color and controlled beams. She also recognizes it as the most elemental of narrative devices. Light has been used to tell stories all across the world and throughout human history: the first stories told around a fire, the Wayang shadow puppets of Indonesia, the refraction of sunlight through stained-glass windows. Devlin’s work continues this tradition.

“The eye with the brain turns light into information, but you can’t take the process for granted”, writes E.C Krupp, astronomer and director of the Griffith Observatory in Los Angeles. He suggests that our ancestors didn’t. With the beginning of just about every tale of Creation, Krupp writes, “there’s usually a primordial Darkness, and you have to shed some light to get the whole [thing] going. The Bible is on the case by the second verse, which puts ‘darkness…on the face of the deep.’ A verse later, God lets there be light and it’s show time. By the fourth day of
Creation, light has agents in the sky—the sun, moon, and stars”. Thus, the beginnings of narrative, of storytelling; arise with the inevitable appearance and disappearance of the Sun.

Light is a universal expression of life. When it is manipulated and controlled in unnatural ways, it has the ability to affect our emotions. Director of the LACMA, Michael Govan suggests that no one “has so fully considered the ‘thing-ness’ of light itself — as well as how the experience of light reflects the wondrous and complex nature of human perception -- as James Turrell has over more than four decades”. Turrell, who Es Devlin cites as having a direct influence on her work, believes in the physicality of light. He doesn’t draw with ink or sculpt with clay, buts molds light itself. “Light is not so much something that reveals as it is itself the revelation”. In his skyspaces, Turrell designs meditative experiences for visitors to observe the changing of sky light over time.

What happens between the installations like these and those who visit them, is what scholar Arden Reed calls slow art – the process through which art reveals itself to you, when given the time necessary. Devlin’s work doesn’t face the same issues as most art in museums (that the average American museum visitor spends only six to ten seconds with any artwork). Devlin is aware, that like those who visit Turrell’s installations, she already has the prolonged attention of her ticket-holding audiences. She immerses her audiences in the fictitious sunlight of the world she builds on stage. There is no night and day, but rather a world according to her rules.

17 In *James Turrell: A Retrospective*, Michael Govan writes about how the theme of light has preoccupied artists for centuries. “Leonardo da Vinci wrote volumes about the importance of light in rendering nature; Romantic artists described the sublime through light; and others, from Russian icon painters to modern artists, used abstract forms to account for a divine or inner light”. (Govan, 15)
19 Ibid. p.15.
21 Ibid. p. 10.
The room flashes red, then green, then blue; it is no longer empty. In its center, once occupied by
a beam, is a rotating cube too large to see above or below, inviting your participation and to be
observed from all four sides. Each plane has a translucent shape cut-out of otherwise opaque
wall. On one side the beam appears, now as a light bulb, through a square-shaped semi-opaque
gauze. On the others, a circle, an off-set rectangle, and finally, a thin vertical slit just as wide as
the light. Through color, form is revealed.

Es Devlin quotes Hamlet’s line that “I could be bound within a nutshell and think myself king
of infinite space” expressing her work as a designing new worlds within the limited scope the
stage. Whether the amphitheater or proscenium stage, both models are founded in being 3-
Dimensional spaces. Devlin uses the cube as a building block to inspire the imagination of her
audiences. The shape acts as a blank canvas for the consumption of 3-Dimensional media.
Audiences naturally allow their memory and experience to complement the ‘narrative’ presented
on stage. And relying on their memory, they must too rely on preconceived models of reality.

The apertures of Devlin’s cube, which also feature abundantly in her work, support this two-
way relationship of simultaneous production and consumption. Devlin likes to use the word
“aperture”, perhaps in reference to the camera, or more specifically the model of a camera
obscura, which renders the outside world “as a projected image within its dark interior space”.
The stage, like the camera, must act as mechanism of consumption in order to be one of
production. This may be true across theatrical performances, but is an essential part of Devlin’s
understanding and approach to her work.

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22 Head Space: Es Devlin at TEDxYouth@Manchester 2012.
The performances Devlin designs are miniature, condensed versions of reality. The miniature, as Susan Stewart writes, “is a world of arrested time…one we attend to the miniature world, the outside world stops and is lost to us”. Like Gulliver, who travels to the world of the miniature, audiences give themselves over to the dilations of reality and perspective that the stage presents. We map what we think we know onto this fiction, to assume a fuller understanding of the world. Devlin takes advantage of the fact that models of reality always change reality.

In addition to form, the cube represents that which is held within. The simpler and clearer the form, Devlin may suggest, the easier it is to take control of audiences’ imagination. Speaking of pop stars like Beyoncé, Adele, Kanye, and U2, Devlin says “They’re all to a degree religious – they have a sense of spirit, of a force greater than themselves. And they’re all interested in accessing that”. It’s an essential part of Devlin’s job, and reflected in the concealing quality of the cube. In the center of Box of Miracles is a light – typically an interior that Devlin doesn’t reveal. “The architectural embodiment of the Buddha often takes the form of a stupa, a temple like structure that is both mound and cave; in the most general sense, it is also an axis mundi, a world-center connecting the earth and the heavens.” Beyoncé begins her show exiting from the seven-story prism on stage. Her likeness is projected supernaturally on the enormous display from

25 Returning to James Turrell, Reed says, “No matter what kind of installation, whether we move or not, the drama unfold in our minds. Our perception of the external world reflects back onto us so that we watch ourselves watching, rather than simply fix our attention on actors playing in Oedipus or Hedda Gabler” (Reed, 230).
26 Turrell, a pilot as well as an artist, gives the following example: “The Cartesian space of three dimensions is, as all mathematical spatial concepts, a model which has evolved from the range of experiential reality as Descartes knew it. But if you are flying a plane his concept holds true for very short distances only. If you fly [between widely separated points], you will realize that the curved space of Riemann, in which the triangle can have more than 180 degrees, comes closer to reality. But even in this case you tend to think, wrongly, that the mathematical model covers reality. We superimpose the model on reality, and believe that the model actually is reality. The space we experience subjectivity though out observation is more bizarre. It is a space that comes close to dreams” (Govan, 75).
27 Medford, Sarah. "Es Devlin's Otherworldly Stage Sets."
29 James Turrell has long studied the studied the stupas of Borobodur, and it wouldn’t be too far a stretch of the imagination of Devlin is implying a similar spiritual nature with the cube’s relationship with imagination (Govan, 28)
which she has emerged. The prism incites wonder and awe. The reality is that the underlying workings of the show – the technical crew, backup dancers, sound and light engineers, are all hidden inside the prism. Kanye and Jay-Z stand upon giant cubes exposing themselves as small and vulnerable, but powerful as though having transcended their recluse.

3.2.3 Hands

The cube turns white, like paper, and the hands of a woman appear on each visible side of the cube. Her hands carry tools: rulers, pencils, knives, scissors, and clay. They measure, slice, cut and mold – each time re-revealing the light in the center of the cube.

Hands demonstrate the preliminarily work in making models. But the actions of the hands are ironic. They don’t produce anything. In fact, they primarily work as a force of destruction – tearing, pulling, and removing. Devlin’s focus is on exposing the illusion. Giant hands, moving rapidly on all sides of the cube, render the experience intense and overwhelming. The light beneath the projections seems to glow brighter with each reveal.

In a 2013 talk, Devlin uses the image of the handprints found in a cave in Spain. They are considered remnants from the Upper Paleolithic revolution – when, as she presents that some evolutionary scholars suggest, humans first became aware of death, and the myth of afterlife came into existence. The handprints are some of the earliest examples of human imagination, creativity, and desire for memorialization.

Nothing remains from Devlin’s work after the shows are completed (except for a few models). In response to this, she says, “what I’m really designing are mental structures, as opposed to physical ones. Memories are solid, and that’s what I’m trying to build.”

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3.2.4: Constellations & Conclusions

Another moment of darkness, then photographs appear on the walls of the prism. These images are of crowds, musicians, and actors all with the backdrop of stages that mimic the cube’s manipulation of light and aperture.

*Box of Miracles* models Es Devlin’s practice, exposing its creative process – how she creates, from empty, intimate darkness, massive immersive experiences. It embodies the iterative nature of her process – a fluid continuum of networking the way we think we understand the world; a world constructed by models. In Latourian fashion, she allows her models to live outside their intended use and act upon each other as independent, autonomous agents. Thus, they oscillate between weak and strong, reminding audiences of the familiar, while Devlin simultaneously proposes the new.
4. Installation 1: *in_paradiso*

(See Appendix A for documentation of this installation.)

*in_paradiso* is a site-specific installation that embeds itself in, and transforms the dogwood gardens behind the Rubenstein Arts Center at Duke University. The installation is composed of a two-way mirrored box, with a projector inside. It sits at the end of a pathway which abruptly stops with no clear point of destination. There is no sense of arrival at this endpoint. Audiences are met, instead, with a proposition to venture independently into nature, beyond the designed guidelines of the pathway. *in_paradiso* embodies this intersection of the designed, technological world and natural space in a conceptual time-based physical sculpture.

This installation is just as much a time-based installation as it is rooted in its location, yielding its cinematic quality. During the day, the monolithic sculpture appears almost invisible, but once noticed, its size and unnatural orthogonal composition impose the structure’s presence on the environment, and within the consciousness of its audience. Though physically motionless, when placed in outdoor greenery, *in_paradiso* evolves with its environment as time progresses. It lives, breathes and responds to sunlight, wind and rain just like the trees surrounding it. At night, in synchronization with the setting of the sun, the once opaque, reflective walls of the sculpture turn transparent. The space inside, now revealed, is illuminated by the projection of an A.I. system’s vibrant, multi-colored floral interpretation of the same scene. Floral patterns cyclically appear to grow and recede from the projected image of grass. *in_paradiso* is a man-made, electrically powered, and digitally fueled creation that embraces the natural world, working in tandem with its observers in simultaneously regenerating the world in its own nebulous image.

*in_paradiso* emerges through a balance of the technological and natural worlds. The word technology (n.), deriving from the Greek *techne* “art, craft, cunning of hand” and *-logia*, the
technological world refers to that which is constructed and designed. The natural world speaks to that which we, as tool builders and designers, do not control – the way the sun breaks through the clouds, and the blueness of the sky; the speed at which a flower blooms, and how its petals fall; and, how the morning dew sits atop a field of grass. Through this balance, *in paradiso* turns space into cinema. The stillness of the structure provides counterpoint to the natural motion that surrounds it. While the sun is out, the five perpendicularly adjacent rectangular panels that make the walls of the prism act as displays that, through reflections, frame and fragment the surrounding environment as distinct images. In this action, *in paradiso* reorients the space as an axis mundi centered at a clearly defined intersection of three axes the structure defines. Its low one-foot tall profile takes advantage of the indistinct textures of grass and pavement so that they pass seamlessly from physical reality through the illusory reflections. Rather than appearing as mirrors, these sides appear to disappear altogether. Light and shadow are not manufactured but natural. As a result, when viewed from a distance, the box appears more a mirage than a physical body, blending in and becoming indistinguishable from its environment. The sculpture disappears in the light.

When viewed in close proximity, however, the disappearing act of the structure is consumed by a thirty-inch wide, ninety-two-inch long face that reflects the sky. Depending on the viewing angle, audiences may see portions of peripheral trees in the frame but when viewed from directly above, the top panel becomes a wide-format display for the colors of the sky. Whether saturated blues and whites on a clear day, cloudy greys, or hazy orange and purple at dusk and dawn, the colors contrast sharply with the green grass on which it appears to float, controlled and defined within the dimensions of the rectangle. The proportions are familiar and human scaled; the dimensions of the rectangle (30” x 92”) are those of a doorway (extended by one foot). Accordingly, the frame acts as an invitation to enter.
While physically inaccessible, by bringing the sky to ground-level and formatting it to human scale, the phenomenon of displacement and re-contextualization forces audiences to consider the fluctuation between their subjective and objective reality that occurs at this point of interaction. Here, *in_paradiso* makes audiences aware of the insubstantial, psychological components of ourselves that we impose on the world around us. The structure not only upends preconceived expectations, but also temporarily suspends the viewer in a state grounded neither on land nor in the sky above. Consciousness is separated from embodied reality and subjectivity trumps objective vision. You know that the sky is above you, but you can’t help but look down to see it – this displaced horizon is so close that you desire to touch it and splash your hand in it as if it is a reflecting pool of water.

Art Historian Johnathan Crary writes on a work by Olafur Eliasson titled *Your color memory* which, though through different means, achieves a similar effect of illusion through awareness of subjectivity. Eliasson’s piece is a composed of an immersive oval shaped room in which the walls are illuminated by mono-frequency lights. The lights envelop the space and change over time. The result of this overwhelming sensory experience is a lasting afterimage – like the image that retains in the back of your retina when you close your eyes after looking directly at the sun. As the colors change, and when a viewer leaves the space, the previously exposed color temporarily filters a person’s view of the world despite it only existing within his mind like a ghost of that particular memory. The experience of that piece, Crary writes,

…recalls something of the cognitive conditions in Andrei Tarkovsky’s film *Solaris* (1972). In this science fiction parable, human beings in an artificially constructed environment find that their memories and other contents of consciousness become fully externalized as ghostly but physically real entities fluctuating between subjective and objective reality.\(^1\)

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Though audiences experience no ghostly afterimage with in_paradiso, its clearly defined form contrasted with an ever-changing, unstable image (whether due to a viewer’s perspective or the sculpture’s own subjectivity to nature – more on this later), make the experience fundamentally subjective. The spectral experiences in Tarkovsky’s film, Crary writes, “are unsettling indications of sensory derangement and impoverishment of contemporary life but are at the same time hopeful portents of the creative power of human memory and its myriad affects and emotions”.\(^2\) in_paradiso makes a different argument, not necessarily of derangement and impoverishment, but of augmentation and simultaneous experiences. Memory, however, does play a fundamental role in recognizing the change that brings about awareness of subjective thought imposed on objective truth. And as Crary suggests, it is in memory that lie the “affects and emotions” that charge creativity.

At sundown, in_paradiso transforms and shifts the focus from the external world to the space enclosed inside the structure. As the sun sets, the walls, made with two-way mirrors slowly turn transparent. A white light which had been present at the far end of the box starts to glow brighter and from certain perspectives, thin beams of green, blue, purple and yellow light are visible dancing on the walls, appearing for a brief moments before disappearing. Meanwhile, the world outside continues to fade into darkness, the projected the light inside grows brighter and illuminates the grass on the floor of the contained area. The grass is moist due to captured humidity and glistens as the dew refracts the multicolored light beams. Once the environment is pitch black, the projected content itself finally emerges opposite the end of the projector, on the side where the box meets the path. Superimposed on the otherwise transparent view of the illuminated grass is a moving image of the same grass transforming into colorful floral patterns

\(^2\) Ibid. p. 25.
and returning to grass. The sequence repeats three times at different speeds before fading to black while in “full bloom”. At this moment, the box also momentarily disappears into the night before returning with the same vibrancy as the video loop repeats.

Once again, in this illuminated state, the technology of the system serves as a platform that reveals both the physical natural environment and a filtered subjective interpretation of it. The mechanics of the projection are unhidden and the box is a theater miniaturized to a subhuman scale. As audiences to an unfolding scene, we have an omniscient perspective from above, but one that still changes depending on the viewing angle. There is only one source of light and it is traveling in a single direction, so even at night the two-way mirrors still effect our point-of-view. One may not even see the projection with a cursory glance while passing by. Like when stargazing, your eyes must calibrate with the darkness in order to see the vivid detail.

Over time in_paradiso reveals itself to its audiences. Perhaps this experiencing this installation would categorize as what scholar Arden Reed calls slow art – the process through which art unveils, when given the time necessary. Ten seconds with in_paradiso, and all you would see is a box, insignificant and not worthwhile. The same is the case if you approach the work with expectations for immediate response. in_paradiso unfolds over twenty-four-hour cycles, and no cycle is ever the same. This is in-part due to the installation’s interdependence with the natural environment which cycles with the rising and setting of the sun. The core of this aspect of the work is once again rooted in the subjective and our need to see the world through mediating technologies. If not clear, the art of in_paradiso is not the box; it produced by the audience and each person’s individualized experience. You are simultaneously spectator and

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protagonist. Eliasson warns of the “Disneyfication” of art when experience is generalized to meet safe expectations for “universal” experience. A “Disneyfied” experience does “not leave room for individual evaluation, feelings, and thoughts”. \(^4\) Instead, Eliasson suggests we should encourage variety and individuality in the experiences of audiences. “In other words, in preserving the freedom of each visitor to experience something that may differ from the experiences of others, art can continue to have a significant impact on both the individual and society as a whole”. \(^5\)

The content, in particular, plays to the enhanced subjectivity of contemporary human consciousness in a data-driven, digital age. The floral patterns, which are computer generated and “grow” iteratively from a seed-image of grass, are created with a process that visualizes the trained knowledge of artificial neural networks. This method, known as DeepDream, was created by machine learning researchers at Google in 2015 to better understand the emergent behavior of neural network models. \(^6\) Artificial neural networks are the backbone of significant recent progress in areas of image classification and speech recognition. This technology has brought forth the age of once futuristic dreams of self-driving cars and A.I. personal assistants to present day reality. DeepDream was created because despite remarkable results from these techniques, we still do not completely understand why certain models work effectively and others do not.

The floral patterns are generated by inverting a neural network, specifically the type known as a Convolutional Neural Network, trained to classify images and identify over 1000 different things ranging from penguins to bananas. In short, Convolutional Neural Networks are modeled on the human visual system. These networks are structured by weighted “neurons”

organized in layers, with each layer acting as a (convolutional) filter. High-level layers (on the end of the network closer to our input – the image we are asking the system to classify) distill pixel-level information, like color and intensity. Neurons which are activated in deeper layers detect edges, contours, features and, ultimately, objects. These results are scored against what the network already understands and the image is appropriately classified. By visualizing the deeper layers, we can understand how the system perceives penguins, bananas, or in our case, flowers. The seed-image, which in the content generated for *in_paradiso* is a photo of grass, is just the canvas on which the neural network interprets. By isolating the neurons that are activated when network detects flowers, we can use DeepDream to iteratively transform the image, enhancing floral patterns when those particular neurons are most activated. This process is iterated many times over on the generated outputs. As a result the image generated has a fractal quality and with each iteration, the floral patterns grow ultimately populating, and consuming, the entire frame of the original image.

This experience of watching the natural world (visible through the semi-transparent panel on which it is projected) compete with, but ultimately be consumed by the fake nature produced by the A.I. system engages a subconscious anxiety. Perhaps this anxiety is rooted in contemporary doubt and guilt about the place humans occupy that straddles the deteriorating natural landscape our planet and the virtual realms we escape to. It is no coincidence that the slab-shaped installation resembles the iconic monolith from Kubrick’s 2001: A Space Odyssey. Yet, in *in_paradiso* the technological aspects of the installation share equal prominence with the natural elements. They work in synchronization with each other in a harmonious relationship. Marie Laurberg, curator of the Louisiana Museum of Modern Art in Denmark notes that “nature, represented by light conditions or meteorological phenomena, is woven into an unbreakable continuum with the technological world of human creations” in Olafur Eliasson’s work. “This
continuum”, she writes, “is human reality”.7 The natural elements of in_paradiso are not intended to be interesting as an expression of something “natural,” but, as in Eliasson’s work, to create an environment that works with the technology to enter “the viewer’s body, consciousness and memories”.

Hence, the flowers grow, retreat and disappear completely – the A.I. asserting and reasserting its presence -- in each brief looping cycle, and the projection remains on through both night and day, whether it is visible or completely obscured.

Along with the body of Olafur Eliasson’s work, in particular the previously referenced Your color memory, but also the communal illusory experience of The weather project and landscape embedded mirrors of Your glacial expectations made with Guther Vogt, the design of in_paradiso is inspired by two other primary references: 1) the Japanese torii gate, and 2) James Turrell’s Stone Sky, 2005. In Japan, the location of a Shinto shrine is indicated by the presence of a torii gate. These structures, which symbolize a separation of sacred from mundane, are notable in that they do not present any barrier to entry. There is no door, and there are no walls. Instead, a large rectangular frame presents a window to the other side that must be seen, before entered.

And of course, the sacred realm which it protects can only be accessed by passing through the gate, and not around. The gate is not indicative of a necessary ascension or descent, but rather a realm that exists parallel to the present.

While torii gates in Japan may date its origin to over a thousand years, the implications of the design remain true today. Perhaps more so than ever, life in the 21st century reflects one of multiple simultaneous existences. Let alone the parallels of the natural and technological worlds which we have discussed, but also the realization of a twenty-four-hour globalized economy and

8 Ibid. p. 28.
social media that similarly connects people regardless of place or time. Night or day, actions hidden or unseen halfway across the world can have personal, social or cultural ramifications. The gateway is a reminder of parallel lives that we all lead and must balance and acknowledge even when we choose to be more present on one side over the other. in_paradiso is a statement on parallel, but frequently invisible, spheres of life that we all occupy. It invites audiences to confront and appreciate the beauty of hidden and unseen aspects of nature and life.

Turrell’s skyspaces are meditative experiences for visitors to observe the changing of sky light over time. The two-way mirrors of in_paradiso in conjunction with the internal projector function as Turrell’s skyspaces do. The experience is composed by the interplay of controlled and natural light. Stone Sky, 2005, also known as Stonescape, is a monolithic cube that sits at the end of an infinity swimming pool. From the perspective of the pool’s end, the cube appears two-dimensional, like a monolithic slab made of white stone. The cube can only be entered underwater, lending the pool to act as a guiding path inside the otherwise inaccessible, and perhaps unnoticed, space inside. With help from the still and reflective water, the monolith assumes the color of the sunset at particular times of the year. Stonescape is located in the mountains where the sunsets are vast. The monolith frames this color and appropriates it as art on a canvas. This was the inspiration to capture and ground the colorful North Carolinian sky in designing in_paradiso. Arden Reed writes of Turrell’s slow revealing art that “No matter what kind of installation, whether we move or not, the drama unfold in our minds. Our perception of the external world reflects back onto us so that we watch ourselves watching”. In this dramatic space, light and time work together to create an intimate yet expansive cinematic experience.

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*in_paradiso* evolved through many design iterations to achieve the final result. At first, the design was trapezoidal: ten-feet tall, four-feet wide and eight feet long, with a rectangular screen facing the path on which audience would approach the structure. Taking direct inspiration from the torii gate, the screen would present a life-size gateway to an alternate digital realm. Not only was the design too large to disappear, even with the help of mirrors, the intended incidental (rather than intentional) experience did not seem to justify the design’s size, material cost, and complexity. Ultimately, the final low-profile design arguably generates the greater experience.

The box has no screen and is made entirely of plexiglass lined with two-way mirror film. There are no support beams to obstruct the projection and the design, composed entirely of right-angles, disappears almost seamlessly into its environment. While the structure will eventually give way to entropy (as all artworks, arguably do), the final design also resulted in an experience that is multi-dimensional. It embraces the mechanics of illusion to create a novel experience composed of time, light and space beyond the extent that a traditional two-dimensional screen could fulfill.

The premier of *in_paradiso* revealed an unforeseen, but gratifying aspect of the installation. What was intended to be an intimate, personal experience became a communal one. Audiences willing to patiently witness the installation evolve throughout the day, became more and more familiar how what they could see inevitably differed from others. And thus, in the communication between artwork and audience, a sharing of experiences was born between friends and strangers. Perhaps this was due to an emerging realization of the singularity and fragility of our own independent perception. As a public work, *in_paradiso* presents a reminder that a community can be formed through the exploratory coming together of small-scale acts of sharing and exchange.

The title of the installation, *in_paradiso*, is a reference to the experiences of Dante Alighieri who travels between the parallel realms of Inferno, Purgatorio and Paradiso in *The
Divine Comedy as he observes the mechanisms of the cosmos. *in_paradiso* is stylized the way it is because there are no spaces in properly formatted computer file names. The hope is that *in_paradiso* can shift the focus from art, the object, to the experience of seeing and being present the world through a harmonious relationship between nature and technology. It is an invitation to challenge and reinterpret our understanding of the world and awareness of self -- for it to be, as Olafur Eliasson may suggest, a “reality machine”.
5. Installation 2: Strange Loop

(See Appendix B for documentation of this installation.)

Strange Loop is a follow-up work to in_paradiso. Assembled and installed in Duke University’s Smith Warehouse for the month of October 2018, the process of creating Strange Loop was heavily informed by lessons learned producing in_paradiso – both in terms of theory and practice. Like in_paradiso, Strange Loop is conceptually rooted in light art and space-oriented minimalist sculpture; it is also made entirely of clear plastic, and features imagery generated using DeepDream. This time, however, rather than the sculpture embedding itself into its environment, Strange Loop imposes its presence in the given space. Built to human scale, Strange Loop is a labyrinth of colorful banners suspended in mid-air; it is an attempt to physicalize and spatialize the emergent visual interpretations and perceptions of an artificial intelligence. The immersive design draws attention to the act of perceiving through both human and machine vision systems. It provokes the audience to interpret what machines see in the age of artificial neural networks.

The labyrinth is formed of twenty-five three-foot wide banners made of plastic translucent film which are each supported by one-inch thick clear acrylic braces on top and bottom. They are suspended vertically from a pre-existing grid structure by transparent monofilament fishing line to appear as if they are floating. The banners are distinguished by three distinct forms: the spectral array, the bridge, and two triptychs.

The aspect ratios of twelve of the banners are fifty-eight and ¼ inches tall and thirty-six inches wide to match the golden ratio of 1: 1.618. Level with each other and floating approximately one-foot above the ground, these hang centrally in the installation space. They are organized in two offset parallel rows of equal length separated by a gap of four feet. These
banners form the spectral array. Each banner is uniquely colored and double-sided: one side is just color, and the other is augmented with textures generated using DeepDream. They are ordered sequentially, presenting the spectral range of colors visible to the human eye. The corresponding generated textures reflect the hierarchical layers through which a neural network distills unstructured information into concepts. Higher-level layers interpret, and thus generate, abstract lines and contours; deeper layers begin to show knowledge of complex, figurative forms: faces, flowers, bridges, architecture.

The bridge visually connects the two rows. These seven uniform banners are smaller, just three-feet tall, and square in shape. The bridge weaves through the spectral array, filtering the multi-colored banners and alluding to the filtering that takes place in a convolutional neural network. These filters hang only a few inches above the ground, but on a sloping elevation. The bridge acts as both physical obstacle and marker of space. It prevents visitors from walking through the spectral array, instead encouraging movement along the perimeter, to circumambulate the centerpiece.

The installation space is defined by a twelve-foot square area bordered by walls on two adjacent sides and is open on the opposite sides. The walls are lined with six banners forming two triptychs. Eighty-one inches tall, they span nearly the full height of their respective walls. The triptychs feature imagery generated by DeepDream, but here, the textures are generated through the neural network’s interpretation of large-format photographs. These augmented photographs, of Mount Fuji and waterlilies, reference iconic imagery. They call attention to pre-existing images embedded in the minds of viewers, but present them as fragmented and as reinterpreted by a machine intelligence that knows nothing about iconic value of the content. The triptych banners are also lined with two-way mirror film, adding to the illusory nature of the generated imagery and producing reflection of the physical world in the computationally augmented images.
Previous works installed in this exhibition space typically decorate the walls with 2-dimensional media; in contrast, as a 3-dimensional piece, *Strange Loop* reorients space by intervening with form. Richard Serra, well known for his imposing forged-steel sculptures, describes the influence of sculpture in space as creating an “anti-environment”. A sculpture “alters and changes the exiting condition, whether it is urban, architectural or landscape. It changes how one relates to those spaces and places both perceptually and conceptually.”¹ *Strange Loop* generates a new environment that can be entered and circled. Specifically, the spectral array and bridge form a distinction of interior and exterior space and challenges the viewer with the question: How can one enter a space when there are no walls?

Unlike Serra’s installations which are characterized by their immense weight, *Strange Loop* is characterized by lightness. Serra writes,

> We are all restrained and condemned by the weight of gravity...The constructive process, the daily concentration and effort appeal to me more than the light fantastic, more than the question for the ethereal. Everything we choose in life for the lightness soon reveals its unbearable weight. We face the fear of unbearable weight: the weight of repression, the weight of constriction, the weight of government, the weight of tolerance, the weight of resolution, the weight of responsibility, the weight of destruction, the weight of suicide, the weight of history which dissolves weight and erodes meaning to a calculated construction of palpable lightness. The residue of history: the printed page, the flicker of the image, always fragmentary, always saying something less than the weight of experience.²

Serra’s work emphasizes human experience. On the other hand, *Strange Loop*, attempts to embody the experience of an artificial system. The parallel of “experience” for a neural network is the training process driven by statistical machine learning algorithms. However, an algorithm does not feel weight, it is not burdened by gravity; it is simply a set of operations. This

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is reflected in the disorienting artificiality of *Strange Loop*. The installation, though expressing the structure of emergent and natural processes through color, texture and imagery of nature, is profoundly unnatural. It is made entirely of clear plastic. The hanging banners, though large, rigid structures, appear to be weightless.

The labyrinthian form of *Strange Loop* was particularly inspired by two works: Robert Irwin’s *Excursus: Homage to the Square* and Olafur Eliasson’s *Seu corpo da obra (Your body of work)*. Both make use of large sheets of translucent material to divide space. Irwin’s piece uses a semi-transparent white woven scrim, while Eliasson’s work features transparent plastic sheets colored cyan, magenta and yellow. In both works, as you move around the space, your perception is altered. Upon entering *Excursus*, the world outside is clearly visible through the scrim walls, but as you move further into the space, the scrims filter each other and becoming increasingly opaque, washing the world in an ethereal white. This gradual diminishing of color brings attention to form, which in this case, emphasizes the repeating square shape that lends form to that particular labyrinth. *Seu corpo da obra* similarly relies on movement to bring life to the installation. Despite being a static structure, viewers witness rearranging chromatic variations incited by the layering and un-layering filters. In both installations visitors find themselves simultaneously looking at and looking through; everything is filtered and everything is in a constant state of flux. These two installations, like *Strange Loop*, use movement in space and compositional layering to bring about a self-awareness of perception in visitors.

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In interacting with *Strange Loop*, visitors find themselves looking at looking. The installation models a world in which human perception is not only filtered through color, but also through the abstraction of data and machine intelligence. *Strange Loop* draws parallels between the emergent perceptual systems of humans and artificial neural networks through embodying fragmentated, isolated elements that make these systems whole. Immersion in *Strange Loop* is like entering the emergent mind of an artificial intelligence.

In the end, we are self-perceiving, self-inventing, locked-in mirages that are little miracles of self-reference – Douglas Hofstadter, *I Am A Strange Loop*\(^5\)

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6. Conclusions

Work comes out of work. I can’t think [conceptualize] my way through a problem. I have to work my way through a problem…You realize that you could not have foreseen the conclusion of your intention. The physical facts count for a lot more than the thought that doesn’t take a physical manifestation. – Richard Serra, Forged Steel

This thesis explores the co-option of artificial neural networks in the production of art. In producing two original art installations, I attempted to establish what could be considered, conceptually, as a new hybrid art form. Engaging two autonomous, intelligent, complex systems – an external pre-trained artificial neural network, and my own internal (developing) aesthetic intuition – the artworks that resulted became emergent in their own right. Strange Loop and in_paradiso both simultaneously draw from the emergent structures of the artificial neural network and those of the natural, human kind, through the use of DeepDream, and the study of light, space, and illusion.

These installations represent not only the very first stages of my own design work, but also where I see potential for further work based on collaboration between autonomous human and artificial intelligences in design. Notably, in my art so far, artificial intelligence has played no role in formal design. Although, I refer to these works as the product of human-computer collaboration, the role of the human actor greatly overshadows that of the computer. I conceptualized the work, deliberately chose a neural network model to use (let alone one trained on data assembled by humans), optimized the algorithm to generate imagery I found aesthetically compelling, and built the physical work with my hands. While the works express a particular A.I. system’s emergent structure, the relationship between that system and the actualized artwork could potentially be closer linked.

I believe this proposed hybrid art would be more persuasive if the emergent structure expressed was that of an intelligence being used to the design the subject. Many of the deliberate decisions I made in designing these works could be automated. Elements of my aesthetic tastes and intuition could potentially be reverse engineered (as proposed by Bill Seaman in *Emergent Constructions: Re-embodied Intelligence with Recombinant Poetic Networks*) and re-embodied into their own artificial neural networks.² Not only would this perhaps enhance the unpredictable emergent behavior of this design process, which I view in itself as an increasingly complex system, it would allow the human designer to be even more intentional with his aesthetic intervention.

In particular, I am interested in the role this kind of human/computer collaboration can play in architectural design. Parametric, algorithmic forms are increasingly common in construction to reduce costs and environmental footprint, to maximize natural light and optimize the programming of spaces. What kind of training and structure would enable artificial neural networks to reach these goals while providing human users of space a sense of wellbeing? And how can neural networks be used in the design of not only formal structure, but functional design features, program and materials.

Generative Adversarial Networks are a new class of A.I. in which two competing neural networks battle each other to better solve problems with ruthless efficiency. Yet, efficient design alone may not serve the human purpose. Purposeful design, especially in architecture, should start and end with the human. Japanese architect, Tadao Ando, articulates this well. He writes,

[T]hough the means by which buildings are made may have become digitalized, human beings are the ones who conceive, and ultimately make and use, buildings. If buildings are to be created for those imperfect beings full of contradictions, then ideas born of flesh

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and blood, ideas that are at times violent and tenacious, at other times so subtle and sympathetic as to seem irrational are surely also necessary.  

Hence, the hybrid collaboration between human and computer proposed in this thesis; a collaboration in which each actor promotes the other. Emergent systems like artificial neural networks can open new avenues for creativity by enhancing human intuition. Human experience is defined by the inefficiencies of irrational human behavior, and it is only the deliberate inefficiencies that separate art from science. We still need the human touch. 

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Appendix A: *in_paradiso* Documentation
Appendix B: *Strange Loop* Documentation
Bibliography


*Head Space: Es Devlin at TEDxYouth@Manchester 2012*. Produced by TEDxYouth. YouTube. December 03, 2012. http://www.youtube.com/watch?v=h0s6Hmw4S3c.


