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Project Report on Plotter Drawings

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Introduction

This writing tracks the emergence and development of my interest in machine assisted drawing in relation to a body of work that I am producing for my final project at Piet Zwart Institute. The full body of work involves 3d-animated video works and plotter drawings derived from the 3d animations. While the animations and the drawings both inform and influence each other, this document will only focus on the plotter drawings. With the 3d animations I'm using the latest technology, often exploiting the newest features of 3d software released only months ago, and pushing the limits of what's possible on high-end consumer hardware. In that regard I'm firmly rooted in the present. At the same time with the drawings I'm making use of plotters which are some of the oldest digital technologies, being first introduced in the late 1950's and first adopted by artists in the 1960's. In this document I will look at some of the early pioneers in this medium to see both where things come from and how they have evolved since. I will also provide examples of contemporary artists' approaches to drawing machines, looking at how differing artist practices both historical and contemporary intersect, influence and push up against my own work. I will be investigating the questions we share and the questions we don't share, and how my position relates to theirs.

This thesis attempts to gain an understanding of my own previously held assumptions about the kind of drawings that can be produced by my own hand and with the assistance of machines. Much like the way Vilém Flusser describes "The apparatus does as the photographer desires, but the photographer can only desire what the apparatus can do" (1985, p.20), I'm attempting to uncover what that might mean for my own position as an artist in relation to the apparatus of the plotter. This will also involve an examination of the desires of both my predecessors and contemporaries in relation to my own work. This investigation means treating the apparatus not as "a black box", but to attempt to illuminate some of what is happening on the inside, showing the evolution of a process, and a history of my encounters with the technology.

I hope to question the assumption that technology moves only in a forward direction and that to engage with technology is necessarily to engage with the new, the present and the future. The past is always reaching into and directing our present, and consequently our future. The possibilities enabled by these technologies were determined by engineering decisions long ago but still these design decisions still have reach in the present day. This is why it is interesting for me think about what it means to use these tools in the present moment, as a way of considering in broad sense of what counts as "contemporary."

A Brief Intro To Plotters

Over the course of the last year I've been making drawings using computer-controlled pen plotters. During my time at the PZI and WDKA I've come across several of the machines, and found both the machines and the drawings they produce intriguing. Digital technology evolves quickly and hardware becomes obsolete so it's rare to continue to use machines that have been around for more than 10 years. These machines continue to be used by both faculty and students, many of the students were born years after the machines ceased to be manufactured.

The manual for the main plotter I'm using has instructions for connecting the plotter to an Apple II computer, which gives an indication of how old the machine is. In spite of their age the machines are robust, reliable and easy to program. You can use some basic commands that tell the machine to either place the pen up or down and move to a

specified coordinate. Many of my colleagues use the machines in workshops and lessons as a tool for experimentation and as a way of illustrating how to use programming to control external machines.

Plotters have been superseded by printers for nearly all uses, with the exception of vinyl cutters most commonly used for sign making. The design and operation of both vinyl cutters and pen plotters are essentially the same, only instead of a pen, a knife is moved across the surface of whatever material is loaded into the machine. Perhaps one reason why interest in the machines persists is that they can be controlled in real-time in a way that printers cannot. Printers expect to print a finished and prepared page, while plotters can easily be sent a constant stream of updated commands telling the pen to move to a desired position.

What distinguishes images made by a plotter from images made on a printer is that plotter images are built up line by line rather than dot by dot. A printer outputs the image sequentially, left to right, and top to bottom. The output is entirely logical, start at the beginning and finish at the end. Conversely the plotter builds the image in a very inefficient fashion, constantly moving the pen and paper back and forth for each line. Lines are not sorted to minimise travel time, and are output in whatever order they were generated in software. Before the advent of inkjet printing they were one of the only ways of producing highly detailed images on paper.

I've long been aware of plotter machines and their role in computer history. Surprisingly given my history of working in media labs I had never personally used a plotter or had access to one. Working from 2008-2010 in the FabLab at the Waag Society in Amsterdam I encountered a number of digital fabrication machines which share the same technical DNA of plotters, including CNC routers, Laser Cutters, 3d printers, and a vinyl cutter. During my time in the lab I worked with many artists and designers using the lab's machines in quite unexpected ways but I don't recall anyone using the vinyl cutter or the CNC router to make drawings. Before that I worked from 2002 to 2007 at a digital media lab within the Banff Centre for the Arts called the Creative Electronic Environment where working as a technician I came across many obsolete technologies used by previous generations of artists but never to my recollection did I come across a plotter. Before coming to the Piet Zwart Institute my main exposure to plotters was through hackers and hobbyists on social media where there's a wide range of vintage hardware enthusiasts who continue to develop tools to enable users to work on old plotters using current computers and software.

Artistes et Robots Exhibition:

While using such antique machines in the creation of my work I am often thinking about how my work would relate to works made by early computer artists working in the late 60's and in the early 70's. I was especially interested in the use of plotters as a way of making art objects through technical processes which often emphasise some form randomness and that would result in a "traditional" works on paper. During my initial research I saw the exhibition "Artistes et Robots" (2018) at the Grand Palais in Paris, which featured works from a number of artists working with drawing and painting machines, with works spanning from the 1950's to the present day. In this exhibit I got to see works by Jean Tinguely, Manfred Mohr, Vera Molnar, Patric Tresset among many others.

The exhibition featured the works of Jean Tinguely, whose mechanical drawing machines could be seen as a precursor to works created by early computer artists. Starting in 1954

Tinguely created a series of drawing machines called Méta-Matiques. The drawings produced by Méta-matiques were the result of mechanics, using electric motors, irregularly rotating parts, linkages, springs and angular motion to produce chaotic and unpredictable results. The drawing machines were often interactive, allowing the spectator (in the original presentation, not in current exhibitions) to change the speed of the electric motors that drive the machines, altering the outcome of the drawing. The machines are designed with the expectation that outcomes are never the same and can therefore produce an infinite number of outcomes.In the 1959 Biennale de Paris, his Meta-matique #17 produced over 40,000 drawings. The material and mechanical affordances for randomness are present in the mechanical design of the drawing machines and these features account for the variation in outcomes.

Manfred Mohr was an early pioneer of computer art and produced the majority of his work by means of a plotter. Unlike Tinguely the machines used by Mohr are expected to operate in the same way each time (within a small margin of error). It is the programming not the machinery that produces the variation in outcome in Mohr's work. In that regard if one of Mohr's programs is run in the same way, the machine should output the same work. The same could not be reasonably expected from some of Tinguely's drawing machines. In Mohr's work, the role of chaos and randomness is shifted to the next order of abstraction; from physical, material and mechanical, to conceptual, digital, and programmatic.
Also featured in the exhibition were works by Vera Molnar, using similar techniques. Her drawings on printer paper with sprocket holes, grids on repeated boxes, undergoing a transformation, becoming more and more unrecognisable, chaotic, random.This piece works on this same order of abstraction.

A more contemporary example of drawing machines in the exhibition was by Patric Tresset in his installation " Human Study #2.d, La Grande Vanité au renard." The focus and concerns of Tresset's work are significantly different than the more modernist concerns of his computer art predecessors. The installation uses dramatic staging, putting the machines making the drawings on display and showing the drawings in the process of being made during the exhibition. The installation features three desks on which are mounted anthropomorphic drawing arms, comprised of servo motor linkages articulated like jointed human arms, sketching out a still life vanitas scene. Each desk also has an articulated webcam that can switch from looking at the drawing on the desk to the still life scene in front of it, suggesting a visual feedback loop. Tresset states that theatricality is a central concern in his works.

Some of the finished drawings are shown in a grid arrangement on the adjoining gallery wall. The drawings are even signed, with the name of the robot Paul rather than the artist himself. Tresset has produced multiple iterations of this installation, with varying numbers of robot arms, sketching different scenes from still lives to live models. The installations are usually designed in a way that they look like drawing classes at an art academy.
On Tresset's website he states that he designed the robots in order to overcome a serious case of painter's block. The website also states the drawing techniques used by the robots are based on the artist's own drawing technique but that "Even if the way Paul draws is based on Tresset's technique, its style is not a pastiche of Tresset's, but rather an interpretation influenced by the robot's characteristics." (Tresset, n.d.)

While not featured in the exhibition, one other contemporary example of an artist using similar drawing machines is Sougwen Chung. Where Tresset's works are theatrical, Chung creates works that are performative, combining marks made with her own hand with those made by machine. In her series "Drawing Operations" she uses robotic arms similar to

Tresset's, and uses them to create work which she describes as "an ongoing collaboration between an artist and a robotic arm." (Chung, 2015) Like Tresset, Chung has given her robot a human-like name: D.O.U.G._L.A.S.

In "Drawing Operations" the artist and machine work together simultaneously in a feedback loop creating abstract marks on the same piece of paper, reacting to the generatively produced drawings and making her own additions and modifications by hand. While Tresset's installations use robots as a stand-in or replacement for the artist, in Chung's works the robots are always featured alongside the artist drawing in concert with the machines. The documentation of the work, the photographs of the artist and robot together seem almost more important than the final drawings. As the project has evolved, the robots have increased in size from small table-top drawing arms to massive industrial robot arms in increasingly theatrical fashion, including live performances where an audience is invited to watch the artist draw along with the robots.

These theatrical elements are something that I've consciously tried to avoid in my own work. Anthropomorphic drawing 'robots' tend to draw speculation on the role of the machine as artist, and invite questions of the possibility of machine creativity. In "The Machine as Artist as Myth" Andreas Broeckmann describes how our conception of the machine can often take on a mythic dimension where we concoct an immanent future where the machine is set to replace us. For Broeckmann to describe the machine as artist "implies that […] even the use of these words makes us slip into a mythological realm where neither the figure of the artist nor that of the machine can easily be called into question. Instead, we automatically see them pitched against each other, struggling for supremacy and survival."(Broeckmann, 2019) My selection of plotters does not directly call into question the role machine intelligence or of the human hand, because the way the operate is so unlike a human being. Indeed their status as obsolete devices seems to prove the point that we are in no danger of the machines replacing us anytime soon.

Plotters at the WDKA / PZI:

There are a surprising number of different plotters at the WDKA**.** In the Media Design Masters' studios at the PZI there's an old HP model 7470A **(**released in 1982, can plot on A4 paper**)** sitting in a display with other antique computer hardware which I see every time I'm working in the studio. In addition to my studies at the PZI, I work part-time in the Interaction Station as a teacher and helping students in the station's media lab. In my first year at the station one of the programs the station supported was the Digital Craft minor, taught at the time by Jon Stam and assisted by Tim Knappen. Several of Stam's students were experimenting with plotters for their assignments**.**

The Interaction Station has two HP7475A plotters, which were originally released in 1983 and can plot on A3 and A4 paper. Stam's students were using these two plotters to create an installation that would take images from a webcam and use the plotters to plot a raster lines version of the webcam photo in an endless scroll. I was called upon by Stam's students to assist with some programming issues they were having. As they were beginner programmers, they were copying and pasting bits of code together from various examples and not everything was working well together. My role was to help troubleshoot, find some of the errors in the code and help them find a solution to make their installation work (and hopefully teach the something in the process). I managed to help them to get their code in a more functional state but in working quickly I realised that I did not have a full understanding how the plotter machines worked and the function of many of the plotting

commands. I knew enough to get the job done, but both inspired by the types of images the students were creating and anticipating that more students might need assistance, I set aside some time to start experimenting with the machines on my own so that I would have a deeper understanding of how the machines worked. If I understood the machines more fully I would be in a better position to explain and help the students work.

At first I stuck to working with the HP7475A plotters, but the ageing hardware had some mechanical problems which prevented it from being a reliable choice to use for regular use, so I set upon finding out about the other machines that were available. I found another plotter sitting in storage at the Interaction Station, the Roland DXY-980a which appeared to have not been used in a while. According to the Roland website the plotter was discontinued in December 1987, but was in remarkably good shape especially compared to the HP devices I had been working with before. This plotter has a flatbed design which can accommodate A3 sized paper. There are fewer moving parts and as a result the machine was much more reliable. The Roland plotter proved to be my favourite machine to use for a time and was used for some of my first plotter portrait experiments.

I wanted to experiment at a larger scale than these A3 scale machines, so my next option was to work with the Roland CAMM-1 vinyl cutter in the Publication Station's print studio. The vinyl cutter is similar to model that I worked with in the FabLab 10 years ago, and remains in production to this day. On the vinyl cutter you can remove the knife holder used for cutting and plotter pens will fit exactly in their place, something that never occurred to me 10 years ago. You can send drawings to the plotter directly from Adobe Illustrator, making it very easy to use. This means that the vinyl cutter is one of the more popular machines in the print studio. Normally vinyl cutting jobs don't take very long to complete on the machine. My drawings, on the other hand, would take a few hours to complete and all the while I would have angry impatient students hovering around the machine, hoping to get some last minute work done.

Not wanting to feel the pressure of having to rush through experiments and wanting to make work even bigger than what was possible on the vinyl cutter, I went in search of another machine. I knew there was one larger plotter at the academy, the Hewlitt Packard DraftMaster (first manufactured in 1988) that I had seen sitting in the Drawing Station, but they decided it was too much of a hassle and took up too much space so they moved it to the Publication Station with the intention of storing it out of the way. I asked that it could be moved to the Interaction Station so that I could experiment with it further, at my own pace.

The DraftMaster can be challenging to work with, it's a major hassle to get it to accept a large sheet of paper (100cmx70cm), and won't start until the paper is properly loaded. It won't return pens to the pen carousel, so I have to reach inside the machine and try grab the pens so that they don't dry up between jobs. The carousel design prevents you from using standard length pens, as it was designed for HP’s own pens that they stopped making decades ago. It’s impossible to tell if data from the computer is actually being sent to the plotter, so I would spend a long time waiting until the hulking and noisy machine would suddenly spring to life. Shortly after I was able to get the machine up and running, one of the timing belts broke and the plotter ceased functioning completely. I ordered a new belt from an industrial supply company online, opened the machine and started disassembling the plotter, following a copy of a service guide that had been archived online by the site HP Computer Museum. I replaced the broken belt while nearly breaking two other brittle plastic parts inside the machine in the process. I also had to improvise a new tension spring to ensure the larger belts driving the pen would remain at the proper tension. The first time I fired up the machine the belts made a terrible grinding noise, but

after a small adjustment I was back in business. Eventually this is the machine that would be the one that I would use the most, making dozens of drawings of the course of a few months.

The characteristic that all the machines share, is that they are only capable of producing lines of a fixed width. It's possible to create filled shapes, but in the end a filled shape is just the result of many lines densely stacked next to each other. The plotters are capable of producing drawings, but they only use a limited subset of techniques possible in the realm of drawing. The machines introduce a set of limitations through their mechanical design, communication protocols and they types of media that they accept. These limitations had a strong influence on how I would proceed with my experiments.

Evolution of Experiments with the plotters:

Ever since I encountered the plotters at the academy I had a desire learn how to use the machines, but in order to use them I would first need lines to send the machine. Programming the lines seemed the natural thing to do, as my most recent exposure to plotters was through artists that use computer code and programming to generate their work. This includes artists such as Mario Klingermann, Fredrik VanHoutte, and Joanie Lemercier, who could loosely be grouped into the "Creative Coding" scene, and whose works on the plotter tend towards geometric abstraction and random generative output.

My first experiments started with generating random straight lines in a programming environment such as Processing. With 4 lines of code in Processing you could automatically fill up a page with randomly drawn line segments. From this approach of using straight lines to generate imagery I was able to make a connection to the idea of using triangulated wireframe meshes that are the basis of most 3d models. The most common way that three dimensional shapes are displayed on a computer monitor is by way of triangular meshes, in which each triangle is a straight line connecting point to point. With this approach in 3d graphics the straight line makes up all forms from the rigid and rectilinear to the organic and bulbous. While this may be obvious to someone working in 3d graphics it was still a necessary starting to point which led me to experiment with translating the work I was doing in 3d into 2d drawings on the plotter.

My first tests were simple 1-to-1 translations of wireframe meshes from 3d characters to drawings of the wireframes on paper. The resulting drawings were rigid and mechanical but they held my interest as they don't totally function in ways that would expect a drawing should. They had the material qualities of a pen and ink drawing but they read differently as the lines of the wireframe mesh describe the surface morphology in a mathematical way, rather than in the way that human eye would interpret them.

The characters that I used were selected from models that I had appeared in my earlier animations. The choice to use these models from the drawings was initially a practical one, I needed lines to send to the plotter and I already had a sizeable library of models to choose from. However, it quickly became apparent to me that this could be a way of learning new things about my screen-based work, and could help expand on approaches of the way information passes from physical state to digital state and back to physical.

In these tests I attempted to create portrait-like works, using wireframe images of the faces of 3d characters. The use of 3d faces has been central to my work for many years. By creating plotter drawings that resembled portraits it could also serve as a useful point of comparison. How would these drawings function differently than hand drawn faces?

The wireframe meshes describe edges and boundaries, things that usually become invisible when viewed in their intended final output of a shaded and rendered form. Wireframe meshes in their 'unshaded' form do not describe how light falls on a surface. In the 3d models of the characters I was using, the wireframe density varies across the mesh; from sparsely packed in areas such as the cheeks and forehead, and more densely packed near the eyes and mouth. This packing leads darker areas and lighter areas, but the darker and lighter areas correspond to areas of information density rather than areas of actual light and dark (shadow, value, shading). This has the effect of drawing the gaze to these more densely packed regions in the drawings where lines overlap and the ink bleeds, drawing the eye not as intentional act but as an act of technical circumstance. I still found the drawings lacking as the aesthetics of the wireframe meshes seemed to only directly refer back to the models on the screen, without changing in any significant way when they were put to paper. In the animations that I originally used the wireframes, mistranslation, distortion and degradation were important features, and this was missing in the drawings. Aside from slight imperfections the results were not qualitatively too different than a standard inkjet print of the wireframe meshes, the very devices that have most directly replaced the plotter.

The approach of using unmodified wireframe meshes as a source for drawings was ultimately abandoned after observations I made while watching the drawings being output by the machine. This process can take several hours for an image to be completely output by the plotter. In that time the plotter will move from the middle of the page, draw a few lines, move to the top of the page draw a single line, move to the bottom left draw a long extended segment of lines and then a cluster of lines nearby. The software sending the lines to the plotter doesn't output them in any readily discernible order, and definitely is not optimised for either logic or efficiency. The result is that image is built up in an almost random fashion.

What I soon discovered was that the images were transformed in unexpected and unpredictable ways in their halfway finished state. While the drawings contained the same information, their source was less immediately apparent. Though they were made up of straight lines, the incomplete meshes almost felt almost gestural, sketchy and hand-made. I wanted to explore further to see if I could find a way of emphasizing those qualities, and transform the diagrammatic qualities of the source material and the rigidity of the machinery into something softer and more imperfect.

This led me to experiment with ways of modifying the wireframe meshes to create lines that felt more gestural. Everything was already inside the wireframe meshes, only the information needed to be rearranged. I accomplished this in new plotter drawings by randomising the positions of each of the line segments by a few millimetres, also rotating the segments by a few degrees. By making these changes, a reference to the original form is maintained, but the resulting image is looser, more chaotic. By establishing a set of rules, I could produce a series of variations on these images.

This turns out to not be a novel discovery or approach. In 1967 artist Chales Csuri working alongside programmer and technologist J. Shaffer created an animation of an illustrated hummingbird morphing from a single starting point to a recognizable line drawing and then to a chaotic exploded arrangement of all the constituent line segments moving from full exploded , going from what he describes as “scrambled” to “realistic image” (p. 83). His work was featured in a program of computer animation at the MOMA in New York as well as in the landmark exhibition of computer art Cybernetic Serendipity, which opened at the ICA in London in 1968. In the exhibition catalogue he describes using a process of

scattering the lines by means of “up to 6 inches of radial displacement in distance, and plus or minus forty-five degrees in angular displacement […] and let the random number generator decide where the point would fall.” (Reichardt, ed. 1968, p.83) Strikingly, this is nearly the exact same formula that I would apply to my own drawings, some fifty years later.

Csuri figures prominently in the history of technology and art, so I found it surprising that I wasn’t really aware of his work when starting to create my own plotter drawings. I would have surely seen his work in books in the Library Archives of the Alberta College of Art and Design when I was a student from 1998 to 2002. My recollection is foggy but I remember two books about computer art, one of which I can confirm is still in their catalogue, the 1987 book Digital visions : Computers and Art by Cynthia Goodman. The book features an image of Csuri's Sine Curve Man from 1965 which is listed

Charles Csuri trained as a painter but eventually started using computer technology in his work, credited as having created "one of the first figurative images produced by a computer for purely artistic purposes.” The work, called Sine Curve Man, consists of "a hand drawn image from Csuri, scanned and digitized and then "transformed with sine curve functions." (Goodman, 1987, p.32). In an interview in the Cybernetic Serendipity catalogue, Csuri describes his process: “The type of mathematics one can use in, say, doing hand pictures - if you will excuse the expression - is restricted by how much time it takes to solve a problem, that is, normal methods of working are too slow.” (Reichardt, 1968, p.81)

Speed was not the only concern he considered the computer as being able to help overcome. The use of computer generated randomness was central to many of the early computer artists’ work and continues to be central to many present day artists, myself included. Csuri describes his reasoning for using randomness as a way of overcoming personal bias:

> *I think when you deal with so-called structures or distortion of points, values, lines, or whatever, that you have a certain bias. This bias is based on past experience, pre-conceptions of what is structure in art, and one way of breaking away from this is to introduce a mathematical system that can’t depend up that kind of conception. This is a way of breaking the bias and perhaps getting to an interpretation that you ordinarily would not think of.* (Reichardt, 1968, p. 81)

Unpredictability becomes a factor in the work, (both from the randomness and from the abstraction required from programming with punch cards on the early computers) “You approach this in such a way that is would be impossible to visualise what will happen, and perhaps this is that part that makes it interesting.” (Reichardt, 1968, p.83) He differentiates this mathematical method from what he considers “working in conventional terms and could anticipate exactly the result.” (Reichardt, 1968, p.83) However, this is not to say that it is an easy process or a guarantee for success. “You’ve got to work hard in order to set the game up so that your output is interesting. You’ve got to set up strategies … there are certain things you can do that would be obvious and quite predictable…” “… it is rather difficult to set up a sophisticated game.” (Reichardt, 1968, p.83)

This challenge is something that I recognise and relate to in the creation of my own work. Beyond randomising the position and rotation of all the line segments I am still working hard to set up a sophisticated game through the use of physical simulations influenced by

motion capture sequences which influence the arrangement and posing of the 3d characters that are the sources of my drawings. While this may be more apparent in the animations which the drawings are sourced from, it still has a significant effect on the appearance of the drawings. Quite often I have arrived at totally unpredictable arrangements that emerged from this process of simulation, but at the same time as I become more familiar with the process it becomes something that I direct and influence to more controlled aims.

Anthropomorphism and Artificial Intelligence:

The early pioneers of computer art were enthusiastic about showing the potential of technology as a way of moving beyond human limitations, while at the same time engaging with computer technology that was at its most embryonic and limited form. Fifty years later the landscape is completely different, and yet discussions about this potential for endless variations is now animated by emerging forms of machine learning and artificial intelligence. In a recent article in The Guardian, Arthur Miller describes an artwork by Mario Klingermann who works with machine learning algorithms to generate his work:

> *screens that display an endless stream of surreal male and female faces, with one morphing into the next. There is no human curation. The machine creates, and no two portraits are ever the same. Sit and watch the machine and it almost seems to be thinking.* (Miller, 2019)

This is strikingly similar to Grant Taylor's description of artist Harold Cohen's machine artworks controlled by artificial intelligence software he developed called AARON as it was exhibited at the Los Angeles County museum of art in 1972 :

> *the audience was captivated by the physical mechanical device. They attentively watched the computer as it produced the drawing. Many believed the machine possessed sentience. When the pen paused, people would believe that the machine was "thinking of what to do next"* (Taylor, 2014, p. 132)

Unlike the previously listed examples of Tresset and Chung, who embrace the anthropomorphic qualities of their drawing machines, Cohen found this to be a point of frustration:

> *[…] Cohen reported that it was hard for the audience not to "anthropomorphise the machine's activities." However, he always insisted that his art was not about the spectacle of the mechanical device and that he had no great interest in machines and their peripheral devices. He believed that the difference between drawing by hand and drawing by means of a mechanical device was essentially trivial. The audience needed to be reminded of the programming process—that the machine's identity that animated the drawing process resided in the knowledge that had been extracted and externalized from the artist's mind. As if trying to counter the power of the machine or the frequent criticism that computer artists merely push a button and art comes out, Cohen vigorously announced: "I give the machine its identity. It is doing what I have in mind.* (Taylor, 2014, p. 132)

Cohen works were seen in the context of early artificial intelligence research, a term which only compounds the tendency to anthropomorphise. The gulf between his perception of his work and the way the audience received it may come from the lack of understanding of the processes involved and the capabilities of the technology at the time. This is something

the Cohen would had intimate knowledge of as he built his own systems from the ground up. Lev Manovich in AI Aesthetics explains:

> *Why are some intelligent tasks that computers can accomplish seen as "real" AI, and others are not? Observers and historians of the AI field talk about "AI effect." It means that "when we know how a machine does something 'intelligent,' it ceases to be regarded as intelligent* (Manovich, 2019)

I've chosen to avoid any talk of machine intelligence in relation to my own work, as foregrounding some sort of machine intelligence feels like an act of misdirection which imbues intelligence on a machine that has none. This misdirection recalls Wolfgang von Kempelen's Mechanical Turk from the late 18th century where a hidden human operator is pulling all the levers underneath or in the Wizard of Oz where we're asked to "pay no attention to that man behind the curtain." It's no coincidence that Amazon named their crowdsourcing marketplace Mechanical Turk, a service where scores of human operators are manually labelling data to train machine learning algorithms. Massive amounts of human labor is necessary to create the illusion of machine intelligence. In a recent New York times article about Chinese "data factories" which manually process data, they quote a worker who states: "I used to think the machines are geniuses,[...]now I know we're the reason for their genius." (Yuan, 2018)

Additionally, while other artists may describe their relation to the machine as one of collaboration I find that designation problematic. It would sound strange to say that a pianist works in collaboration with the piano, and I find the idea of the plotter as my machine collaborator equally strange. I approach both the hardware and software as tools to be used, or instruments to be played. The collaboration, if it is anywhere, is with the real people who made the tools, designed the machines and wrote the software. I have a fascination with the tools, with their history, design and inner workings, but I don't hold any grand notions about the potential of machine intelligence or creativity. From my technical background I know enough about the inner workings and limitations of technology that I would never think of either the hardware or the software as being capable of intelligence.

From this standpoint it's hard to answer the question of what it means to collaborate with the machine in any meaningful way. By removing the machine from view in my own work I hope to make this question less central. I've learned from watching the machines in use, but it's not important for me to show to an audience the machines being operated. In an interview Tresset explains the reason for his robot's existence in a (charmingly) self-deprecating fashion "It's a nice bit of entertainment" and the machine "[...] always attracts crowds at an exhibition." (Tresset, 2012) In the works were the machine takes centre stage I've found that the drawings themselves feel less important, becoming secondary artefacts in a theatrical staging of process. They highlight potential, rather than focusing on the actual outcomes. This is something that I'm consciously trying to avoid. My intention for the drawings to be able to stand on their own, and I would prefer that questions of their source and status remain ambiguous rather than having everything explicitly revealed through the direct demonstration of their making.

Conceptual Art vs Computer Art:

In the book **When the Machine Made Art,** Grant Taylor gives an account of the early days of computer art and the extreme difficulties computer artists had in having their work

accepted by the art establishment. Taylor contrasts the approaches of conceptual artist Sol Lewitt with the computer artists such as Manfred Mohr. In Lewit's essay **Paragraphs on Conceptual Art** he states:

> *To work with a plan that is pre-set is one way of avoiding subjectivity. It also obviates the necessity for designing each work in turn. The plan would design the work. Some plans would require millions of variations, and some a limited number, but both are finite. Other plans imply infinity. In each case however, the artist would select the basic form and rules that would govern the solution to the problem. After that the fewer decisions made in the course of completing the work, the better. This eliminates the arbitrary, the capricious, and the subjective as much as possible.* (Lewitt, 1967, Cited in Taylor, 2014 p.48)

As Taylor explains while the critical reception to computer art and conceptual art were vastly different,*"Aesthetically, the idioms of conceptual and computer art were often identical." (Taylor, 2014, p48)* Furthermore: "*As LeWitt stipulates, "art is about not making choices. It's in making an initial choice of, say, a system, and letting the system do the work." It meant that all of the "planning and decisions are made beforehand and the execution is a perfunctory affair." Producing a system that was prefigured, visually unpredictable, and autonomous was entirely consistent with the aims of computer art."* (Taylor, 2014, p. 48)

Taylor attributes the differing perception of Mohr and Lewit's work to the following distinction:

> *In LeWitt's work, the tension of the work arises from the relationship between the idea and its physical realization. For Mohr, in contrast, it resides in the potential of the computer algorithm and its power to generate vast amounts of signs. [...]Whereas LeWitt's work shows absolute clarity, comprehensibility, and self-containment, Mohr's work is seemingly complex, fluid, and open-ended, as if part of an ongoing search.* (Taylor, 2014, p. 53)

This distinction was not evident to me, most likely due to my affinity to programming and digital processes. A human being working in a procedural manner, as in the work of Sol Lewitt, in my estimation is still executing a program. The likelihood that they would execute the same work in the exact same way twice is fairly small. The question is how faithfully will the person executing the work follow the instructions. Their bodies might betray them, they might perform differently, depending how much they ate, slept, drank etc. Their hands might shake as they get tired. Their arms get stiff, constricting their movement. Their minds might wander and adjust their interpretation of the instructions. The might not read the instructions correctly, or not want to follow the instructions. Both their physical capabilities and their intellectual will could conspire to shift the work off-course from the original intention. This is a built in affordance of the original program, designed by Lewitt. The variability of outcome privileges the conceptual framework and the instructions as the central locus of the work.

For many artists that followed, especially for new media artists like Casey Reas (one of the founders of the Processing programming environment), view code-based work and conceptual work in the same light. Reas' generative software artworks count both computer artists and conceptual artists equally as influences. A 2008 press release artist for an exhibition by Reas states:

> “Reas’ relationship to writing computer code is akin to Sol LeWitt’s authorship of instructions for wall drawings, but generative software procedures in Reas’ art replace the human hand. Specifically from the perspective of programming, artists Vera Molnar and Manfred Mohr have inspired Reas’ approach toward building visual compositions.” (C.E.B. Reas Process / Form, 2008)

Artists using generative systems, like Reas and Klingemann, create works that are often animated to show the software continuously producing an endless amount of a variations. While my drawings emerge from a process that is capable of endless variation, they are ultimately fixed snapshots that are judiciously edited. While drawing might more easily be seen as starting point or as a preparatory stage of things to come, my drawings are endpoints. In that regard it's not important for me to react to the drawings being made in real-time because all the decisions have been made beforehand, my own having been completely removed from the equation. Instead of digitising my own hand drawings, I'm working with an elaborate software pipeline to create my images. To produce the drawings I'm using a combination of 3d programs, stock 3d models of human figures, motion capture data, ragdoll simulations, cloth and hair simulations, lighting and global illumination techniques all of which are passed through vector renderers which perform hidden surface removal and converted into 2d files, which are further modified through noise functions and output through vector graphics editors where the line segments are randomly scattered and rotated. This pipeline differs significantly from much of the work that I've previously cited.

Conclusion

To some extent all the works of the artists that I've previously mentioned call into question the role of the artist's hand. In some the machine become a performative stand-in for the artist's hand. Csuri worked with digitized versions of his own hand drawings. Tresset and Chung work with machines that recreate and reproduce the gestures and style of their own hand drawings through machine learning algorithms and other techniques. This is one area where I diverge from the artists previously cited. My own hand is not present in the drawings, the machines are not imitating or automating the way that I draw myself. While I'm personally drawn to the semblance of gesture in the drawings, gestures are not source or the cause of the drawings. This is reinforced by the choice of the type of machines being used in my drawings. They are ageing beige office machines, industrial in form which don't inspire in me any type of romantic connection. I'm drawn to them because I have a clear understanding of the workings of their main components. I know how stepper motors, solenoids, timing belts, grit wheels, and serial communication protocols work. The machines are not a mystery to me, I know their function and what to expect from them and what not expect from them. They don't move like a hand does, they move in straight lines.

Due to the nature of the machines, I have to make decisions that confound that relationship of what I "desire" versus what the "machine can do". The plotters are machines designed to produce what Vilém Flusser would call "technical images." What I'm trying to do is resist the inherent ability of the plotter to produce technical images and avoid the readings associated with them. Flusser describes:

> *It is difficult to decipher technical images, because they are apparently in no need of being deciphered. Their meaning seems to impress itself automatically on their surfaces, as in fingerprints where the meaning (the finger) is the cause and the image (the print) is the effect. It seems as if the world signified in technical images*

> *is their cause, and as if they themselves were the last link in a causal chain connecting them without interruption to their meaning: the world reflects sunlight and other forms of light which are then captured on sensitive surfaces - thanks to optical, chemical and mechanical processes - and the result is a technical image. It thus seems as if they exist on the same level of reality as their meaning. It seems that what one is seeing while looking at technical images are not symbols in need of deciphering, but symptoms of the world they mean, and that we can see this meaning through them however indirectly. This apparent non-symbolic, 'objective' character of technical images has the observer looking at them as if they were not really images, but a kind of window on the world. He trusts them as he trusts his own eyes. If he criticizes them at all, he does so not as a critique of image, but as a critique of vision; his critique is not concerned with their production, but with the world 'as seen through' them. Such a lack of critical attitude towards technical images is dangerous in a situation where these images are about to displace texts. The uncritical attitude is dangerous because the 'objectivity' of the technical image is a delusion. They are in truth, images, and as such they are symbolical.'*(Flusser, 1984, p.10)

By borrowing the language of the handmade I'm attempting to bypass this hesitancy to decipher, creating a messy overlap of states between technical image and traditional image. In this way I find a connection to Flusser's definition of the the "traditional image":

> *With traditional images[...] the symbolic character is clearly evident because, in their case, human beings (for example, painters) place themselves between the images and their significance. Painters work out the symbols of the image "in their heads" so as to transfer them by means of the paintbrush to the surface. If one wishes to decode such images, then one has to decode the encoding that took place 'in the head' of the painter.* (Flusser 1984, p15-16)

Through machine randomness and allusions to the handmade I'm attempting to introduce a layer of uncertainty into the image. The work on paper creates a different relationship and it invites a different kind of looking. The drawings embed their method of being made in the layering of lines, in the buildup and imperfections of the ink on the uneven surface of the paper, avoiding the flatness of an onscreen image or an inkjet print. Through the layering there is an invitation to decipher and explore, an invitation which might otherwise be refused if the drawings were seen as an illustration of a technical process. While they do not emerge from my own hand they are still representative of my way seeing and thinking. They are the result of processes that have been defined by predecessors through engineering and design decisions, which at times lead me to arrive at some of the same technical solutions but not necessarily the same conclusions. By approaching these obsolete tools with new concerns and new technical capabilities opens a way of reassessing the current technological landscape and its influence on my practice.

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