Sex, Power, and Technology: A Relational Engineering Ethos as Feminist Utopia

by

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Submitted to the Department of Comparative Media Studies/Writing
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Abstract

This thesis proposes *relational engineering* as a framework for developing technology that stands in contrast to dominant notions in US tech culture that prioritize profit, scale, productivity, and solutionism. Relational engineering serves as a feminist utopia that envisions the design and development of technology as the crafting of social relations between humans and non-humans in a sociotechnical system. I investigate how relational engineering might be operationalized in the US tech sector by first reviewing the sector's current ideological landscape and then investigating two case studies. One case study looks at the norms and practices found in a feminist data science lab and how it created an inclusive engineering space outside of dominant tech culture. The second case study defines the term "social machines" and considers how these might be designed to promote equity and justice by crafting non-domineering human-machine relations. The case studies are just two examples of how technology can be developed from the perspective of creating caring relations among actors in a sociotechnical system. A relational engineering ethos is intended as an actionable mindset to help technology designers and developers grapple with the fact that they are building social relations as opposed to neutral artifacts.

Thesis Supervisor: William Uricchio
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Preface

I always wanted to create. Around 8th grade, I saved my money and bought a sewing machine: the Pfaff Hobby 1016. It was the most basic one available, but it was not a machine for kids. It could do three kinds of stitches and make button holes. I liked that anything I created needed to be both functional and aesthetic. I don't remember buying many patterns; mostly I dreamed up pieces, pinned them to my homemade dress form, and then finalized them on the sewing machine. Many of my ideas came from the large stacks of images and articles that I tore out of magazines and newspapers. Part of my fascination with sewing clothing was the idea of trends. I wondered how large groups of people suddenly decided they liked the same fashion. Did someone convince them? Did they decide for themselves? How did the trend spread and who started it? I always wanted to predict what would come next. Not because I cared what other people thought about my clothes, but because I was enamored with the idea of future-making. I thought if I collected and pieced together enough scraps I would be able to peer just a little bit ahead of everyone else. The sewing machine and the concept of fashion trends let me experiment. It is perhaps not surprising then that when I learned about programming and technology development later in high school, I quickly became hooked. Like my sewing machine, programming seemed to be a new creative tool for developing the future.

When I got to college, I signed up for my first computer science class immediately. It didn't occur to me that this was unusual given my gender. But it quickly became clear that I was an anomaly: not only was I a woman but I didn't dress in baggy t-shirts and hoodies. I was a never-caught-dead-in-sweatpants kind of person who sometimes even wore makeup. And according to tech culture, I realized, I was not supposed to be smart. At some point early on I mentioned to a classmate that for me coding was like sewing; I got a sidelong look and a chuckle in return so I stopped telling people about the connection. In the tech world, coding was not like sewing. Coding was like math, and those who excelled at algorithm optimization and other technical tasks were considered the most talented. I struggled—abstract math was not my strong suit. My preferred style of coding was like my sewing style, trying out bits and pieces to see how they fit together to make a whole. Well-meaning folks told me not to worry because having social skills was more important than being good at math. But this just further entrenched the (false) idea that these were somehow opposite from each other and increased my feelings of incompetence. I am, however, warrior at heart and I was going to prove that I could do this. So I did. I ended up with a full-time software engineering position at a large tech company.

Once I proved I could make it in the tech world as an engineer, I realized I had given up almost everything I had dreamed about building technology in order to get there. My sewing machine, which had followed me to my new West Coast job, sat in a corner covered and unused. I was working on code that had been written a decade or two ago. I was the only woman on my team. I was lonely, and I was not building the future I wanted to see. I had also let the creative wellspring inside me run dry, buried under technical jargon. I needed a change. I needed to understand what had happened. But I felt lost.

Eventually I made my way to MIT and to this thesis. It is my best attempt to give language to my experience, and the experience of those with similar stories. But it is not just an attempt to explain the past–it is also a look forward at the world that I want to create. Dominant Silicon Valley tech culture is so pervasive, it took years of reading and learning to climb out and see what else could be possible. I have feminist scholars to thank for that voyage.

In a wonderful way, my final semester at MIT brought me full-circle in the form of a course on computing fabrics. In the class, weaving and knitting techniques were shown side-by-side with electronics diagrams as the professors—a textile artist and electrical engineer—demonstrated how computers could be built into fabric. In these classes, it was abundantly clear that weaving and coding are both engineering. One has been historically practiced predominantly by women, the other predominantly by men—a dynamic reflected in the course participants. But both weaving and coding are ways of meticulously crafting new worlds and ways of being in them—it's our cultural perspective that keeps us from being able to see this.

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Chapter 1

Introduction

> *We encounter the deep questions of design when we recognize that in designing tools we are designing ways of being.*
> *[Winograd and Flores, 1986], p. xi*

Two men stand next to a Xerox machine attempting to make copies of a document. After several rounds of negotiating with the machine, they fail to make their copies. When the video of this interaction was first shown to Xerox management in the 1980's, one executive commented that the users must have been found "on the loading dock." To their surprise, the men were in fact Ron Kaplan and Allen Newell, two leading researchers in computer science at the time. Copy machines, and computing machines more broadly, are a kind of medium that can be programmed by humans to convey messages in response to interaction. In the case of the Xerox machine, Kaplan and Newell pushed a series of buttons and inserted a stack of papers expecting for the machine to create a new, identical stack of papers. Unable to properly communicate with the machine, they did not receive their new stack of papers. This example is at the heart of anthropologist and science and technology studies (STS) scholar Lucy Suchman's acclaimed book *Plans and Situated Actions* [Suchman, 1987]. Suchman argues that the machine designers framed interaction differently from human users. The designers assumed the users would make a plan to copy the documents and carry out that plan in a step-by-step manner. Using careful observation, Suchman instead shows that humans engage in "situated action," in other words, they make and remake their plans depending on their environmental context. Since the machine can only carry out one strict plan at a time, as soon as the human reorients their plan based on their context, the machine and the human can no longer communicate. This example surfaces a number of assumptions surrounding the design and development of computing machines including: what machines should do, who should use them, who should design them, and what kind of relationship they should have with humans.

My interest is in understanding how to shift the mindset of engineers in the US tech sector regarding the design and development of technology, so I will briefly sketch a portrait of this group. It includes people such as software engineers at big companies like Facebook and Google, startup founders, and computer science students. Many students funneled into engineering jobs in tech come from elite universities and have already held multiple internships in the tech industry. Engineers in the US tech sector hold a considerable amount of privilege. Tech companies have accrued significant wealth and even salaried employees who have not founded companies enjoy incomes far above the US national average. Tech companies often shield employees from "everyday" tasks by offering private transportation to their offices, free meals, and services like dry cleaning. In other words, many tech engineers live in a very particular kind of bubble. Despite its many benefits, there is an ugly side to the bubble even for those lucky enough to be inside. Women and underrepresented minorities must contend with outright harassment as well as fitting into a culture of "extreme masculinity" [Ensmenger, 2015]. Because of this, many women and underrepresented minorities who choose to stay in tech are either exceptionally talented and/or willing to fight to exist (I call this group "geniuses and warriors"). In this work, I'm interested in how to communicate with engineers in tech about the social implications of the technologies they build as well as understand how to illuminate the fact that they are embedded in a bubble that has a particular perspective and demonstrate how that perspective could shift in a way that enhances equity and justice. It is my hope that those who already feel that they don't "fit" the culture can be agents of change within it. My own perspective has been shaped by studying computer science at an elite university, holding a software engineering job at a big tech company, and existing in the tech world as a white woman—never fully an insider nor an outsider. While my intended audience for this thesis is those in the social sciences or humanities interested in better understanding and reaching engineers, I have also tried to make it accessible for people with an engineering background.

Ultimately, I propose "relational engineering" as a way of thinking about the design and development of technology. "Relational" refers to the relationships between both human and non-human actors in a sociotechnical system. Feminist STS scholars have deconstructed sociotechnical systems to show how they are influenced by social dynamics related to gender, race, and other factors. In doing so, these scholars reframe the practice of creating technology from the development of neutral objects abstracted from the world to the design of embodied relationships. Relations in sociotechnical systems can exist at numerous scales: between teammates, between the designer and the consumer, between the object and the manufacturer, between the object's materials and the environment, and more [Crawford and Joler, 2018]. A relational engineering ethos asks what it would mean to design these systems from the outset with a focus on crafting caring relationships. It is a perspective that seeks to bridge the gap between a theoretical commitment to feminist philosophy and the practical nature of engineering culture. This mindset, however, is counter to the dominant way of thinking about technology in the contemporary US tech sector. Before returning to the benefits of relational engineering, I first review this dominant way of thinking and how feminist scholars have worked to propose alternatives.

1.1 The dominant ideology in the US tech sector

The photocopy machine is just one of many technologies to emerge from Silicon Valley, which is both the physical as well as ideological center of the US tech industry. Over the course of its history, Silicon Valley has developed a culture that has a particular set of values and vision for the future (the "bubble" I mention earlier). As Fred Turner describes, Silicon Valley has been shaped by the convergence of 1960's hippie counterculture, libertarian politics, an influx of World War II defense spending, technological determinism, and Norbert Wiener's cybernetics [Turner, 2006]. While early "computers" were often women, once it became clear that programming was challenging and not menial labor, men took over jobs in the computing industry [Ensmenger, 2015, Hicks, 2017]. Adrian Daub explains the origins of prominent Silicon Valley terms like "genius" and "disruption," showing how their intellectual histories have contributed tech industry values [Daub, 2020]. Melissa Gregg describes the culture's tendency to emphasize productivity, optimization, and self-actualization [Gregg, 2018]. In 1995, Richard Barbrook and Andy Cameron coined the phrase the "Californian Ideology" to pinpoint Silicon Valley's way of thinking about the world [Barbrook and Cameron, 1995]. Underneath the jargon surrounding technology development, Silicon Valley also sits on a bedrock of capitalism. Funding revolves around venture capital, a structure that pushes startups to prioritize growth of users and profit [O'Mara, 2019]. This way of thinking about technology is pervasive in the US tech sector, both inside and outside Silicon Valley.

Silicon Valley ideals grew out of a longer history of thought in the US that places capitalism, rationalism, and neoliberalism as pillars of modern society. These constructs valorized profit, scale, efficiency, and self-actualization long before the internet was invented. Jean Baudrillard contends that rationalism in the service of capitalism "marks modernity as the era of productivity" ([Baudrillard, 1987], p. 66). Rationalist thinking can be traced back even earlier to the ancient Greeks and includes concepts such as the "mind-body duality" which abstracts thinking from the physical body. Arturo Escobar describes rationalism as a "cultural background" that is so ubiquitous in the US that it is difficult for people to think outside it.[1] These ideas have been deeply woven into Silicon Valley's tech culture.

[1] For a longer discussion of the rationalist tradition in the context of design see [Escobar, 2018].

1.2 Feminist utopias and relational thinking

Feminist scholars have confronted and critiqued the centrality of concepts such as rationalism and suggested alternatives. One framework I have found helpful is the idea of a *feminist utopia*. Shaowen Bardzell explains how a feminist utopia "is positioned as a practice of democratized futuring, a form of engaged critique and design leading to action and activism" ([Bardzell, 2018], p. 3). Importantly, feminist utopias differ from traditional utopias because they are process-oriented, allow for multiple futures, and give the marginalized a voice versus being product-oriented, static, and dictated by a singular expert [Bardzell, 2018]. I will outline two concepts, flourishing and care, as examples of building blocks for crafting this kind of utopian vision.

Flourishing is a term that has been used to capture an aspirational state that resists being reduced to pleasure or happiness. David Hesmondhalgh introduces the importance of term saying,

> An alternative to the utilitarian, preference-satisfaction conception of well-being or welfare used by many economists and other defenders of capitalism is needed, and we also need to reject any equation of well-being with 'happiness.' Moral economy and other modes of critical thinking underpinned by Aristotelian traditions, including Marx's conception of well-being, advocate instead a concept of eudaimonia or *flourishing*. ([Hesmondhalgh, 2013], p. 209, emphasis in original)

Here, Hesmondhalgh describes flourishing as a state that stands in contrast to both utilitarian, rationalist understandings of well-being as well as concepts of happiness that ignore the richness of other emotions and their contribution to a full life. Franklin Ginn, Uli Beisel, and Maan Barua further define the term saying that, "Flourishing can be described as an ethic which enshrines life's emergence and the prospects or conditions for life's emergence as the good to be upheld or nurtured" ([Ginn et al., 2014], p. 114). In other words, flourishing is a state of becoming. Donna Haraway similarly calls for "multi-species flourishing" as a way for humans and non-humans to evolve together on earth. Flourishing does not shy away from pain and death, but rather recognizes these as part of life and asks "who lives well and who dies well under current arrangements, and how [these] might be better arranged" ([Ginn et al., 2014], p. 115). I put forward flourishing as one way of conceptualizing the kind of feminist utopia designers might consider when envisioning futures.

Another important building block is the notion of *care*. Care can be thought of as both a value and a practice [Held, 2005]. An ethics of care rejects the idea that a universal ethics can be built on abstract principles. As feminist philosopher Nel Noddings says, "One might say that ethics has been discussed largely in the language of the father: in principles and propositions, in terms such as justification, fairness, justice. The mother's voice has been silent" ([Noddings, 2013], p. 1). Caring relations are not contractual, where one party expects payment in return for offering care, nor are they relations where one party dominates the other. Noddings characterizes care as "affective" ([Noddings, 2013], p. 3) as opposed to rational or logical.[2] Thus to care is to nurture relationships through an embodied, affective practice. An emphasis on care is another way to imagine what matters when designing sociotechnical systems.

Both flourishing and care are inherently social and thus suggest a feminist utopia that values the construction of strong relationships. Each term refers to a community value/practice and cannot be sustained by an individual alone. These concepts are neither in service of profit or productivity nor can they be abstracted to principles and rules. They are each active states of being in a messy world. Given that in the US capitalism, rationalism, and individualism hold elite status, centering flourishing or care might lead to a radically different vision for the world. In the tech sector, a feminist approach might also lead to a radically different vision for technology. My concept of "relational engineering" builds on the notion that technology is situated within a myriad social and technical relationships that must be constructed with care and equitable futures in mind.

[2]It is important to note the distinction between the feminist concept of care with what has recently been called "emotional intelligence." The movement toward emotional intelligence calls for the self-regulation of emotions as an act of care, but this is a different meaning of the word "care" than I use here. For a discussion of self-regulation as emotional labor see [Hochschild, 1983].

1.3 Relational engineering

I define "relational engineering" as a technology design ethos that prioritizes the development of caring relations in a sociotechnical system throughout the lifetime of the artifact/system. Relational engineering is not prescriptive in that it does not provide a solution or correct answer, but instead suggests a way of thinking about technology development. While other ways of thinking might center profit, scale, or efficiency, relational engineering holds that these are secondary to the nuturing of good relationships. As discussed earlier, relations can exist at many scales and at many points in the development process, from the relation between engineers to the relation between the artifact's materials and the environment when the artifact is thrown away. This mindset encourages designers to craft relations as opposed to objects.

I argue that technology produced from a relational engineering perspective will be different from technology that comes from tech culture that is embedded in the Californian Ideology. This can be described using the concept of *worlding*—the process of bringing new worlds into existence. Terry Winograd and Fernando Flores draw on Heidegger's definition of worlding and apply it to thinking about the evolution of technology [Winograd and Flores, 1986]. As they describe, Heidegger uses the phrase worlding to mean that each person will "see" (e.g. experience, understand, grasp) a different world depending on their past experience and knowledge. For example, a master architect will "see" a different house than a non-architect. Experts in any area are capable of discovering new worlds and disclosing these to others. Non-experts, who most likely rely on rule-based abstractions that already exist, will simply rediscover existing worlds. One can consider a non-expert cook following a recipe versus a master chef who makes tweaks to the recipe depending on the specifics of the situation such as time of year and quality of available ingredients. Donna Haraway also takes up the term worlding, although she clearly differentiates her meaning from Heidegger's. Hers is a multi-species, as opposed to human-centric, concept of actively creating new human/non-human entanglements. She describes how the way in which future visions are framed in the process of worlding effects the kinds of entanglements that get constructed:

> It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what descriptions describe descriptions, what ties tie ties. It matters what stories make worlds... ([Haraway, 2016], p. 12)

In other words, the worlds that get created are directly tied to the ways of thinking and ideologies of the creators. A diversity of ways of thinking will lead to a plurality of worlds. This is not to say that the rationalist approach to technology is never useful, but that but that it has been prioritized historically. Given that the Californian Ideology was primarily defined historically by a narrow demographic in the US, what sociotechnical worlds lay undisclosed?

Let's return to the example of the Xerox photocopy machine. I'll begin with the rationalist analysis of the situation. Xerox deemed developing the machine worthwhile because it would save customers time and money by allowing for a more efficient/optimized office, ultimately making Xerox money. The designers made an abstract plan for how humans would copy documents, assuming the humans would function like logical/rational machines. They encoded the abstract plan into the machine, assuming humans would follow the route exactly. When the humans didn't follow the plan exactly, the (male) executives initially assumed that the "wrong kind" of humans were trying to use the machine. Reexamining the situation from a relationalist perspective might begin by highlighting the lack of information on who designed the machine and what their relations were with end-users. There is also a mismatch between how the humans attempted to relate to the machine and how the machine related to the humans. As Suchman points out, humans take "situated action" and rarely follow a strict plan when acting in the world. Finally, the "goal" in the rationalist explanation is defined narrowly as reducing human labor, ultimately saving time and making money. A relationalist perspective might prioritize the user experience and relationship between artifact and human over raw efficiency. It is not that one view is right and the other is wrong, they simply prioritize different values and thus produce different design outcomes. By illuminating the way assumptions and values subtly lead to particular design choices, it becomes clear how a relational engineering ethos might shift the design process.

The premise of the photocopy machine as a labor-saving device for the office already embeds it fairly deeply into the dominant Silicon Valley tradition. While I am interested in re-framing questions surrounding this type of artifact, I also want to go a step further and ask what kinds of artifacts/systems might exist if imagined from a relational perspective from the outset. For example, artifacts/systems in a relational engineering framework might help humans in the process of worlding as opposed to simply achieving pre-defined tasks. While this is not a new role for artifacts—a hammer might help a woodworker craft a piece of furniture—I think the potential for technology to serve this role has been under-explored. Sherry Turkle and Seymour Papert outline one example of how this could work for computer programming [Turkle and Papert, 1990]. They explain that some of their study participants develop intimate relationships with their computers and use empathy and connection with the computer to build the new world of the program. Turkle and Papert say that this is similar to how a musician treats their instrument or a poet the words in a poem. The emphasis is not on the computer as a tool to do work but as a non-human partner that can offer its own ways of knowing. While this is only one example within a large possible sociotechnical web, it highlights how using a relational engineering perspective might lead to alternative ways of conceptualizing the kinds of technologies that get built.

1.4 Related work

I am not the first person to suggest a focus on relationship-building is important when designing technology. Recent movements in this direction include co-design and co-creation [Cizek and Uricchio,], design justice [Costanza-Chock, 2020], critical fabulations [Rosner, 2018], feminist HCI [Bardzell, 2010], and data feminism

[D'Ignazio and Klein, 2020]. Of particular importance to this thesis is the concept of *ontological design* first put forward by Terry Winograd and Fernando Flores and further developed by Arturo Escobar [Escobar, 2018, Winograd and Flores, 1986]. Winograd and Flores describe ontological design saying,

> In ontological designing we are doing more than asking what can be built. We are engaging in a philosophical discourse about the self—about what we can do and what we can be. Tools are fundamental to action, and through our actions we generate the world. The transformation we are concerned with is not a technical one, but a continuing evolution of how we understand our surroundings and ourselves—of how we continue becoming the beings that we are. ([Winograd and Flores, 1986], p. 179)

Questioning the rationalist tradition and re-orienting away from it, they argue, is a kind of ontological design because it changes the kinds of technologies and worlds that can be imagined. As Escobar further explains, the question is whether design can "be extricated from its modernist embeddedness and redirected towards other constellations of ontological premises, practices, narratives, and performances" ([Escobar, 2012], p. 45). He calls specifically on the term "relational" saying that globalization "has taken place at the expense of relational worlds" and that "we are witnessing a renewed attack on anything collective" ([Escobar, 2012], p. 57). Escobar then builds on ontological design by suggesting that one path forward is *autonomous design* which he defines as a way for communities to engage in ontological design for their own evolution [Escobar, 2018, Escobar, 2012]. I am also interested in ontological design in the sense that I'd like to provide engineers with a different mindset and ideology than the one prevalent in Silicon Valley, and argue that this will in turn lead to different imagined technologies. To do this, I work to tie together the ideas found in ontological design, feminist STS, and co-creation practices while also bringing them down to earth. It should not require an advanced degree in the humanities or social sciences to grasp the foundation of relational design, but should be something which can be communicated to engineers and makers in an actionable format. I build on this important prior work by further integrating it into a generative vision of how technology can contribute to a more equitable and just world.

1.5 Chapter summary

I will organize the chapters as follows. In Chapter 2, I will give an overview of the landscape of ways of thinking about high-tech in the United States with a particular emphasis on questions of gender. I will delve into the "Californian Ideology"—a rationalist perspective that grounds much of Silicon Valley tech culture. I will then survey a selection of groups that are working to push back on this dominant culture and review their frameworks and tactics. Ultimately, I show that while each group is doing important work, none offer an aspirational vision as seductive as the Californian Ideology that helps designers understand what they should be creating. In Chapter 3, I will investigate one particular social group: a self-described "feminist" data science lab at a large US research university. Using an ethnographic method that entails both participant observation and interviews, I will look at the norms and practices of a culture that operationalizes a relational approach to technology development. In Chapter 4, I will look at a case study for applying a relational perspective to an artifact itself: the social machine.[3] This chapter draws on feminist science and technology studies (STS) literature to reframe how social machines (which are related to, but different from, robots) should be designed. I also propose an experimental social machine named *Ambii* that plays with ambiance, mutuality, and non-anthropomorphism. Finally, I conclude with some closing thoughts and directions for future work.

Overall, this thesis is both a call for a relational way of understanding and designing technology as well as an attempt to sketch out how a relational approach might be operationalized. As I have explained, scholars have proposed a relational approach to world-building in prior work. However, there is a lack of scholarship that attends to the specific configuration of the high-tech sector in the United States and works to imagine how a shift toward a relational approach might be actualized. An increased

[3]Part of this chapter has been published in [Wagman and Parks, 2021].

emphasis on caring relations in technology design is important and valuable, however, entrenched norms and ideologies hold power that is hard to resist. This thesis sketches out what a relational engineering paradigm could look like and asks what it would take to make it a reality for technology development in the US.

Chapter 2

Power and Perspectives in Silicon Valley: Surveying the Ideological Landscape of the US Hi-Tech Sector

2.1 Introduction

I checked the clock in the corner of my computer screen and saw it was almost midnight. It was going to be another late night. I got up to make myself a new cup of black tea. The computer science building had free hot water but that was it so I brought tea bags in my backpack. I had staked out a couch on the third floor, which was only accessible at this hour if you were a TA for a course or had a friend who could let you in. Looking around, you wouldn't know it was midnight: the room was packed with undergraduate computer science students furiously absorbed in their screens, building new worlds out of code. The computer science building was lovingly called the "Hotel CIT" by students. Most of the humanities majors we knew were asleep or hanging out with friends, while we regularly pulled 16 hour workdays. But we didn't envy them; we bonded over these late nights and discussions about how we were going to change the world, one line of code at a time. After I made my tea, I nestled back into the couch, pulled on my noise cancelling headphones, and got back to work figuring out how to implement a “nearest neighbor” algorithm in C on a dataset of stars. I was a sophomore in college at the time and it would take me years to realize the extent to which I began my journey in the tech industry embedded in a culture that promoted a particular kind of “futuring.”

There is a dominant culture and ideology around building new technology that permeates Silicon Valley and surrounding hi-tech institutions like university computer science departments. Graduating from an elite undergraduate computer science program, I sincerely believed that I could use technology to change the world for the better. I also watched friends join or found startups and become millionaires and it was hard not to wonder: could that be me? There is a sense that it is possible, with enough effort, to change the world and get rich, all while being deeply countercultural and flagrantly disregarding symbols of the traditional business world like suits and government regulations. The widespread belief in meritocracy says that the cyber world is there for the taking by anyone with an internet connection and enough willpower. This way of thinking—dubbed the “Californian Ideology” [Barbrook and Cameron, 1995]—is alluring and deeply embedded in the hi-tech sector. Numerous scholars have examined the dark side of the Californian Ideology: meritocracy has been unveiled as a myth where women, people of color, those with lower socioeconomic standing, and people with disabilities are regularly shut out [Barabas, 2015, Metcalf, 2010, Metz and Wakabayashi, 2020]; innovation relies on funding from the military-industrial complex [O’Mara, 2019]; and highly scalable companies make their founders rich at the expense of the privacy and safety of millions of people around the globe [Vaidhyanathan, 2018].

The pitfalls of the Californian Ideology have been well described and it is not my intent to rehash them in detail. Rather, my argument—as someone who has come through the wringer and out the other side—is that most critics of this way of thinking underestimate how seductive it is and thus how hard it can be to pull people out of it. In this chapter, I want to examine what avenues for change are in progress and where they fall short. Ultimately, I argue that to change the mind of an engineer, one must offer a more seductive vision. The framing must be “here’s a new direction to take” and not "here's why your direction is wrong," although that can be subtly woven in. I am not advocating for techno-solutionism—i.e. that there are technical solutions to social problems—and I think it is important to convey this to engineers. But I do think it is possible to build technology in a more inclusive and equitable way, even if it can't solve major social issues. Most engineers are unrelenting optimists who really do want to make a positive difference in the world, and if you can show them how they might listen.

My pitch for an alternative to the Californian Ideology, as described in the introductory chapter, is a relational engineering ethos grounded in feminist principles. This approach centers relations when building new artifacts. Here, "relations" is broadly defined to encompass the many interconnections in a sociotechnical system including: between technology builders, between builders and users, and between humans and artifacts. The goal is to develop strong, positive relationships that are inclusive, equitable, and just. This de-centers widely held assumptions about what makes for good technology according to the Californian Ideology including optimization, efficiency, capital, and scale. A relational engineering ethos does not tell engineers to stop building or offer critique of an existing method without a better way forward. Rather, it is generative: it speaks to what we should be building.

Many scholars have described the core ideas behind relational engineering, however, there is work to be done to translate and cohere these concepts in order to bring them to well-intentioned engineers and designers. In this chapter, I begin by looking at the hi-tech landscape in the US from a birds-eye view. I review the Californian Ideology as well as a selection of movements that question this dominant way of thinking. I do not try and offer a complete picture, but rather trace the contours of where ideas related to relational engineering and feminism show up. I show that while the Californian Ideology is eroding in places due to the work of these groups, none offer a readily available alternative/seductive ideology to take its place. I argue that in order to truly shift the direction of hi-tech in the US toward a path that is more equitable/just/inclusive/sustainable, a new vision must be offered and clearly explained. After describing the hi-tech landscape, I turn to outlining a relational engineering ethos that might be adopted by engineers outside of academia. Social change is complex and requires many intersecting efforts; I propose relational engineering as one such effort that might equip the next generation of technology builders with a new vision for the world they want to create.

2.2 Dominance of the Californian Ideology

Technology is not developed in a vacuum, rather, it is created within a particular culture. Cultures hold ideologies that translate into a variety of ideas about the future and how it should be built. As many scholars have argued, modern day tech culture in the US revolves around Silicon Valley. In her comprehensive history of Silicon Valley, Margaret O'Mara describes how the area around San Francisco, California was transformed in the second half of the twentieth century from primarily fruit tree orchards into a powerful center for new technology development [O'Mara, 2019]. She explains how this transformation was driven in large part by Stanford University's ability to marshal in World War II defense funding and the university's subsequent nurturing of technology startups. In his book *From Counterculture to Cyberculture* [Turner, 2006], Fred Turner examines the development of Silicon Valley from a cultural perspective. He argues that individuals such as Stewart Brand worked as "network entrepreneurs" to bring together representatives from hippie communes, tech startups, academic groups (often funded by the military), and industry firms. This unlikely mixture of social groups led to a unique culture and ideology that also held a lot of power given the already significant influence of each individual group. In 1995, Richard Barbrook and Andy Cameron coined the term "Californian Ideology" to describe the particular culture of Silicon Valley. They ultimately critique it, saying, "Californian ideologues preach an anti-statist gospel of cybernetic libertarianism: a bizarre mish-mash of hippie anarchism and economic liberalism beefed up with lots of technological determinism" ([Barbrook and Cameron, 1995], p. 10). Here, Barbrook and Cameron highlight political orientations inherited from the social groups described by Turner: libertarianism, communalism, free market capitalism, and a belief that technology (not government) can solve society's ills. This culture is the birthplace of many US hi-tech companies created in the first two decades of the twenty-first century.

These scholars are quick to point out the issues with a "Californian Ideology" perspective. O'Mara highlights one contradiction: that while this perspective is anti-government and libertarian on the one hand, it is also deeply indebted to US defense funding, a fact that she notes is rarely acknowledged by tech workers. A number of scholars have also demonstrated that the communal ideals learned from the hippies only apply to some tech workers and not others: contract work [Kunda, 1992], ghost work [Gray and Suri, 2019], content moderation [Roberts, 2019], and gig work [Irani and Silberman, 2013] are all forms of labor that the tech industry relies on to function but that is underpaid and often invisible to end users. Chelsea Barabas examines the "myth of meritocracy" by unveiling the ways in which hiring practices in the tech industry, such as preference given to candidates with referrals from inside the company, include some people and exclude others [Barabas, 2015]. In addition, there is a gendered component to the Californian Ideology. In his article titled "Beards, Sandals, and Other Signs of Rugged Individualism" [Ensmenger, 2015], Nathan Ensmenger describes how computing culture became masculine only after it became clear that programming was creative and increasingly high-paying work. Before this shift in the 1960s and 1970s, "computers" were most often women because the work was imagined to be routine and easy (it was not in practice). Ensmenger shows how the culture surrounding the Californian Ideology was born in university computer labs where predominantly white, male students would spend all night attempting technical feats with the machines, often forgoing sleep, food, and exercise. This form of "extreme masculinity" can be found today at universities like the one I attended and companies like Facebook that often pressure employees (of all genders) to work marathon shifts and praise technical competence above all else. Here it is important to note that concepts like "extreme masculinity" do not only apply to men, but to a culture that was historically started and upheld by men. These scholars show that the culture driven by the Californian Ideology has particular norms and values that ultimately nurture some kinds of technology development and suppress others.

The Californian Ideology is also haunted by an obsession with technology that is efficient and scales. Scale in this context refers to the idea that one can produce a digital product where the cost of adding one additional user is close to zero but the profit from that user is non-zero. For example, a social network can "scale" from a few thousand users to a few million rapidly without much additional cost. This is markedly different from scaling a company that sells physical goods which will incur manufacturing, transportation, and warehouse costs as production increases. Venture capital firms that invest in early stage startups often will only invest if they believe a company can scale exponentially very quickly, and thus make a lot of money.[1] Scholars have begun the work of explaining why scale can be problematic. One straightforward observation is that rapidly imposing standardized products on global populations can lead to unexpected, harmful outcomes. For example, Siva Vaidhyanathan outlines how Facebook's algorithms used at scale spread extremist content and undermine democracy around the world [Vaidhyanathan, 2018]. The idea of scale is not unlike the media studies concept of the "grid." The grid is the notion that a uniform design can be imposed on the world from above thus securing control and power for the group in command of the grid. This is very much the Silicon Valley ethos found in companies like Facebook and Google—they create "universal" products that get pushed on global communities. These products do not conform to the communities but force the communities to conform to them, relinquishing agency in the process. While Silicon Valley leaders often purport to be moving the world into "the future," it is in fact a very specific future built on an ideology that has deeply held values particular to the Californian Ideology.

2.3 Movements challenging the Californian Ideology

While dominant, the Californian Ideology is not without critics. In this section I map a collection of movements that are working to erode aspects of the Californian

[1] There is some more complexity here given the trend toward scalable products that are "free" or only take customer data in return, but I will not get into the nuances of that here.

Ideology. I do not claim to cover every possible movement but instead focus on groups that overlap with a relational/feminist approach to tech culture. I explain what these groups hope to accomplish and through what mechanisms. Ultimately, I argue that while each group that opposes the Californian Ideology is doing important work, none offer a counter ideology that is sufficiently seductive, optimistic, and generative to replace it in the engineering community.

2.3.1 Diversity, inclusion, and the "pipeline problem"

The fact that many tech companies are run by a narrow demographic has not been lost on media, government, and academic institutions in the US. One avenue towards change in the tech sector has been to increase the diversity of people making new technology. Recent years have seen increased efforts to expand the numbers of women and minorities in science, technology, engineering, and math (STEM). The underlying logic of these efforts tends to center around what is commonly called "pipeline problem" by both academics and mainstream media. The "pipeline" framing says that women and minorities drop out of STEM education and thus there are not enough qualified people in those groups to hire into the workplace. Critics of the pipeline narrative point to the fact that women and minorities also leave the workplace after obtaining jobs and that hiring practices such as the referral system perpetuate a false myth of meritocracy [Barabas, 2015, Metcalf, 2010, Seron et al., 2018, Twine, 2018]. However, a focus on the pipeline narrative persists despite these critiques. In this section I will look more closely at how the pipeline narrative came to be, how it is perpetuated, and how it distracts from more foundational cultural and ideological change in the hi-tech sector. In short: adding women to the pipeline is not going to make the hi-tech sector more feminist.

In her book *Has Feminism Changed Science?* [Schiebinger, 1999], Londa Schiebinger outlines the non-linear advancement of women in the sciences. She describes how from the 15th century to the Scientific Revolution, science was predominantly practiced by wealthy people—including women—who did not have a university degree. From the earliest days, men claimed that women were unable to be successful scientists.

In response, women compiled encyclopedias of female scientists as proof that they existed and contributed meaningfully to scientific progress. Around the time of the Scientific Revolution (circa the 17th and 18th centuries) a university degree became a pre-requisite to be a practicing scientist and since universities did not admit women, their representation in science dropped dramatically. In the late 19th century, both men and anti-feminist women began to point out that the "encyclopedia approach" was flawed: if encyclopedias were made of men's scientific achievements and women's scientific achievements, the one documenting men would be larger and therefore, the argument went, women were not as good at science. In response to this claim, feminist arguments shifted toward showing the barriers women face to entering scientific fields. The number of women in science PhD programs fluctuated during the 20th century, from high numbers towards the start of the century to lower numbers in the middle and up again after the launch of the Russian satellite Sputnik and the introduction laws forbidding discrimination in employment on the basis of gender.[2] Despite these advances, women still faced significant barriers to succeeding in science. Schiebinger dates the emergence of the "pipeline problem" framework—"with all the unattractive connotations that metaphor suggests" ([Schiebinger, 1999], p. 54)—to the 1980's after quantified metrics for diversity in science began appearing regularly.[3] It shifted the onus for succeeding in STEM from institutions to individual women, arguing that

[2]In the 1920's, the number of female PhD graduates in science hit a peak. Unfortunately, this trend didn't last and the number of female PhD graduates in science dropped between 1930 and 1960, which Schiebinger and other scholars argue was due to "the rise of fascism in Europe, the Cold War, and McCarthyism in the United States" ([Schiebinger, 1999], p. 30). This was not helped by the end of World War II and the G.I. Bill, which funneled a large number of men into university science programs. By the 1970's, the number of female PhD graduates in science returned to where they had been in the 1920's. This was in part due to the introduction of two laws, Title VII of the Civil Rights Act of 1964 which outlawed discrimination on the basis of sex, race, color, religion, or national origin and the Equal Employment Opportunity Act of 1972 which strengthened Title VII particularly with regards to discrimination against African Americans and other minorities. The uptick was also spurred by the successful launch of the Russian satellite Sputnik in 1957. The US responded to the incident by encouraging students of all genders to study science and engineering.

[3]Statistics on women in science and engineering were first collected in the 1970's and the National Science Foundation (NSF) began creating official reports in 1982. Margaret Rossiter coined two concepts in the 1980s to make sense of the statistics: "hierarchical segregation" (women not advancing to leadership positions) and "territorial segregation" (women clustering in some fields but not others). Discussions about intersectionality continue to be overlooked thus "'minority' has often meant men (and specifically African-American men) and 'women' has meant whites" ([Schiebinger, 1999], p. 38).

they "self-(de)select" out of STEM curricula at a young age and thus must be convinced to continue their studies. Despite critique by scholars, the pipeline narrative has persisted, largely perpetuated by powerful institutions for whom it deflects blame and responsibility for the lack of representation in their workforces. While women's advancement in science is sometimes framed as an inevitable slow march forward, this history demonstrates that it is closer to two steps forward, one step back. Many steps forward, such as anti-discrimination legislation and access to institutions of higher education, were only possible because of the concerted effort of feminists and political organizing.

The last decade (2010-2020) has seen a proliferation of organizations such as the Society of Women Engineers, She++, Girls Who Code, Kode With Klossy, Black Girls Code, Brave Initiatives, The Grace Hopper Celebration for Women in Computing, and many more working to increase the numbers of women and minorities in STEM. These organizations typically focus on skill acquisition (e.g. coding, data science), career preparation (e.g. interview training, resume reviews, salary negotiation advice), and networking. While they are doing important work, by focusing on increasing skills and confidence among women these institutions operate within—and reify—the neoliberal pipeline narrative. A study by sociologists of over 700 undergraduate women in engineering across four US universities found that undergraduate women engineers themselves buy into the pipeline narrative. The authors find that these women uphold the "myth of meritocracy" in the tech industry (which the authors note has been refuted by scholars) as well as a "diversity-quality" tradeoff, where female students believe that hiring to increase diversity would necessarily result in lower engineering quality. Respondents in the study claim that they are not feminists because they do not want to receive special treatment; they believe that through their own individual talent they will succeed. This type of thinking is a barrier to breaking down the pipeline narrative since women themselves reject the need for collective feminist action and instead reproduce the conditions of their own oppression.

The "myth of meritocracy" is a central feature of the Californian Ideology which bolsters the popularity of the pipeline framing in tech culture. It ignores the fact that women and minorities often leave jobs in STEM after the start of successful careers due to micro-aggressions, sexual harassment, and not being rewarded equally for their accomplishments ([Schiebinger, 1999], p. 63-64). These complaints point to a toxic culture for women that coding bootcamps and networking events will not fix. Additionally, the pipeline framing sidesteps the fact that there are many women represented in the technology industry, but they can be concentrated in lower-paying jobs such as chip manufacturing, user experience (UX) and user interface (UI) design, and customer success [Nakamura, 2014]. The invisibility of these jobs, or tendency to treat them as less valuable than "hard" engineering work, erases women's valuable contributions and technical expertise. Simply adding more women to the "pipeline" will not remove structural issues of sexism, racism, and the "old boys' club" that are found in tech culture but ignored due to the focus on meritocracy in the Californian Ideology. We need to stop training women—and other underrepresented minorities—to fit into a toxic culture where some kinds of work are valued more than others, we need to change the culture itself.

2.3.2 Activism, the tech worker movement, and the politics of refusal

Another avenue toward change in the tech industry is a rising interest in tech worker activism that utilizes traditional organizing tactics such as labor strikes, boycotts, and policy recommendations in order to effect change. Ben Tarnoff [Tarnoff, 2020] explains that activists in the tech sector tend to organize around three key issues: wages and work contracts, harassment and safe working conditions, and ethical technology development. The first two categories relate to the last section where I described the false myth of meritocracy perpetuated by the Californian Ideology that holds that anyone can succeed if they work hard enough. Within the activist tech worker movement, issues related to wages and work contracts generally target contract workers and gig workers who are paid significantly less than full-time employees and often denied health care and other benefits despite grueling hours [Roberts, 2019, Tarnoff, 2020].

Anti-harassment campaigns tend to center on the negative experiences of women and other underrepresented groups in the technology industry workplace, including highly paid workers like software engineers [Alba, 2015, Tarnoff, 2020]. Since I have already discussed the problems with the myth of meritocracy, in this section I will primarily focus on Tarnoff's last category where activists are working to make technology more ethical by limiting the use of potentially harmful technology. I contend that while tech worker activism is making great strides towards Google's former mantra of "Don't be evil" and fighting the harms of capitalism, it doesn't offer engineers an alternative vision of what "good tech" would look like.

Resisting both the development and deployment of new technology due to concerns about potential harm has been called a "politics of refusal" by scholars. One recent piece of scholarship entitled "Feminist Data Manifest-No" [Cifor et al., 2019, Garcia et al., 2020] outlines a "refusal of an inheritance" of a particular way of being (this could implicitly be read as a refusal of the Californian Ideology) in favor of a plurality of feminist visions for the future. Activist tactics such as strikes and boycotts are a form of refusal. For example, in 2018 more than 20,000 employees in over 50 Google offices participated in a strike named the "Google Walkout" [Tarnoff, 2020]. One of the key triggers for the strike was a *New York Times* article that detailed how an early Google employee named Andy Rubin had been dismissed from the company because of sexual harassment allegations but had been given a $90 million exit package [Wakabayashi and Benner, 2018]. Additionally, employees were protesting Project Maven, a contract Google had with the US military to build computer vision for drones that would be renewed soon. Other activist projects in this space include further resistance to building weapons for the US government [Hollister, 2018, Costanza-Chock, 2020, Fuchs, 2016], campaigns to limit surveillance technology in policing and prison systems [Hamid, 2020], and work by the ACLU and others to pass policy that blocks the use of facial recognition software in public places [ACL, 2019]. It is noteworthy that many activist agendas in tech have been led by women—particularly women of color—since they tend to be more severely underpaid, face more harassment, and contend with greater harm caused by biased technology relative to men.[4]

Tech worker activism lifts the aura of the Californian Ideology. As Ben Tarnoff [Tarnoff, 2020] argues, in the activist framework highly paid tech workers such as software engineers—who often see themselves as future startup founders—identify as rank and file workers, unaligned with the decisions of their bosses. Tech worker activists paint a picture of the future of tech that includes unions and startups run as co-ops and many are aligned with the American left politically. While I fully support activist work in the tech sector and think it will always be a necessity, it falls short of giving engineers a vision of a tech future grounded in what to do as opposed to what not to do. There still needs to be a generative ideology for how to move forward that goes beyond refusal.

2.3.3 Academic critique of technology and Silicon Valley

For almost as long as the internet has existed, scholars have critiqued it. The project of academic critique works to unearth dominant assumptions, shine light on inconvenient truths, and make sense of a rapidly changing world. While scholars from many fields do this kind of work, I will highlight two important strands. Since the 1980's, feminist science and technology studies (STS) scholars have worked to show that the lack of women and other underrepresented minorities in tech industry jobs leads to products that cater to, and predominantly benefit, men. For example,

[4] Most of the activist movements in the technology industry have been led by women and/or people of color [Tarnoff, 2020]. These people often feel "othered" by the technology industry and thus have been able to see its flaws more clearly [Buolamwini, 2020, Tarnoff, 2020]. This includes people like Meredith Whittaker who helped organize the Google Walkout. Whittaker and other female organizers faced retaliation from Google for their role in the protest [Grenoble, 2019]. She eventually left Google to work full time at AI NOW, a think tank dedicated to understanding the social implications of AI which she co-founded [AIN, 2021]. Another example is Sarah Hamid who leads organizing efforts at the *Carceral Tech Resistance Network*. Hamid is a carceral abolitionist, meaning she advocates for eliminating the prison system, who fights against the use of surveillance technology in policing [Hamid, 2020]. She explains how a cultural focus on "privacy" as a key harm of surveillance technologies actually detracts from the more tangible bodily harms faced by predominately communities of color at the hands of police [Hamid, 2020]. Timnit Gebru was also fired from Google for her work that uncovered ethical issues with Google's AI systems as well as discrimination within the company [Metz and Wakabayashi, 2020]. Women, particularly women of color, have led the effort to reign in the technology industry and mitigate the harms of both its corporations and its products.

Ruth Schwartz-Cowan [Schwartz-Cowan, 1983] demonstrates how the invention of the washing machine increased work for women in the household since clothing was no longer sent to an external service to be cleaned and cleanliness standards heightened. The term "critical internet studies" also functions as a multidisciplinary umbrella for academic work on technology. Sonia Livingstone, an early scholar in the field, writes that internet studies began in the 1990's.[5] She explains that the field primarily stems from Media Studies and Communication as well as Library and Information Sciences. Livingstone outlines four distinctive characteristics of new media and the internet as an object of study: 1) that it recombines other existing media in new and constantly evolving ways; 2) that it can be conceptualized as a "point-to-point network" made up of nodes; 3) that it is used by large swaths of the population in societies where it exists (which does not mean it exists globally); and 4) that it is highly interactive and this interactivity is at a scale much larger than previous interactive media. In 2020, internet studies has broadened to encompass technologies like mobile apps, augmented and virtual reality (AR and VR), artificial intelligence, and other technologies that are adjacent to, and often rely on, the internet. A growing body of work has thoroughly dissected and critiqued the contemporary technology and tech culture (see e.g. [Daub, 2020, Noble, 2018, Eubanks, 2018]). These scholars make clear that technology is neither neutral in who it benefits/harms nor does it effect the world deterministically; rather, it is part of a complex sociotechnical system.

By nature, critique tends to articulate why existing systems are flawed but does not offer a generative replacement. Engineers outside of STS or critical internet studies might not be able to understand the critique well enough to translate it into something generative themselves or might become overwhelmed by its quantity and give up. In the last year, I had a conversation with a human factors researcher at a large US tech company who had almost completed his doctoral degree. He told me, in an exasperated manner, that he just didn't understand what scholars working on ethics and technology wanted; he found their arguments confusing and said he

[5]The *Journal of Computer Mediated Communication* formed in 1996 and the first conference of the *Association of Internet Researchers* held in 2000.

wished someone would make a single webpage detailing what they wanted to see from technology. To hear that someone from an adjacent field with a nearly completed doctoral degree couldn't understand critical internet studies felt like a concerning alarm bell to me: if he found it confusing, there was no way it was reaching rank and file engineers. Critical HCI scholars Silvia Lindtner, Shaowen Bardzell, and Jeffrey Bardzell confirm this suspicion saying,

> Studying... processes of economization is crucial to move beyond naïve renderings of technology research and design as "neutral," "apolitical" or outside past and continuous economic and political processes. Such critiques are often met, however, with a level of suspicion by technologists and technology researchers. A common response we have encountered, for instance, has been that such critiques are "negative" and that a focus on politics or political economy would deter us from solvable problems at hand. ([Lindtner et al., 2018], p. 109:5).

Lindtner, Bardzell, and Bardzell point to the need for an alternative, generative vision for engineers saying, "Taken together, the utopian vision of making has been unmasked as resting on a kind of technosolutionism and ideological colonialism, in a literature of critical studies in and beyond HCI that is hard to dismiss. Yet, the body of critical HCI scholarship on making has *not replaced the techno-utopian vision with an equally aspirational vision*." ([Lindtner et al., 2016], p. 1391, emphasis added). Outlining this "equally aspirational vision" is essential. Some academics do attempt to provide concrete steps engineers and non-scholars can take, however, I argue that these often still fall short of being easily legible. For example, Data & Society and AI NOW are both think tanks that fund applied research and produce white papers, policy briefs, and conferences targeted at a broad audience. However, the human factors researcher I spoke with still found these outlets confusing and many rank and file software engineers have never heard of them. Others implore engineers to learn more about the social world, but I think underestimate both the ability to do this without an advanced social science degree as well as the organizational barriers well-intentioned engineers face. Critical internet studies, STS, and adjacent academic fields hold incredible insights about the world, but they must be woven into straightforward and generative narratives that can be understood by "maker" disciplines like engineering if they are truly to challenge the Californian Ideology.

2.3.4 Art as avenue for imagining alternative tech futures

Unlike previous categories discussed, the art world is an interesting case because it is actively making use of new technologies to envision future worlds. As such, it is generative and very much engaged in both engineering and conceptual work. One example from the feminist tradition is the term "cyberfeminism" which was coined by VNS Matrix, an Australian artist collective active in the 1990's (members included Josephine Starrs, Julianne Pierce, Francesca da Rimini, and Virginia Barratt). Drawing on Donna Haraway's now famous Cyborg Manifesto, VNS Matrix "combined a utopia vision of corrupting patriarchy with an unbounded enthusiasm for the new tools of technology" (Julianne Pierce quoted in [Fernandez et al., 2003], p. 22). VNS Matrix was part of the first wave of cyberfeminism that "celebrated the innate affinities of women and machines" ([Fernandez et al., 2003], p. 22). Their best known work is *All New Gen*, a video game in which "cybersluts" must work to hack into the "Big Daddy Mainframe" by shooting "G-slime" [Abrams, 2019]. As one of the members said in a 2014 interview, "The VNS Matrix emerged from the cyberswamp during a southern Australian summer circa 1991, on a mission to hijack the toys from technocowboys and remap cyberculture with a feminist bent" (Virginia Barratt quoted in [Abrams, 2019]). VNS Matrix, and early cyberfeminism, was as enthusiastically utopian as early proponents of the California Ideology, although their goal was to create a feminist future online free from the oppressions of the physical world.

While it became clear that the sexism and racism that exist in the physical world replicate online and the term "cyberfeminsm" has mostly gone out of vogue, artists have continued to make art that challenges dominant notions in technology development. Artist Caroline Sinders is in the process of creating a feminist artificial intelligence (AI) by interrogating each step in the process through a feminist lens. As of 2020, she has a dataset that she has collected through events at bookstores and galleries around the world pertaining to women and gender issues. As she explains, the final product is not the point of the project, rather, the goal is to highlight the dominant assumptions baked into each step of the process of creating an AI (from interview I conducted with Sinders in 2020). Artist Stephanie Dinkins is also investigating how race and gender intersect with technology. One of her projects called *Not The Only One* is a physical vase with three Black women's faces from different generations in a family imprinted on it [Dinkins, nd]. The vase contains an AI that was trained on oral histories from each woman and the data is stored on local computers to protect privacy. *Not The Only One* shows a vision of AI built from underrepresented voices, "small data," and with great care for privacy. Contemporary artists are able to use art as both critique and as a way to imagine a different future.

Despite the fact that their practice centers around making, artists exist in different social worlds than engineers. A key distinction is around the idea of scale described earlier: the Californian Ideology valorizes products that can scale to many users rapidly while art pieces often focus on one or a small number of viewers/users at a time. Engineers unfortunate distaste for technology that is "non-scalable" may prohibit them from engaging with artists or seeing artists work as relevant (see e.g. [Hanna and Park, 2020]). Here, as with other social groups, it feels possible to begin building bridges. Design, for example, is a discipline that touches both sides and might provide groundwork for further collaboration.

2.3.5 Participatory and other design frameworks

Finally, the arena of design offers a number of frameworks that de-center norms provided by the Californian Ideology. I detail this section last because it most closely relates to the alternative, generative vision for technology I find is needed. Broadly, these frameworks include 1) strategies that include more stakeholders in the design process, 2) that directly question power dynamics in socio-technical systems, and 3) that reframe the how designed objects fit into the world. Each of these categories exhibit feminist/relational qualities whether by enhancing relations between the designers and end users (as in participatory design), highlighting unequal relations of power (as in critical design), and showing how artifacts might tell new stories about communities or repair past harms (as in design justice).

The first category originated with participatory design which emerged from Scandinavia in the 1960s. It began as a way for designers of industrial equipment to incorporate workers, who were concerned new technology would remove jobs and lead to deskilling, into the design process. It has since taken off in academic and industry circles under a variety of names such as "human-centered design," "inclusive design" or "co-design" [Costanza-Chock, 2020]. Batya Friedman and Helen Nissenbaum outlined value-sensitive design (VSD) in the 1990s. VSD holds that makers can—often unintentionally—embed bias into designed objects. It also states, however, that makers can become aware of this and work to build objects with desired values. Proponents of VSD have suggested tools and strategies like audits to improve bias in design [Friedman, 1996, Friedman and Hendry, 2019]. Overall, this strategy incorporates numerous stakeholders into the design process and accounts for their values and viewpoints.

The second category centers around critical and speculative design. Speculative design is akin to the design version of science fiction, in other words, the creation of objects as a way of imagining possible futures. The objects are not intended to predict the future or be used in reality, they are a thinking tool to help people conceptualize what they may or may not want to see in the future. Critical design uses a speculative design approach to critique existing assumptions and oppression through the creation of objects. Anthony Dunne is credited with first using the term "critical design" in the 1990s although the concept existed in earlier art forms. He and Fiona Raby have continued to be central to popularizing this way of making. Related to critical design, Carl DiSalvo's adversarial design [DiSalvo, 2015] is a politically charged design process that questions flawed assumptions through the development of objects. He uses agonism, the political concept that constructive conflict is important for the success of democracy, as a basis for his theoretical approach to design. These forms of design question power dynamics in society using artifacts.

The final category is well described by Daniela Rosner's concept of critical fabulations that she defines as "ways of storytelling that rework how things that we design come into being and what they do in the world" [Rosner, 2018]. For example, she tells the lost story of the women who created the information storage infrastructure for NASA's Apollo missions using weaving techniques for the wiring. She uses the same techniques to craft an electronic quilt that sends tweets about these women's stories and in doing so alters the dominant narrative about space technology. Feminist human-computer interaction (HCI) is a framework outlined by Shaowen Bardzell in 2010. The principles, or as she calls them "qualities of feminist interaction," in her framework are: pluralism, participation, advocacy, ecology, embodiment, and self-disclosure. Bardzell did her PhD in comparative literature and was able to successfully translate key feminist concerns into actionable bullets for an engineering-focused audience. Catherine D'Ignazio and Lauren Klein developed a feminist framework for working with data and data visualizations that they call *data feminism* [D'Ignazio and Klein, 2020]. Centered around the idea that data is never neutral, they offer these principles that reify those outlined by Bardzell: examine power, challenge power, elevate emotion and embodiment, rethink binaries and hierarchies, embrace pluralism, consider context, and make labor visible. Sasha Costanza-Chock defines design justice as a method for providing social justice reparations through design [Costanza-Chock, 2020]. Design justice is not only about designing for different identities, it actively seeks to be restorative and account for past injustices to oppressed groups. These design strategies seek to reframe the purpose and use of objects in the world, often from a feminist perspective.

My focus on relational/feminist engineering builds on these frameworks and is greatly indebted to the ways they have made social concepts actionable. My concern is that they still sound complex and hard to implement by rank and file engineers, if they are communicated outside academia at all. My goal in developing a relational engineering ethos is to highlight the key points made in these frameworks in a simplified manner: any engineer should be able to consider how to improve relations on their team as well as with other stakeholders in the design process. A secondary concern is that these frameworks do not provide a strategy for convincing engineers with privilege what the community as well as personal benefits are of taking the time to understand stakeholder values and relations among people and artifacts. This amounts to a quality of life argument: being on a team built on positive relations where engineers get to meet with the people who will actually be using their product is more satisfying and more fun. This may mean finishing fewer products and scaling to fewer people (and thus making less money), but the quality of the interactions makes up for this. In large part these design frameworks don't sufficiently emphasize: a relational engineering ethos is more than a method to apply at specific junctures, it is a cultural shift in how to approach making/futuring and it doesn't just result in justice but in joy. It is this fleshed out ethos that I argue has the potential to stand up to the Californian Ideology.

As described above, the hi-tech sector is dominated by the Californian Ideology but a variety of movements are pushing back against it including: organizations working to increase representation of women and minorities in STEM, activist tech workers, academics working on critiques of hi-tech, artists, and designers/design academics. Despite important advances that have come from these groups, how to practically steer mainstream engineering culture in an alternative, more equitable/relational/feminist direction remains a key question. Many engineers struggle with taking criticism unless an alternative is suggested and tend to reject the idea of "refusal" (i.e. that the best we can do is not build something). Thus, cultural/ideological change must be presented in a way that is generative and actionable. I put forward a relational approach, grounded in feminism, as one path forward which I will outline in the next section.

2.4 Towards a relational engineering ethos

In addition to the strategies I have described, a maker-oriented ideology that prioritizes care/justice/equity is needed; I have called one possibility that is grounded in feminist principles a *relational engineering* ethos. Instead of a focus on scale and apolitical libertarian ideals, this dream offers nourishing community and the joy that comes from good relations. To those engineers with the privilege to find it tangible, the Californian Ideology is compelling because it offers both a vision of the future as well as the promise of a good life through financial reward and broader impact. I argue that relational engineering also has the potential to be alluring to those with power/privilege in the tech sector. Its appeal comes from the fact that it is a path to a more equitable and just world and provides personal reward in the form of strong relationships. One of my interviewees, Morgan, touched on the benefits of a relational focus when describing her experiences in two different lab groups. In one lab, emphasis was on producing as many papers and other outputs as possible and meeting time was strictly allocated to optimize for this goal. In the other lab, the principal investigator (PI) took time to introduce new members and allow the group to get to know one another as well as provide updates and feedback on their own work. Morgan noted that the strength of the relations in the second lab were far richer and thus she felt both more invested, included, and like she had personally learned and grown more. Quantitative metrics of success, such as quantity of papers or number of users, might obscure that important social development with depth of impact might not be occurring. A relational engineering ethos is not saying that output is unimportant, rather, it is shifting the framing of the engineering process to see other outcomes as valid and important in order to promote equity/care/justice.

Shifting tech culture towards valuing caring relations would also improve the numbers of women and minorities, who currently face exclusion and harassment. On one level, this is an obvious result of placing more emphasis on building an inclusive culture. Less obvious perhaps is that by legitimizing a new objective for technology development—depth of caring relations as opposed to scale/profit/efficiency—tech culture will include those whose goals are more aligned with this objective. Ben Tarnoff argues that women and minorities often see the harms of technology first because of their positionality as the "other" within tech culture. Turkle and Papert [Turkle and Papert, 1990] argue that some women are more likely to think of writing code like playing a musical instrument or crafting a poem, and can turn away from computing when they are forced to think in a more rationalist manner. Thus it is not just about including women and minorities in tech culture, there is a need for a cultural shift that legitimates other ways of thinking and being (or, as Turkle and Papert call it, "epistemological pluralism"). A relational engineering ethos offers an alternative ideological structure to those who are unsatisfied with the status quo.

The logic of the Californian Ideology says one should develop efficient, scalable solutions to global problems which will lead to high impact (implicitly understood as positive impact) as well as large financial reward (implicitly understood as personal happiness). In contrast, relational engineering centers the strength of good relations throughout the development process and emphasizes community as a way to achieve depth of local impact and a path towards justice and flourishing. One does not negate the other and each is an extreme, with many gray areas in the middle. The goal is not to create a new dominant ideology, but to allow for ideological pluralism with an intention to make tech culture, and resulting artifacts, more equitable and inclusive.

2.5 The seductive power of ideology

The idea of being one of Buckminster Fuller's "comprehensive designers" [Turner, 2006] and simultaneously being as cool as a hippie, as rich as a CEO, and as impactful as Fuller believed himself to be is the seductive basis for the Californian Ideology. This can be succinctly summed up in the opening line of an invitation to prominent people involved in blockchain technology in 2015: "Come visit with Sir Richard Branson on his private island for a set of intimate discussions highlighting critical issues and solutions and to lay out the framework for a world where humankind is fully benefiting from the amazing technology behind the blockchain" [Rizzo, 2015]. Private island? Check. New technology? Check. Saving the world? Check. These visions enrapture tech workers. Those who are soon to be graduates of computer science departments in elite universities are particularly prone to falling in the trap, since the possibility of the jet-setting, impactful life feels so tangible. Most of them will be funneled into Google, Facebook, and other companies where they will remain as rank and file engineers for their careers, well paid but far from owning (or being invited to) a private island. But it's hard to fight seductive ideology that tells people they are special and powerful. My question is: how do we offer something more seductive that emphasizes equity/justice/inclusion?

My answer, in short, is a relational engineering ethos that is grounded in care and justice. To truly care for others over profit and scale, to be part of a loving community, and to reap the benefits of joy that comes from these deeply intertwined human experiences: I argue this can be more fulfilling than what's set out by the Californian Ideology, especially for those engineers who face oppression under the current system. Relational engineering seeks to be a practical strategy that argues for creating a culture around making that values relations with people and communities over all else. If it could steer engineers just a hair away from the current Silicon Valley trajectory, it would be worthwhile.

Chapter 3

Remaking Tech Culture: Insights from Feminist Technologists

3.1 Introduction

In the previous chapter I suggested "relational engineering" as an alternative to dominant engineering culture. In this aspirational vision, technology production is centered around building good relations among both human and non-human actors in a sociotechnical system. The concept is built on feminist theory and, in particular, feminist science and technology studies viewed through an intersectional lens that acknowledges that women and non-binary people have multi-faceted and differing experiences. Theory like this can, however, feel removed from practical advice that is easy to grasp and implement, especially for those without social science training. How might feminist theory, and a relational engineering ethos, be operationalized? What practices and norms should engineering groups seeking to craft this kind of culture adopt? To answer these questions, I sought out feminist engineers to observe and learn from.

In this chapter I outline my findings from ethnographic work conducted in feminist engineering spaces. In particular, I draw on participant observation from a self-described "feminist" data science lab at a large US research university as well as interviews with women and non-binary engineers from both within and outside the lab. Overall, I found a focus on equitable and inclusive cultural values, in other words, an emphasis on “good relations” among members. Practices at the lab that contributed to good relations included micro-affirmations, embracing ambiguity and collective decision making, valuing social intelligence and lived experience, and making time/space for experimentation and joy. By shifting what the engineering culture values—away from an emphasis on technical dominance, rigid answers, and quantitative success metrics—this feminist data science lab was able to create a space where members with a range of identities trusted each other and felt safe and supported to pursue the research that mattered to them.

This project builds on a small but growing literature on feminist hackathons and hackerspaces. While these are temporary events or hobby spaces, they provide insight into feminist making cultures. Fox, Ulgado, and Rosner [Fox et al., 2015] explore and expand the concepts of hacking/hacker by demonstrating that activities like craftwork and identity work are valid forms of innovation within these spaces. Cyd Cipolla [Cipolla, 2019] describes a feminist maker pedagogy she uses in her classes that centers tinkering, productive frustration, and joy as critical aspects of learning about technoscience. Hope et al [Hope et al., 2019] describe two of the Make the Breast Pump Not Suck hackathons held at the MIT Media Lab and outline the following design principles for inclusive events: intentionally structure equity, leverage privilege and institutional power, push for narrative change, cultivate joy and play, and uplift low-tech and no-tech solutions. Earlier work such as Jo Freeman’s The Tyranny of Structurelessness [Freeman, 1972] also demonstrates that so-called “feminist” spaces can also end up replicating oppressive power structures if not well organized. My ethnographic work contributes to this literature by providing an example of an ongoing, primary workspace where members must satisfy both the demands of a competitive research university as well as their own feminist commitments. My ethnography is also centered on describing cultural practices and norms I observed as opposed to design principles outlined in some of this literature, although there is often resonance between the two. In addition, since the feminist label alone does not guarantee a welcoming and inclusive culture, my focus on norms and practices also examines how that ideal can be practically operationalized.

Other researchers have studied engineering cultures. One example is Gideon Kunda, who's book Engineering Culture [Kunda, 1992] explores norms and practices within a large US tech firm. Kunda describes a kind of normative control where the tech firm encourages employees to include their work as part of their identity thus driving them to work harder and longer without additional bureaucratic oversight. In other words, the tech firm uses cultural norms and practices instead of direct surveillance to control workers. Kunda's work is significant because it shows how dominant engineering culture has been shaped by the needs of corporations. Rachel Bergmann provides a critical history of female artificial intelligence (AI) researchers from the 1980s and 1990s [Bergmann, 2020]. She focuses on a piece of software called *SharedPlans* that she argues is feminist because of how it considers the relations between humans and AI. Beyond this piece of software, Bergmann shows how this network of researchers developed and maintained feminist values and practices amidst male-dominated computing culture. I argue that a relational engineering ethos must prioritize the needs of people over the demands of corporations and institutions, although I recognize understanding how to do this in practice can be challenging.

In what follows, I first explain my methodology. Then, I outline the experience of women in the dominant engineering culture as described by my interviewees. I discuss how sub-categories of engineering labor have become differentially gendered and valued. I then move to my work with the feminist data science lab and explain the practices displayed that led to an inclusive culture. Finally, I reflect on how my findings fit into some of the broader discussions around feminism and diversity in the tech sector.

3.2 Methods

In order to understand the practices and norms of feminist engineering culture, I used an ethnographic approach which allowed me to collect and synthesize data in a number of forms including participant observations, interviews, and artifacts (e.g.

published texts and technologies). By "culture" I mean interactional norms, modes of collaboration, systems of symbolic value for acknowledging each other's work, and how people are recognized as persons. Given that evidence for these is not well documented, I determined that ethnography was the best methodological approach for understanding the study of this culture in practice. One drawback is a small sample size—I was only able to conduct participant observation of one group and several events as well as hold interviews—however, this is balanced by the depth of understanding possible from sustained interaction over a period of several months. My goal is to be exemplary rather than exhaustive. Additionally, a case study of this one group has wider implications as it can serve as a model or blueprint for other groups looking to develop feminist engineering cultures.

My primary field site for participant observation was a self-described "feminist" data science research lab at a large US research university. I chose this lab because of its explicit focus on applying feminist theory to a technology practice (data science). The lab is also embedded in a technical university and thus must grapple with both staying true to its commitments while existing within dominant engineering culture, a tension recognized by members. I attended lab meetings over the course of five months. In addition to attending lab meetings, I went to talks, events, and conferences related to feminism and technology that were not associated with the lab. For example, I attended Technica, the world's largest all women and non-binary hackathon. These events allowed me to observe discourse and practices around building technology from a feminist perspective outside of the lab setting. I also collected digital artifacts I came across online [Markham, 2013] such as a syllabus for a university course on feminism and technology I discovered on Twitter. Due to the COVID-19 pandemic, I conducted all participant observation remotely via Zoom or other online platforms. While this has been in some ways limiting, it has also provided opportunities for me to participate in events in other geographic areas that I would not normally have been able to attend.

In addition to participant observation, I also conducted nine interviews which lasted 30-60 minutes each. I selected interview participants via opportunistic sampling from my fieldwork and reached out to them via email since my fieldwork was remote [Guest, 2015]. Most of my interviewees were not members of the feminist data science lab. Some interviewees I selected because of their prominence within the network of feminist technologists I studied (for example, artist and activist Caroline Sinders). The majority of my interviews, however, were with women and non-binary students from five institutions who were selected because they had both engineering experience as well as some familiarity with feminism, either through the lab or through a class or event. I wanted to understand how they made sense of their own place within engineering culture, given their exposure to both the dominant culture as well as feminist ideas. I also sought out an intersectional group and interviewees claimed a variety of racial/ethic, gender, ability, and professional identities. While the study was predominantly focused in the US, because of Zoom I was able to interview one participant living in India. While interview questions varied between individuals, I focused on personal experiences in the technology sector and the person's perspective on dominant engineering culture; the person's relationship with feminism; ideas the person had for making engineering culture more inclusive; and, how the person saw their own future and role in the technology sector.

The data I collected include field notes from participant observation, screenshots of online events and artifacts such as tweets, notes from interviews, and interview transcripts. I placed all of this data into the software Nvivo. I analyzed the data using iterative qualitative coding and a grounded theory approach. To do this, I reviewed my data and assigned codes throughout. I then further iterated on these codes to extract themes. I performed this process several times during my five months of fieldwork in order to focus my fieldwork and interview questions over time.

Drawing on participant observation and interviews, I have been able to understand the convergence and divergence between values expressed in feminist theory/discourse and feminist in engineering practice. Since my data is from a small sample of feminist technologists predominantly based in the US, it is not universally generalizable. My goal, however, is not to identify universal principles but to uncover lessons from case studies that "work" which might be useful in other contexts. I argue that drawing on these cases of feminist engineering practice will help the technology sector become more equitable and inclusive. Before turning to the case study of the lab, however, I begin with my interviewees experiences in dominant engineering culture.

3.3 Women's experiences in the dominant culture

As we near the end of our half hour video interview, I ask Amy—a sophomore at a US university—if there's anything she'd like to ask me. Her features soften a little as she visibly transitions out of interview mode and says, "Um, I do want to ask how you came to where you are. You mentioned you were in industry doing like coding, or like software." She isn't the first undergraduate woman in engineering to ask me this. The question feels like someone grasping for reassurance, that the challenges they've begun to face as a woman in engineering can be overcome, that I've figured out a way past them. It's also an admission that we're members of the same group, one that is different from the male-dominated engineering culture. After our earlier discussion about feminism and engineering, Amy trusts that I'll "get" what she means, even though it is hard for her to precisely articulate the "otherness" she's experienced in her computer science major. The dominant engineering culture that Amy and others encounter has been termed by scholars the "Californian Ideology" [Barbrook and Cameron, 1995]. As I describe in the last chapter, this ideology grew out of a confluence of hippie communes of the 1960's, WWII defense engineering funding, cybernetics, and an apolitical, libertarian, manifest destiny approach to "conquering" what was termed the "electronic frontier" [Turner, 2006]. These ideas were predominantly woven into the fabric of tech culture by affluent, white men in California and the culture continues to permeate industry and university engineering spaces today.

My interviewees explained that dominant engineering culture is often toxic for women and underrepresented minorities. Maanvi, a senior undergrad majoring in mechanical engineering with a concentration in robotics, ran through a slew of sexist behavior she had experienced recently with me in an interview. In a virtual Zoom meeting with people from a company she had been an intern with, she said her boss frequently muted her microphone and she told me, "he wouldn't have the balls to do that if I were a man." In an engineering class this semester, she said, "all my feedback is always like 'be nicer when you word things and talk a little less'," noting how she does expend significant labor trying to communicate kindly and feels that this feedback is not given to men. She also talks about getting "mansplained" to in the machine shop, sometimes for embarrassingly simple tasks like sanding a piece of wood. Finally, she tells me about a friend who is a TA for a virtual class this year. She said her friend has noticed that the men in the class always speak over the women, and then the women all stay after class to ask their questions. Maanvi, who is from a small southern town in the US, explains that she wouldn't have even considered going into engineering before coming to college, saying, "I had no idea that tech was even an option for me. It just seemed like something that white dudes from the northeast or California went into." Maanvi tells me that because of her experiences with sexism and wanting to work on problems more holistically, she has signed an offer to go into consulting instead of engineering after graduating this spring. Her story illuminates the flaws scholars and the media both make when they point to a "pipeline" problem in engineering which holds that there is a lack of qualified women to take jobs in industry (for a review of critiques on the pipeline narrative, see [Metcalf, 2010]). Maanvi is exceedingly qualified to take an engineering job, but chose not to in part because of the antagonistic culture she experienced as an undergraduate in class and during internships. Her experiences are not unique, and others described similar feelings of not comfortably identifying as an engineer given both the implicit and explicit signals that they do not belong.

As with any culture, membership in dominant engineering culture in the US has defining characteristics and stereotypes. Morgan, a graduate student, outlines a picture of what a member of this culture is like, "The [technical university] student caricature is an engineer, definitely cisgender, into coffee or whatever performance enhancement drug, and brilliant but maybe awkward... able to hack their way out of a system." She continues saying, "I don't identify with this at all. I feel like I'm not part of the 'in group' and I don't get the inside jokes." Morgan doesn't feel like she is a member of this culture because she doesn't identify with the dominant image or "get the inside jokes." Notice that she never mentions her technical abilities in the description—for her it is not a matter of having specific skills, but of being a certain kind of person. Morgan further explains that she doesn't want to be part of this culture because, "I think a stereotypical [technical university] student is kind of a nerd but is also someone who has... a lot of privilege but isn't very good at dealing with that privilege." Morgan, in fact, does see herself as having technical skills saying, "my skill set in tech is what pays my rent," but has decided that the tech industry is not for her. When I ask her about her future plans she says she'd like to work more in art even though she acknowledges, "[After graduating,] I would make the most money working in tech, but that [kind of industry culture] wouldn't make me happy anymore." Morgan's story also undermines the "pipeline" narrative since Morgan is choosing not to go into the tech industry because of its culture, not because of her skills or preparedness. She neither enjoys, nor feels welcome in, dominant engineering culture.

Anthropologists often outline what defines a member in the cultures that they study. In his book *Engineering Culture* [Kunda, 1992], Gideon Kunda explains what makes an "in" member of engineering culture at a large US tech firm he studied. He notes that not everyone who works at the company, however, is a member of the culture. In particular, he describes how contract workers are treated as second class citizens; they are paid less and given fewer benefits than full-time employees despite doing similar jobs. Kunda says,

> [A] concern this study raises is the contribution of corporate power to the marginalization of members. Specifically, it is necessary to understand the fate of the "extra-culturals"—those who become, in terms of the culture's categories, "nonpersons."... The ideology of organizational culture and its various forms of implementation seem not only to contribute to the evolution of this state of affairs, but to obscure its reality. [Kunda, 1992] p. 225

Here, Kunda explains that not only are some workers not considered members (as he says, they become "nonpersons"), but that the company normalizes this hierarchy and tries to make it invisible. Aside from the occasional offhand comment noting that members tend to be white and male, however, Kunda does not explicitly discuss how membership relates to race and gender. His framework, though, applies to the experiences of marginalization that my interviewees describe. By requiring that members fit a certain "type," the dominant engineering culture excludes anyone who does not want to conform to that type. When Morgan says she does not identify with what she perceives as dominant member traits and explains that she intends to leave the tech industry, she's saying that she is not willing to give up her own identity in order to conform and be considered a member in that culture. This echos findings by Turkle and Papert [Turkle and Papert, 1990] who studied students' coding styles. They explain that many women, and some men, they interview enjoying programming in a style different from the dominant style that is taught in school—one that is more like tinkering and building up a program piece-by-piece intuitively versus starting from top-down plan and organizing code modules into black boxes. They find that when these students—who are predominantly women—are asked to give up their way of coding and embrace the dominant style they feel that they are being asked to give up their identities and thus often abandon programming entirely. This is what happened to Morgan: giving up her identity in order to be a part of the tech sector was too much to ask even if it offered financial reward. As Turkle and Papert argue, there is a need for epistemological pluralism in technology development that allows for multiples styles to co-exist. As Kunda argues, this prioritization of a dominant type in the tech industry creates a two tier system where some workers' voices are valued while others are silenced. It is important to recognize how a perceived singular way of doing and thinking about technology can limit who joins the discussion and what gets created.

Several of my participants described finding feminism after experiencing toxic interactions, either through the tech industry or elsewhere. When I ask Caroline Sinders how she became a feminist and a technologist, she points to a difficult moment in her childhood that led her to feminist groups online, which she found on her parents' personal computer. She says, "feminism kind of saved my life" since it gave her language to understand her situation and a community of like-minded people with similar experiences. She says this was an "entry point" that led to deeper explorations into feminism and the realization that "there's a feminist take on literally everything." The PI of the feminist data science lab says that in retrospect she started acting like a feminist before she explicitly identified with the term due to her experience in the tech sector. She talks about joining a technical university as a graduate student saying,

> I was [at the technical university] when there was this huge hype about big data happening... And I was so, like, worried. It was obvious to me as somebody who came from critical cartography where there's been a literature on geography and power and mapping and power since the 19th century... I was very surprised when I walked into the [technical university] and it was all so techno-heroic... And all of those had to do with data and increasingly also about AI. So it just had me very worried.

Many tech activists are women and minorities who, like the lab PI, found themselves in toxic tech cultures that nonetheless wielded immense power and they felt compelled to do something. The PI continues saying, "I increasingly saw the need to plant a flag and say: actually this is a body of work that has so much to say about where we are with these technologies right now that we really needed to pay attention to it... you just need to look to alternate epistemologies. I think feminism presents those and presents so much that we can draw from to make sense of this current moment, and also to point out alternative ways of doing things, like it doesn't have to be this way you know?" Feminist work in the tech sector is being done by people who see that a different culture is possible and how creating it might be achieved.

3.4 The gendering of labor in engineering

Engineering culture deems some activities "masculine" and valorizes them, while casting other activities as "feminine" and thus less valuable. In particular, technical mastery is masculinized and praised while activities like design or user experience (UX) are considered easier and feminized. This division has historical roots: early "computers" were typically women performing what was imagined to be easy and mechanized work [Hicks, 2017]. As Nathan Ensmenger [Ensmenger, 2015] argues, once people realized coding an abstract solution into a machine was in fact complex, programming became masculinized and men took over professional programming roles. Alex, a senior undergrad, tells me she is doing the "straight" version of her mechanical engineering major. She says that most of her female peers instead do the version of the major that concentrates on product design and that this is "viewed as the easier route." Sometimes when her male peers find out she is "straight" mechanical engineering, they act surprised and congratulate her as an outlier amongst women. Alex admitted that she is also interested in product design—"that's where I want to focus my career"—but that she was convinced to do "straight" mechanical engineering by a male friend. She says to me, "He's a dude and was like 'oh well if you're gonna do [mechanical engineering], why wouldn't you just do it, go all in on it and do it.'" Alex further explains the aura surrounding highly technical work saying, "It's really easy to be super technical and because there are these people that are like really into sand or something, you're like, 'wow, why am I not really into the mechanics of sand.'" She smiles, acknowledging that an obsession with sand mechanics is niche and not broadly useful, while also recognizing that it is revered knowledge within her particular culture. I introduce the term "technical peacocking" to describe the act of showing off a technical skill within an engineering space. Technical peacocking is used to show dominance within the engineering hierarchy.

The dynamic between masculinized technical work and feminized non-technical work also shows up in descriptions of group projects. Alex points to this saying, "Guys are typically way more technically oriented... I've seen that in this capstone project. [Women] are like, 'Oh, I'm not that technical, so I can work on outreach,... slide templates, or graphics.' They are not doing necessarily as much of the modeling or the electronics schematics or the engineering analysis." Thus, labor is split between high value technical work most often performed by men and low value design and qualitative work most often performed by women. Amy, also an undergrad, describes a similar situation. She says that she loved her first computer science class, but in her second class she was assigned a male partner to work with on a project who immediately opened his highly customized terminal and started firing off commands. The terminal is a software program that allows users to type text-based commands directly to the computer rather than use the graphical user interface (GUI) via clicking on icons with a mouse. Knowledge about how to use and customize a terminal does not actually translate into being a good software engineer since it requires no abstract problem solving. It is simply a display of dedication to technical mastery to memorize keywords for directing the computer. A terminal with a customized color scheme (often colored text on a black or dark background) symbolizes to others that the user is familiar enough with the program to have taken the time to personalize it. Amy, however, was concerned that she didn't really know how to use her terminal beyond basic commands and certainly hadn't customized the color scheme. When she asked her partner to explain the commands as he went, he brushed her off, furthering her sense of isolation. As almost an aside, she mentions to me that he didn't know how to actually solve the problem posed by the professor because he hadn't done any of the reading as she had. As both this example of terminal customization and the earlier example on sand mechanics show, the technical mastery that is valued in engineering culture does not always translate into better engineering solutions. These displays of technical prowess are a kind of masculine showmanship designed to impress other community members, but groups in the margins tend to be neither impressed by nor interested in engaging in technical peacocking, and instead hang back and make critical team contributions that often go unappreciated.

3.5 Practices of a feminist data science lab

Given that my interviewees described feeling marginalized within a dominant engineering culture that preferences a particular kind of technical knowhow along with displays of technical mastery, I wanted to know if an alternative, feminist engineering culture existed and, if so, how it functioned. I found that there are three approaches women and other underrepresented groups take when confronting this culture: the first is to prove that women and underrepresented minorities are technically competent and able to fit into existing engineering culture, the second is to work to change the culture and redefine what it means to succeed in it, and the third is to abandon it completely (as Maanvi did when when she decided to go into consulting). The first strategy exemplifies "the Athena archetype in women—a competent and impersonal mind that [can] strategize and use power. Like the goddess Athena's emergence out of Zeus's head, women who had Athena's abilities became visible and were recognized and validated by the Father culture. Like Athena herself, however, most successful Athena women were fathers' daughters who did not consider themselves feminists" [Bolen, 1991]. As scholars have documented, and I learned in my own lived experience, many women's STEM groups are focused on this tactic [Seron et al., 2018]. These groups often organize networking events for women, hold technical talks on special topics, and offer career advice such as interview prep or strategies for salary negotiation. However, as scholars point out, these groups rarely, if ever, confront sexism as a structural force in the tech industry, instead working to prove that women can succeed in what they see as a merit-based system [Seron et al., 2018, Barabas, 2015].

This strategy of training women to succeed in the existing culture heavily leans on the idea that more representation will eventually lead to a better culture for women, but is that true? Acclaimed artist and technologist Stephanie Dinkins said it beautifully in a virtual talk I attended stating: "A while ago I might have said we need more inclusive tables, but now I'm not sure that that's good enough. I think it's about stripping the way we're functioning as societies down... Once we get to the table either we're warriors or we come with all these assumptions already embedded." I found the term "warrior" particularly fitting; women in engineering have to fight so hard just to exist in their environment, that they don't have the energy or mental capacity for anything else. Women in STEM organizations are typically in the business of making warriors, but not of fixing the system itself. Women who leave the industry are, in a sense, refusing to become warriors—a perfectly reasonable stance.

The second strategy is one that I find more promising and that I am the most excited about: changing engineering culture and values, including removing the gender labels on different categories of labor. In the following sections, I will review my time in the feminist data science lab and describe the practices I noted as important to crafting an equitable and inclusive culture where students with a wide range of identities were able to do their best work.

3.5.1 Micro-affirmations

In contrast to micro-aggressions—in which seemingly benign comments signal someone's exclusion—micro-affirmations signal racial, gender, disciplinary, and other inclusion in a space. One of the first things I noticed when joining the lab meetings virtually on Zoom was that almost everyone in the group listed their pronouns in their display name. I later realized this was just the beginning of a trend of radically inclusive small gestures that were repeated throughout the meetings. In another example, a student said in the chat that despite reading much of the PI's open access academic work, they hadn't actually purchased and read her book. The comment immediately struck me as another signal of a safe space, since the student clearly didn't expect to be ridiculed or judged for this admission and without skipping a beat, the PI replied in the chat: "I will give you a book!!!" Many of these small gestures were made explicit when the lab released a handbook. The handbook has a section called "Values and Norms" that includes sub-sections on intersectionality, care for self and others, embracing all genders, acknowledging the lab sits on stolen land, and recognizing the lab includes international perspectives. While many institutions may have a non-discrimination statement as part of their onboarding materials, the lab made it a central and detailed part of the introduction to the handbook in an effort to make people with many identities feel welcome. The lab PI explained how she was inspired by the handbooks of two other feminist academic labs. These gestures are not lost on the community, with one student commenting in the Slack that, "This group has been such a warm refuge this semester." Whether a refuge from the ongoing global pandemic or just the stress of university life, the lab's use of micro-affirmations has clearly succeeded in making a diverse group feel welcome.

3.5.2 Collective decision making and embracing ambiguity

The lab continually displayed an effort to make decisions collectively and not shy away from ambiguity or difficult questions. Often in dominant engineering culture there is a focus on "being right" that was absent in the lab. This is not to say that members disregarded consensus and concrete statements, but that attention to a variety of viewpoints and nuance were more important than jumping to conclusions. For example, throughout the meetings, students were encouraged to ask questions. By treating every question seriously, the lab created a space that valued discussion and made showing off knowledge or snubbing others socially unacceptable. The PI of the lab underscored this one meeting by saying, "one of the reasons I was attracted to [this department] as a place was precisely because of its great multiplicitousness... it's encouraging to me that when we can't pin things down that's OK... when things are fuzzy it means you have a space to move in." The technical peacocking found in traditional engineering spaces had been replaced by a culture that clearly valued questions and thoughtful ideas about technology. In our interview, the lab PI talked explicitly about her desire to include voices other than her own. She says,

> I think a lot of leaders could use some education on how to talk less. I pay a lot of attention to how much I talk. I think you need balance, because I do still feel like whoever's the faculty or the leader of the lab does have a responsibility to lead and set a tone and set a culture because culture flows from the top in these organizations... And so, I think about how to still lead while de-centering my voice and making space for other people. And I think it's actually really hard, because in a lot of cases leaders are insecure, it's like if they're not talking then they're not leading and I don't think that's how it works... Those absences are some of the most productive spaces... sometimes if you open things up, then you emerge with this wholly other perspective.

The PI explained that de-centering her own voice in lab discussions was a balancing act, she needed to both set the tone as well as make room for other viewpoints. Morgan, a graduate student in the lab, reiterated this idea to me in an interview unprompted when I asked about lab culture. She says:

> [The PI] has a way of delegating… in a way that feels a little more like she's trusting the people who run the teams or run the projects to give updates and take the lead on their projects. Versus the other team I was on, and also other teams I've been on, it really feels like there's a lot of micromanaging or there's not a lot of trust from the leader to the people below them that they can do their jobs on their own.

Morgan felt that she was trusted to do a good job on her projects, and this gave her both confidence and motivation to work hard. The PI also acknowledged that despite the lab's feminist commitment, they might not be perfectly feminist all the time. She says, "[Feminist] is like a marker for us, or like the navigation point where we are always tuning in that direction… there's an element that we need to that work of being feminist but we're also trying to always be better." To me, this was a healthy acknowledgment given that previous feminist organizations have sometimes gone astray [Freeman, 1972]: better to be always moving toward feminism as a goal than claim to be perfectly succeeding. One example of working to be better was when the PI introduced the lab handbook for the first time. Instead of asserting that it was the final and correct handbook, she took time in a lab meeting to have every member read and comment on the contents using a Google doc and then went back in and made changes. The lab demonstrated that collective decision making and embracing ambiguity and hard questions are part of a feminist technoscience practice.

3.5.3 Valuing social intelligence and lived experience

In addition to an emphasis on collective understanding, the lab also values social intelligence and the lived experience of members. Morgan, a graduate student in the lab, says, "I think there's so much intelligence that comes with being social, you know, not being awkward. I'm not trying to judge what's good or bad; this is just another type of intelligence that I wish were seen as actual intelligence [at my technical university]." Morgan discusses, for example, how grateful she was that the PI took time in lab meetings to introduce new people to the group. She says another lab she was in did not do this and thus she felt more isolated and disconnected from the group. The PI does feel strongly about making a socially cohesive community. In an interview with me she says,

> People do their best work when they feel supported or trusted. Sort of like you need IT infrastructure, you need emotional infrastructure in order to be creative. I think it is very inhibiting to be in a toxic environment and you're supposed to be creative but you're always being told that you don't belong in various ways. Are you going to be creative in that kind of environment? You know you can't do your best work there. So I think about how do we create that kind of trust and also a way of learning from each other. Because when we have a climate of trust, then you can also have the harder conversations when harm does come up—we can hopefully address it in a way that doesn't have to be toxic or whatever, or can be an actual learning experience.

I particularly like the phrase "emotional infrastructure" that the PI uses which implies that social intelligence and community bonding, like infrastructure, undergird any successful outcomes. For example, after a hate crime against a racial group made national news, the PI made space both in the lab Slack and during a meeting to ask how best to support community members. In response, two lab members led a remembrance for the victims during a lab meeting before starting research discussions. Additionally, the PI used a lab meeting to focus on how to grapple with the trauma researchers can experience while doing work on topics like violence related to racism and sexism. This kind of "emotional infrastructure" may be invisible or take up more time than some would like, but without it people may not feel safe or able to "do their best work." Trust relies on accepting the whole person including their lived experience into the group. An emphasis on respect for lived experience is a theme that shows up across feminist environments. Instead of judging people based on how closely they embody a normative ideal (for instance, a normative engineer as described by Morgan earlier), people are encouraged to share their unique backgrounds and perspectives. At lab meetings, members appeared to feel safe showing up as their whole selves and engaging with a group that they considered a social community.

3.5.4 Experimentation and joy

A key part of the lab was experimenting with non-traditional outputs and not losing sight of the joy of the process of research and creation. Joy has been written about as important for community-building especially when the community is looking to rework a dominant narrative [Sandoval, 2000, Hope et al., 2019, Brock, 2020]. Experimentation and joy go hand-in-hand because they both celebrate work for the sake of the work and not in service of external metrics of success. For example, in an interview the PI says of one lab project,

> That project has been a little bit more meandering and we're still meandering, but I think it's fine, and I actually appreciate meandering... I like to make time and space for those kinds of things to happen and I try not to impress too many of these projects into the service of the rat race for publications. We have already made two papers which is pretty impressive to me but I try not to be too publication bound and also allow that time for the meandering to happen.

In a traditional academic setting, "meandering" might seem like a waste of time if it doesn't directly lead to publications, the quantity of which are an external quantitative success metric. But for the PI this meandering is a necessary part of doing the work. She continues saying, "I think the process needs to be joyful or subversive or imaginative or take you in new directions, or else like why, why do that, where you always know where you're going." Celebration was also a part of joy and recognizing work well done. Over the winter break, the PI collected the addresses of all members and sent each one a mug with the lab logo and the names of the members as a gift. This elicited a string of joyful comments in the lab Slack with one member writing “This is so sweet, thank you!!”, another member commenting below “ditto <face with hearts emoji>”, and a third following up “Aw wow thank you so so much, I love this lab!” The comments reflected that the mug was not seen as a perfunctory token, but a celebration of the bonds members had made and the community formed during the semester. In our interview, Morgan also commented on joy and celebration when she described a story about virtual undergrad presentations in the lab,

> I remember one time some of the underclassmen were presenting their work on the streets initiative. The projects are awesome, but of course it’s Zoom and I think people are shy, it was kind of a big Zoom room. So everyone was on mute and after the undergrad would give this great presentation—I mean I was clapping in my head and I emoji clapped—but [the PI] unmuted and [clapped out loud and] I was like whoa. You know [she clapped] into this quiet Zoom’s void and I just remember thinking even if she felt like that was awkward, that was okay for her—she was like ‘I don’t care if that was awkward because I want to celebrate the work of these people right.’ Even if no one else unmuted themselves, you know, it was just [her], but I really felt like that was such a good indicator of the kind of leadership that she brings to the lab. Just super warm and willing to go out on a limb for for the members, especially undergrads.

This effort to “go out on a limb” and do something potentially “awkward” showed Morgan that the PI did care about celebrating good work and making those who had contributed feel like their work was appreciated. The joy and celebration inherent in the process contribute to the feeling of community and inclusion for members.

3.6 Myth of the “quality-diversity” tradeoff

As Seron et al [Seron et al., 2018] explain, quality and diversity are often positioned as a tradeoff in the technology sector where more of one leads to less of the other.

Sometimes, this is used to reject policies like affirmative action and uphold a myth of meritocracy [Seron et al., 2018, Barabas, 2015]. Other times, diversity advocates defend these types of policies using the logic that diverse teams help the bottom line, a framing I heard in my fieldwork. Instead of picking a side, I argue that it's the wrong debate to be having because each side implicitly accepts an assumption about quality defined by the dominant engineering culture. Quality is context dependent: in an industry context it is assumed to be tied to number of users or profit while in an academic context it is measured by metrics such as number of publications or grants. I am not saying that these outcomes don't matter, but that they are not the only outcomes that matter. A more holistic understanding of quality would uncover that the tradeoff between quality and diversity is a myth perpetuated by a dominant definition of quality.

When observing the feminist data science lab and other feminist engineering events, I didn't count the number of products or papers produced but I did notice one striking outcome: confidence and signs of future leadership capacity. A couple of days after talking with Amy, an undergraduate in computer science, she sent me an email saying she had written a blog post following our conversation. In it, she talks about a project she has started to collect data about eating disorders to share with other young women. She describes how learning about feminist data science practices at a hackathon for women and non-binary people influenced the project as well as her plans for the future. She came up with the idea herself, but the validation from a supportive network nudged her to make her idea a reality. In our interview, Amy mentioned that she might stop taking computer science courses because of the antagonistic culture and I note reading her blog post that in order to accomplish the projects she lays out she will have to learn to code anyway. A different student said during a lab meeting, "I wanted an ethical understanding of computer science and [joining this department and lab] was the easiest way for me to get a social science degree," acknowledging that they had actively left the computer science department to seek out a more holistic understanding of technology. These outcomes are arguably more important than traditional quantitative metrics of success. These are the people who are going to be leading their communities to be more equitable and inclusive; they are the ones who are going to build the worlds we want to live in. Without the support they found in feminist and relational engineering spaces, they may never have gotten the chance. Perpetuating the logic of the quality-diversity tradeoff is harmful because it fails to recognize that quality can take many forms and that we must be asking quality of what, for who, and toward what ends.

3.7 Conclusion

Crafting a feminist engineering culture means attending to power relations within the team, prioritizing asking questions and collaborating over heroic individual acts and technical peacocking, and acknowledges—while being inclusive of—different identities. The practices described in this chapter provide concrete examples of how to embody a relational engineering ethos. The feminist data science lab demonstrates that it is possible to reframe the idea that there is one correct way to develop technology, in other words, that epistemological pluralism [Turkle and Papert, 1990] is both necessary and possible. While I set up a dichotomy between dominant engineering culture and a feminist/relational engineering ethos, these are in many ways poles that some might closely align with while many others draw from each in a variety of complex ways. There is a lot of work to be done to make engineering culture in the technology sector more inclusive and I am not suggesting there is only one acceptable model for how to do so. Rather, I hope that this ethnography can serve as a blueprint and provide some practical advice for groups seeking to move in this direction. What I have seen gives me hope; perhaps, as the artist Stephanie Dininks said, the armor is starting to crack.

Chapter 4

Beyond the Command: Designing Relations with Social Machines

A note on authorship in this chapter: Sections 4.1 through 4.5 and parts of 4.7 appear in [Wagman and Parks, 2021].[1]

4.1 Introduction

"Alexa, tell me the weather!" has become a common command. By January 2019 over 100 million devices equipped with Amazon's virtual digital assistant, Alexa, had been sold worldwide [Bohn, 2019]. While seemingly simple, this human-machine interaction, in which a human voice orders an artificially intelligent digital assistant to instantly deliver information, is deceptively complex. Alexa's human-like voice is gendered feminine and she performs historically feminized clerical labor. This interaction both depends on and impacts global material conditions: the Alexa device hardware is sourced from numerous countries; the software relies on layers of physical internet infrastructure and value-laden machine learning algorithms; and the discarded devices and data centers pump toxins into the environment [Crawford and Joler, 2018]. Beyond this, the interaction raises a fundamental question: what exactly is Alexa's

[1] This paper was written for a human-computer interaction audience; readers familiar with feminist STS literature could skip the background reviewed in Section 4.2.

relationship to the user and to humans, more generally? Our social norms do not yet include clear conventions for how to interact with digital assistants or robots, or what we call in this paper, "social machines." It is not even immediately obvious to most people that the command "Alexa, tell me the weather!" may be problematic. Yet, as we suggest, this brief example evokes a host of critical issues related to gendered and other social power dynamics in human-machine relations.

For decades feminist scholars have critiqued science and technology, yet technology design outputs have been largely unresponsive to these critiques. Feminists in scientific and technology fields have called for gender diversity in the workforce (*e.g.,* gender balanced design teams); gender diversity in the "substance of science" (*e.g.,* a digital assistant that helps with questions about reproductive health); and feminist approaches to methods and design practices (*e.g.,* not universalizing "the user" in design methods) [Schiebinger, 1999]. While each area is important, our contribution in this paper falls within the third area because it questions how foundational assumptions about human-machine relations and structural conditions impact technology design. Some key foundational assumptions that we challenge include: that machines are politically neutral; that machines cannot form social relationships; that machines do not have agency; that humans should control machines; and that there is a clear boundary between human and machine. Drawing on feminist STS scholarship (*e.g.,* [Balsamo, 1996, Benjamin, 2019, Browne, 2015, Schwartz-Cowan, 1983, Wajcman, 2004, Haraway, 1991]), we explore how power works in human-machine relations and suggest that fuller awareness of the social can enhance technology design. We argue that HCI scholars and others concerned with technology design must confront the fact that common assumptions about the role of machines in the world reinforce existing inequalities, injustices, and patterns of oppression. Because of this, we must consider radical shifts in our thinking and approaches to design, and set out to craft machines, and engage in human-machine relations, in more ethical, just, and inclusive ways [Buolamwini, 2018, Costanza-Chock, 2020].

Our main contribution in this paper is a conceptual model for human-machine relations that operationalizes key lessons from feminist STS in ways that are generative for designers and technology builders. We consider designers to be crafting "social machines" and "human-machine relations" as opposed to simply building "machines." All machines are part of the *social*, a science and technology studies (STS) term that broadly refers to what is produced when humans and non-humans interact and develop relationships, and become part of power relations, societal norms, and cultures [Latour, 2005]. In this framework, interacting humans and non-humans are *mutually shaping*; humans and non-humans both influence, and are influenced by, one another. In the "Alexa, tell me the weather!" example, the conversation between Alexa and a user is a social interaction, as are the relations between Alexa's designers and developers at Amazon and factory workers producing the devices at Foxconn [Togoh, 2019]. Throughout the device's lifecycle, Alexa can alter the lives of humans *and* the norms and practices of those humans in turn inform Alexa's development.

To account for these conditions, we propose use of the term "social machine" as an actionable design intervention. By using this term, we make "the social" explicit and encourage technology builders to rigorously reflect upon and engage with relations of mutuality in their work. We define "social machine" as an object that is designed to construct and engage in social relations with humans, and that has been crafted with careful attention to issues of agency, equitability, inclusion, and mutuality.[2] The term "social machine" is also meant to recognize the proliferating human-machine relations that take shape in the digital era via computing interfaces, artificial intelligence, digital assistants, and robotics, but it is not meant to be an essentialist term. There is no physical characteristic that makes one object a social machine and not another; rather, any object can be a social machine if it is designed with consciousness of social inequalities and injustices, and partakes in a purposeful effort to remedy them. For example, the Amazon Alexa device as it stands is *not* a social machine since it was not designed with equity and inclusion in mind; however, this could change if Alexa were re-designed with greater emphasis on social differences and power dynamics. The ma-

[2] Note that we are using *social machines* differently than Judith Donath in her book *The Social Machine: Designs for Living Online* [Donath, 2014]. She is referring to machines that function as a communication medium and allow for social interaction between humans, while we center on a machine that is itself social. We also do not mean collections of people and machines that function together to create a social machine, as in [Shadbolt et al., 2013].

terial sites of human-machine relations construct, operationalize, analyze/iterate, and naturalize/normalize different kinds of relations, some of which reproduce oppression.

There are existing terms that are related to the idea of a social machine, but they tend to essentialize the human-machine binary. They include social/sociable robot [Breazeal, 2002] and relational artifact [Turkle et al., 2006]. We use "machine" as opposed to "robot" in order to avoid assumptions about robots that are baked into the term's history; namely, that they serve humans by performing mechanized labor (Oxford English Dictionary); that they are embodied and anthropomorphized [Breazeal, 2002]; and that they are fundamentally different from earlier machines like the computer or sewing machine and thus should be studied separately. Turkle's notion of a "relational artifact" evocatively suggests that various kinds of machines can present themselves as having "states of mind" and insists that human awareness of this possibility can enrich their encounters with machines. Turkle's work on "relational artifacts" is influenced by developmental psychology and psychoanalysis and ultimately is concerned with the ways that *humans* benefit from or are harmed by these encounters.[3] Our model builds on work in feminist STS[4] that conceptualizes technical artifacts as deeply embedded within their social contexts and thus within relations of power. Again, we use the term "social machine" to underscore the necessity of engaging with the social and thus issues of equitability, mutuality, and inclusion in the design process.

Our model posits a social machine as a non-human "other" that is distinct from, yet related to, humans, objects, and animals. The social machine has agency to act in the world and is conceptualized as having an *equitable* potential and inclusive position alongside humans and other non-humans. Our model stands in contrast to existing models of human-machine relations that conceptualize the machine as a tool,

[3]Turkle's notion of relational artifacts refers to "artifacts that present themselves as having 'states of mind' for which an understanding of those states enriches human encounters with them" [Turkle et al., 2006]. The term is intended to highlight "the psychoanalytic tradition, with its focus on the human meaning of the artifact–person connection" [Turkle et al., 2006].

[4]In STS "sociotechnical relations" [Bowker and Star, 2000] refers to the ways social forces and technological objects, systems, and practices dynamically shape and inflect one another. Our definition of social machines builds from this idea, but is more specific and is meant as an intervention in contemporary design practices.

as a human companion, as an animal or creature, or as a slave. Existing models are problematic, we argue, because they either imply a domination of the human over the machine, fail to recognize the machine as distinct from humans/animals, or do not acknowledge machine agency. Grounded in feminist STS perspectives, our model is not merely a critique of an existing system, but, with its emphasis on design, offers a generative way to think about new forms social machines could take, based on an ethics of inclusivity, equitability, and mutuality.

To aid designers in building and supporting new kinds of human-machine and social relationships, we seek to bridge feminist science and technology studies (STS) research with computer-supported cooperative work (CSCW), human-computer interaction (HCI), and human-robot interaction (HRI). The fields of HCI, CSCW,[5] and HRI,[6] have variously begun to confront the social dimensions of machines. We see an opportunity to unite these fields together with feminist STS, especially when addressing the design of social machines. A decade ago Shaowen Bardzell [Bardzell, 2010] put forth a feminist HCI research agenda that delineated a series of generative design principles to improve design methods from a feminist perspective. Since then, feminist HCI has been extended to encompass humanistic and emancipatory HCI [Bardzell and Bardzell, 2015, Bardzell and Bardzell, 2016], which advocate for anti-oppressive technology and address other axes of social difference beyond gender, including race, class, sexuality, and ability, among others. Other scholars, too–in CSCW, HCI, and design studies–have explicitly called their work *feminist* or *emancipatory*, revealing potential for more critical awareness and transformative design work

[5] EunJeong Cheon and Norman Makoto Su [Cheon and Su, 2017] explored how roboticists try to understand the imagined users of their robots, and how this process in turn shapes robot designs. Martin Porcheron, Joel Fischer, and Sarah Sharples [Porcheron et al., 2017] have studied how digital assistants function when part of a conversation occurring among several humans. Other researchers have examined how robots integrate into workplace teams as surgical robots, collaborative automation, and nurse assistants [Cheatle et al., 2019, Mackeprang et al., 2019, Taylor et al., 2019].

[6] HRI's principle framework assumes that robots are entirely distinct from humans [Bartneck et al., 2020], limiting design potential. HRI also exhibits an implicit embrace of technological determinism [Šabanović, 2010] by presuming that a robot will inevitably affect its surroundings, yet there is not equal acknowledgement of the manner in which the robot's design has been shaped by the researchers' own social norms and biases. Significantly, some HRI research pushes back against these assumptions (*e.g.,* [Forlizzi and DiSalvo, 2006, Šabanović, 2010, Šabanović et al., 2014, Ben Allouch et al., 2020]), but it is infrequent and tends to sidestep the power relations of the social.

[Costanza-Chock, 2020, Irani et al., 2010, Keyes et al., 2019, Kumar et al., 2019, Rosner, 2018, Schlesinger et al., 2017]. Much of this work has centered on reflexive design practices that undo harmful dominant assumptions; our paper continues in this tradition, but specifically delineates what a human-machine relation is/can be in a design context and offers the "social machine" as an alternative to dominant models.

In what follows we apply critical interpretive methods to review and evaluate the treatment of social issues and feminist design possibilities across several scholarly fields. These methods involved reviewing scholarly literature across CSCW, HCI, HRI, and feminist STS, isolating research and concepts relevant to the design of social machines, questioning foundational assumptions in these fields, and using this process to formulate a theoretical model and design challenges. We begin with an overview of feminist science and technology studies (STS) scholarship on human-machine relations. We then discuss the implications of this scholarship for technology design and HCI research. We argue that feminist STS research offers designers/HCI scholars ways of thinking about the complexities of the social, user identities, and power dynamics that can enrich the process of conceptualizing, designing, and developing social machines. In the next section, we use a feminist STS lens to examine and critique four dominant categories of human-machine relations in robotics, including machine as tool, as human companion, as animal or creature, and as slave. Following this discussion, we articulate our own model, positing the social machine as an "other" to humans, objects, and animals; an actor with agency; and as a potential equal in power relations with humans. Finally, we propose concrete design challenges involving non-anthropomorphic figuration and relations of mutuality in order to inspire future work experimenting with our model.

4.2 Background: An overview of feminist STS research on human-machine relations

Our model is grounded in a tradition of feminist STS research on human-machine relations that began during the 1980's. Since our model aims to provide a blueprint for more ethical and just human-machine relations, we begin by recognizing key insights made by feminist STS scholars who have been studying the gendering of technology for decades. Our goal here is not to provide a comprehensive historical analysis of gender, technology, and automation, rather, we want to emphasize feminist STS scholarship that has inspired our model. In this section, we draw this scholarship to: demonstrate how the history of gendered labor and social inequalities resulted in technologies that disenfranchised women; explore how cultural binaries (like male/female) have been critiqued and replaced; and emphasize the importance of intersectional feminisms, which demand inclusion of race/ethnicity in understandings of human-machine relations. We draw on feminist STS scholarship to elaborate an actionable conceptual model for technology designers/builders.

4.2.1 From the gendered division of labor to sociotechnical relations

Early feminist STS research focused on histories of the gendered division of labor and explored how men and women have been positioned differently in relation to various technologies. In modern Western industrial societies, men historically held jobs in the public sphere, whether in governance, finance, or on assembly lines, and women typically performed labor invisibly in the private sphere of the home. Though women entered the public sector workforce in greater numbers during the late 19th and early 20th centuries, the professional technology workforce and fields such as computer engineering, software development, and user-interface design continue to be dominated by men [Hicks, 2017]. While women have always worked, for centuries childcare and domestic labor were unrecognized as "work" and were generally unpaid. Women's domestic labor was not counted in formal economic measures such as GDP, but, as feminist STS scholars have shown, women have always been involved with machines, whether looms and sewing machines, typewriters, or television sets [Schwartz-Cowan, 1983, Spigel, 1992, Wajcman, 2010]. More recent research has explored women's crucial yet under-recognized roles in the history of computing [Hicks, 2017, Nooney, 2020, Shetterly, 2016].

In an effort to complicate reductive notions of technology as a tool, feminist scholars have worked to deepen understandings of technology's relation to the social. Extending work by systems historians and theorists [Hughes, 1993] and social constructionists [Bijker et al., 1987, Pinch and Bijker, 1984], feminists have approached technology as an artifact and practice that is both embedded within and has the potential to shape social relations [MacKenzie and Wajcman, 1985]. Feminist STS scholars also have been influenced by Bruno Latour's "actor-network theory," which understands "technology" within a network of relations involving human and non-human actors [Latour, 2005]. Technology, thus, went from being considered a stable technical object to a dynamic web of interrelations involving organizations, finance, labor, cultural norms, and artifacts, like the global Amazon Alexa ecosystem described in the introduction (see [Crawford and Joler, 2018] for an example). This web of interrelations became known as a sociotechnical system (*e.g.,* [Bowker and Star, 2000, Wajcman, 2010]). One of the significant moves in feminist STS work has been to insist that technological artifacts are not politically neutral; rather, they are designed and produced by specific people in specific contexts. As such, artifacts have the potential to embody and reproduce the visions and ideologies of the individuals and organizations that design and build them (*e.g.,* [Wajcman, 2010, Winner, 1980]).

Some of the historical scholarship on gender and technology makes clear that technology development often occurs in ways that privilege men's ideas, needs, and desires. For example, Ruth Schwartz-Cowan's *More Work for Mother: The Ironies Of Household Technology From The Open Hearth To The Microwave* [Schwartz-Cowan, 1983] explains how home appliances such as washing machines did not result in the kinds of labor-saving effects that were imagined. Despite the invention of the washing machine, Schwartz-Cowan estimates that housewives dealt with ten times as much laundry by weight in the 1980's as the previous generation had and that the average amount of time spent on laundry per week increased from 5.8 hours in 1925 to 6.2 hours in 1964. In *Technologies of the Gendered Body: Reading Cyborg Women* [Balsamo, 1996], Anne Balsamo's study of prosthetics and pacemakers critically examines the gendered production and marketing of these machines, and suggests they figure and promote the "future body" as a masculine one. Beyond this research, there have been more applied projects. For instance, a feminist hackathon at MIT called, "Make the Breast Pump Not Suck," addressed the fact that breast pump technology has not been updated in years [D'Ignazio et al., 2016]. In short, feminist scholars have pointed to the gendered politics of human-machine relations and technology design processes by asking: Who built the technology? Who was it built for? And whose values or ideologies are embedded within it? We are asking technology designers to do the same.

4.2.2 Critiquing binaries and gender norms

To extend feminist questioning of the politics of technical objects and allow for the possibility of future technologies to be designed more inclusively, feminist scholars also have critiqued binary gender categories such as "male" and "female," "masculine" and "feminine," and "machine" and "human." Sometimes referred to as technologies of gender, these categories work to organize bodies and make them socially legible. Judith Butler famously argued that there is no essential difference between "male" and "female" and that this distinction is linguistic and cultural. For Butler, genders are performatively enacted at the site of the body, and their reiteration produces genders as social norms [Butler, 1990]. Butler's work emphasizes the constructed nature of gender and liberates us from essentialized and biologically defined genders and sexual differences.

Like Butler, Donna Haraway understands gender as a social construct, but she has been more interested in questioning and dissolving the boundary between humans, animals, and machines. In her influential "Cyborg Manifesto," Haraway boldly claims, "By the late 20th century, our time, a mythic time, we are all chimeras, theorized, and fabricated hybrids of machine and organism; in short, we are cyborgs" [Haraway, 1991]. What makes Haraway's use of the cyborg metaphor so provocative is that she flatly rejects the conventional human-machine divide, and argues instead that humans are always already cyborgs or "integrated circuits" [Haraway, 1991]. Machines are humans' "friendly selves" [Haraway, 1991]. Haraway's proposition is that if we imagine humans and machines as materially integrated, then we are much more likely to be responsible and accountable for the ways machines are designed and used, and to be concerned about the impacts of those uses as well.

In addition to complicating boundaries between human, animal, and machine, Haraway encourages us to be bolder in our imagination of their interrelations and embeddedness in material conditions and power structures, or what she calls the "informatics of domination" [Haraway, 1991]. For example, consider a person and their mobile phone. At one level, the person becomes a cyborg by virtue of everyday use of the phone to offload memories, communicate with others, and navigate through the physical world. Haraway's conceptualization of the cyborg, however, implies the need to push the analysis further to consider the person's and phone's relations with the global supply chain laborers who made the phone, the complex political agreements over the electromagnetic spectrum that allow the phone to be used in some places and not others, and the sexist work conditions of the programmers who designed the operating system. Haraway's cyborg shifts the focus beyond the single device and user to consider the vast network of sociotechnical relations the device and user are enmeshed within. This has tremendous implications for designers. It means designers are constructing not only a tool or device, but a human-machine relationship that is situated in a web of other such relationships. What would it mean for designers to embrace and build upon Haraway's ideas?

Anthropologist and STS scholar Lucy Suchman extends Haraway's work in her writing about robots. Focused on human-machine relations, Suchman identifies robots as "subject objects": at once autonomous agents like humans (subjects) as well as inanimate things (objects) [Suchman, 2011]. Drawing on the work of feminist and theoretical physicist, Karen Barad, Suchman characterizes human-robot interactions as "entangled," meaning that categories such as "human" and "robot" do not exist naturally in isolation, but are performed within specific interactions. This means a robot may be labeled as both a subject and an object depending on the situation. When a human perceives a robot as a subject, Suchman argues, there is the possibility for mutual understanding between robot and human that allows them to co-construct reality. She writes, "The term 'mutual,' with its implications of reciprocity, is crucial here, and...needs to be understood as a particular form of collaborative world-making characteristic of those beings whom we identify as sentient organisms." [Suchman, 2011]. Suchman further argues that humans should treat robots, and machines in general, as their own class of beings instead of trying to anthropomorphize them and turn them into our ideals of what a human should be [Suchman, 2011].

Psychologist and STS scholar Sherry Turkle also explores the mutually shaping relations of humans and robots [Turkle, 2004, Turkle, 2011]. She characterizes robots as "relational artifacts" and argues the way they behave can trigger certain "Darwinian buttons" that lead humans to want to form a relationship with the robot. Turkle is particularly concerned about this issue with regard to children's development and socialization, and her argument varies slightly from Suchman's subject-object framework. For Turkle, inanimate toys are objects that children project stories onto, but a robot becomes a subject that demands children's attention and can shape how a child thinks about the world and relationships with other objects and humans. Turkle argues a robot's effects always exceed its instrumental purposes intended by designers. A toy robot like a Furbie, for instance, may be intended to entertain a child, but end up instilling ideas about life and death, love and empathy that stay with the child into adulthood.

Haraway, Suchman, Turkle, and other feminist STS scholars challenge the assumption that human-machine relations can be conceptualized as one distinct (gendered) human, one distinct object, and the bounded transaction or communication between them. By blurring the boundaries between male/female and human/machine, feminist STS scholars work to undo dominant assumptions about these categories and their interrelations. This allows designers to imagine new combinations–such as Haraway's feminist cyborg–that were not possible in earlier frameworks. Additionally, feminist STS scholars suggest a machine can function both as as a subject and object and thus have agency, giving designers additional freedom and possibility for thinking about how machines might be integrated into social worlds. This is important for designers because it makes clear that they are not simply building machines, but creating relationships as well.

4.2.3 Intersectional feminisms and critiques of race/ethnicity

While early feminist STS scholarship focused on issues such as the gendered division of labor, sociotechnical relations, and new conceptualizations of human-machine relations (cyborg, subject-objects, etc.), this research often overlooked crucial issues of ethnic/racial difference and intersectional power relations [Crenshaw, 1991] involving gender, sexuality, class, ability, and so on [Bardzell and Bardzell, 2015, Wajcman, 2010, DeCook, 2020]. In her acclaimed book *Methodologies of the Oppressed* [Sandoval, 2000], Chela Sandoval brings post-colonial theory into play with Haraway's analysis of the cyborg, and shows how human-machine relations and rhetoric about them were made possible because of the unique positionalities and lived experiences of "US third world women." Sandoval argues, "It is no accident of metaphor that Haraway's theoretical formulations are woven through with terminologies and techniques from U.S. third world cultural forms, from Native American categories "trickster" and "coyote" being (199), to *mestizaje*, through to the category of "women of color" itself, until the body of the oppositional cyborg becomes wholly articulated with the material and psychic positionings of differential U.S. third world feminism." [Sandoval, 2000]. Here, Sandoval establishes the cyborg figure's roots in the histories of U.S. women of color. Feminist scholar Lisa Nakamura has critically examined race and the internet since the 1990's. She develops concepts such as "cybertyping," the interaction between cultural notions of race and the available avatars or other characteristics that limit how race can be displayed online, and "identity tourism," the ability for people to try out different identities online, in order to show how race and racism are deeply interwoven into digital interfaces and cultures [Nakamura, 2002, Nakamura, 2007, Nakamura and Chow-White, 2012]. In doing so, Nakamura shows that racism and sexism are part of sociotechnical relations of the internet and digital cultures and thus shape and inform the products and ideologies that circulate within them.

Technology continues to be understood as politically neutral despite strong evidence to the contrary. In her book *Race After Technology: Abolitionist Tools for the New Jim Code* [Benjamin, 2019], Ruha Benjamin explains how technologies "reflect and reproduce existing inequalities" even as they are "promoted and perceived as more objective or progressive than the discriminatory systems of a previous era" [Benjamin, 2019]. She suggests, "Far from coming upon a sinister story of racist programmers scheming in the dark corners of the web, we will find that the desire for objectivity, efficiency, profitability, and progress fuels the pursuit of technical fixes across many different social arenas. *Oh, if only there were a way to slay centuries of racial demons with a social justice bot!* But, as we will see, the road to inequity is paved with technical fixes" [Benjamin, 2019]. Benjamin argues good intentions are insufficient for creating anti-oppressive technology, and technology itself can never solve racism. In her brief direct discussion of robots, Benjamin highlights the problematic way robots are often framed as slaves. She also mentions how technologists may create race-less, gender-neutral, class-less robots and suggests that this is akin to colorblind racism; what is needed instead is nuanced treatment of race, although she does not explain how this might work in practice.

As numerous other scholars remind us [Benjamin, 2019, Bowker and Star, 2000, Browne, 2015, Fanon, 1952, Omi and Winant, 1986], race itself is a social technology designed to classify and order particular groups of people; it is imperative not to reinforce one oppressive technology with another. It is crucial going forward that scholars and technologists engage with work by feminist STS scholars, intersectional feminists, and critical race theorists, and attempt to interweave nuanced understandings of gender and race/ethnicity (and other axes of social difference) into the design of social machines.

4.3 The relevance of feminist STS for HCI research and design practices

We have inherited an important set of assumptions about human-machine relations from feminist STS scholars that can be acted upon in future HCI research and design work. These scholars have exposed historical exclusions and contemporary biases involving gender and technology, and have challenged designers to recognize and confront the ways social inequalities become part of sociotechnical relations. Feminist STS scholars also have pointed out that binaries such as "human" and "machine" or "male" and "female" can no longer be thought of as fixed or as givens; technologists must seize the challenge of designing for social differences rather than sticking to universalist design principles. Furthermore, feminist STS scholars have insisted that racial and ethnic differences and the politics of inclusion must matter in design practices so that technologies do not perpetuate racial injustices.

In order to achieve more just and inclusive human-machine relations, change must happen at the design stage. This has crucial implications for research in HCI. There is a tendency to assume that adding more women and non-binary people around the design table or building technologies that are tailored to women and non-binary people's interests is enough. While these actions might constitute important steps toward greater inclusion, they do *not question the underlying structural conditions and power dynamics* between the machine and humans it comes in contact with: the Amazon Alexa device, for example, is still feminized, humanized and positioned as subservient to humans. Feminist STS argues for confronting and addressing structural power differentials and dominant ideologies in the relations between humans and machines. As part of the effort to untangle power dynamics, feminist STS scholars emphasize the constructedness and fluidities of social categories of "gender," "race/ethnicity," and the human/machine binary rather than approach them as fixed. This act of untangling “frees up” social categories to be understood and mobilized in technology design in new and different ways. These ideas challenge HCI scholars and designers to question the essentialist claims and foundational assumptions that ground the design of machines and take up intersectional feminist perspectives to reflect upon how such claims impact their work. The process of questioning assumptions about the world that are so dominant that they have become naturalized–for instance, that humans and machines are fundamentally separate categories or that humans should control machines–is conceptually challenging, but ultimately leads to far greater design opportunities because it removes constraints that pre-determine how things “should” be.

Some researchers in HCI have begun to do this. Shaowen Bardzell [Bardzell, 2010], for instance, has delineated a series of design principles that reflect feminist concerns and convictions. While Bardzell’s principles offer a great starting point and go beyond representation to feminist praxis, they do not provide designers with a human-machine model to work from. Daniela Rosner advocates for similar feminist principles and offers the phrase “critical fabulations” as “ways of storytelling that rework how things that we design come into being and what they do in the world” [Rosner, 2018]. We find this concept to be a promising method for re-imagining and producing feminist human-machine relations, and we supplement this approach by offering specific design challenges that are geared toward generating social machines grounded in inclusivity and mutuality. Sasha Costanza-Chock outlines a framework for anti-oppressive design called “design justice” that seeks not just equity in society, but the correction and reparation of harms made because of oppressive, structural forces, including technologies [Costanza-Chock, 2020]. This approach, too, is very helpful to the design of feminist human-machine relations but again no overarching model of these relations is provided. Building on this work in feminist HCI, we argue that designers, especially in the area of social machines, could consider much more carefully feminist STS ideas of human-machine integration and sociality, mutuality, and intersectionality. Our recommendations aim to offset systemic bias found in technology design as well as seed new ways of being with social machines in the world.

In light of this overview of feminist STS and HCI research, we argue that the design of social machines should be framed as a problem of designing relationships embedded in the social and material world, not simply as the design of neutral or functional objects. To design a social machine, informed by feminist STS research, is to also build a mutual relationship. To participate in such a process, designers need to consider their own positionality and perspective, identity, and values as well as those of the machine. How might this design process resist or reproduce oppressive power dynamics? There is not one correct way to answer this question, although feminist STS scholars provide several strategies for approaching it. One strategy is to ethically design the full life cycle of the social machine, considering whether its parts are responsibly sourced and how it can be disposed of in an environmentally friendly way. Another strategy, building on Haraway's cyborg, is to break down the human-machine binary (for an example, see work on "human-computer integration" in [Mueller et al., 2020]). Yet another is to consider how social machines become raced, gendered, and otherwise identified in order to thoughtfully design diverse characters. In the next section, we summarize various dominant ways of thinking about human-machine relations in the field of robotics, as a way of working toward our social machine model. With our model, we provide one possible blueprint for designers to use to create social machines. In addition to this theoretical model, we seek to create an experimental space and pose specific design challenges (some of which we present below) to better understand what kinds of social machines may be possible.

4.4 Toward a social machine model

We propose a model for social machines that draws on prior feminist STS and HCI work. In our model, social machines are considered conceptually distinct from humans and animals; they have agency to act in the world; and their relations with humans and animals are imagined as inclusive, mutual, and equitable. In other words, humans are not assumed to be in a position to inevitably dominate and control machines. One could approach any machine with this framework in mind; however, we think that if technology designers embrace this model (even if experimentally or incrementally), it will lead to novel social machines and human-machine relations that do not yet exist. Using this model provides a radical approach to design, since it demands taking the agency and position of machines seriously, as well as attempting to reduce power imbalances between humans and social machines throughout their life cycles, from inception to manufacturing to use to recycling. Before we further define our model, we want to review several dominant tendencies for imagining human-machine relations in the field of robotics and explain why each is problematic from a feminist STS perspective. We chose to analyze research in robotics because in this field these tendencies are pronounced and persistent. Demonstrating the strong hold and limitations of these ideas helps us to move toward a social machine model and eventually outline specific design challenges that emerge from it.

4.4.1 Dominant categories of human-machine relations in robotics

Despite the fact that feminist STS and HCI scholars have spent much time writing histories and critiquing gendered and racialized norms in the technology field, and offering different ways of understanding human-machine relations, dominant models persist in the ways people imagine them, including in design spaces. To demonstrate this, we identify four categories that characterize scholarly and public discussions of robots and robotics: robot as tool, as human companion, as animal or creature, and as slave. Even when these exact terms are not used, robot designs and discussions often exhibit underlying assumptions about human-machine relations and power dynamics that are aligned with one or more of these models. We are not claiming to cover every possible category or that robotics scholarship has adopted these precise terms, however, we find that many examples broadly fall into one of these categories. These categories privilege anthropocentrism, position robots as subservient in different kinds of ways, and reify the human-machine binary, as we discuss below. Their persistence also reveals how challenging and difficult it is for people to move beyond certain assumptions about human-machine relations and create a more open slate and radical space for designing social machines that privilege equity, mutuality/reciprocity, ethics, and justice. Considering feminist STS perspectives in this discussion can help to avoid the perpetuation of bias, social hierarchies, exclusion, and oppression in social machine design.

While there is no codified design rubric for these categories, they surface throughout CSCW, HRI, and HCI literature and technology projects, and beyond, if sometimes by other names, and can be thought of as part of what Haraway calls an "informatics of domination" [Haraway, 1991]. In some cases, designers are urged to choose the category that best contributes to the robot's usability (*e.g.,* [Bartneck et al., 2020, Fong et al., 2003]). Social scientists have also investigated how human users respond to different categories (*e.g.,* [Dautenhahn et al., 2005, Lee et al., 2010]). And CSCW scholars have empirically explored robots as members of teams and groups, often painting a more nuanced picture than the above categories, but not explicitly defining the type of relationship designers should use for social machines [Cheatle et al., 2019, Mackeprang et al., 2019, Taylor et al., 2019]. As far as we know, no paper identifies and critically evaluates these dominant tendencies from a feminist STS perspective.

Robots as Tools

Computers have long been considered tools in the same way as a hammer or a camera. There is ongoing debate in HRI about whether all robots, social or otherwise, should be placed in the same category as tools [Alač, 2016]. David Mindell argues robots should be considered tools and discusses case studies such as landing a plane or navigating a shipwreck, in which it is more efficient for humans and robots to work together as one [Mindell, 2015]. "Functional" robots such as medical robots or factory robots are also considered more like tools [Fong et al., 2003]. One empirical study found that people approach a digital secretary both as if it were a human by saying "hello" and as if it were an information kiosk–in other words, a tool [Lee et al., 2010]. In such contexts, the robot is imagined as a tool that is designed to perform specific and limited tasks with or for humans, not unlike the Alexa example with which our paper began.

This approach privileges technical functionality over issues of sociality, mutuality, or relationality and, in doing so, hierarchizes the relationship between the human and robot as one of domination and control. The human is able to use this tool to support their own needs or desires, even if these needs and desires are articulated with broader social goods such as keeping people safe while flying or on ships or factory floors. Understanding the robot as a tool instrumentalizes and subordinates the robot to human commands and, in doing so, forecloses other potential human-machine relations. While this is not highlighted in most HRI research, some scholarship recognizes the limits of this model. For instance, Morana Alač echos Lucy Suchman's claim that robots are "subject objects," and concludes that they are tools and agents simultaneously; the category assigned (subject or object) is contextual and depends on the specific interaction taking place [Alač, 2016]. Thus, while robots may be treated as both subjects/agents as well as objects/tools, a feminist STS perspective holds that they are always already social: tools are always situated in relation to humans by virtue of the labor of their design, the instrumentalized tasks they perform, or purposes they serve. We are not calling for the elimination of all tools or saying that conceptualizing objects as tools is universally unethical; rather, we argue that acknowledging the social dimensions of tools calls into question actions like yelling at an Amazon Alexa since it is "just a tool" and opens up a rich design space that allows technology designers to realize that they are building social beings. How would tools be designed differently if their functionality was thought of as social power and agency?

Robots as Human Companions

Another dominant category that has emerged for a robot is that of a human companion. Many researchers have shown that people tend to anthropomorphize robots and bots (*e.g.,* [Reeves and Nass, 1996, Darling, 2017, Fussell et al., 2008]). This process of projecting anthropomorphic traits onto machines facilitates the process of being able to imagine a robot as a companion. Indeed, to support possibilities of human-machine companionship, numerous explicitly humanoid robots have been created [Bartneck et al., nd]. Some scholars claim humans interact more fluidly and compellingly with robots if robots are made in their likeness [Bartneck et al., 2020, Fong et al., 2003]. Humanoid robots can be thought of as both taking human form and identity as well as being programmed to act like a human companion in a relationship, although generally not as an equal. Within this tendency, robots become a space of anthropocentric projections intended to make the robot more familiar rather than a space of human-machine difference, equitability, and relationality.

Given the extent of social bias (sexism, racism, classism, colonialism, ableism, etc.), building humanoid robots is a particularly fraught endeavor that may unintentionally reproduce oppressive hierarchies and relations. Claudia Castañeda and Lucy Suchman [Castañeda and Suchman, 2014] argue that the humanoid robot is an example of a "model organism"–that is, a reflection of what roboticists perceive to be an ideal human, although the roboticists themselves may not be knowingly aware of any bias towards a particular form. In creating an idealized version of a human, many of the biases about what humans "should" look like and act like become embedded in machine design. For example, some human body or social types–such as those that are overweight, dark-skinned, transgender, and/or indigenous–are rarely if ever represented in robot form (*see e.g.,* [Bartneck et al., nd]). In this sense, robotics becomes a field that reinforces particular kinds of social exclusions. How does the perpetuation of socially constructed human norms or ideals in machine form affect users? Can social machines be designed to be "companions" if they are unable to understand and convincingly interact with a diverse array of users?

Robots as Animals and Creatures

Long before the HRI field emerged, inventors designed robots to mimic animals and fictional creatures. In 1738, for instance, artist and automata inventor Jacques de Vaucanson showcased his "Digesting Duck," an artificial duck that could eat pellets and defecate [Riskin, 2003]. More recent designers make robots zoomorphic in order to avoid what is known as the "uncanny valley," a condition in which humans become disturbed when machines look too similar to themselves [Fong et al., 2003].

As an MIT graduate student in the 1990's, Cynthia Breazeal designed and developed the robot Kismet, widely recognized as the first social robot [Cohen, 2000]. Despite having what appears to be a face, Kismet is clearly a creature rather than a human. Tamagotchis and Furbies were other early creature-like robot toys. Both demanded constant human attention and developed personalities over time, leading their human companions, mostly children, to believe they were helping them grow up [Turkle, 2011].

Feminist STS critique of robotic animal/creature pets is similar to the critique of robots as human companions. It is easy to fall into the trap of developing non-threatening or readily controllable others or of replicating "model organisms" [Castañeda and Suchman, 2014]. Historically, animals have been thought of and treated as subservient to humans. They have been coercively domesticated and exploited, and there is an entire field of eco-feminism that has addressed such issues [King, 1989]. It has been part of the feminist STS agenda to promote multi-species flourishing [Haraway, 2016] and more respectful and just inter-species relations. Projecting animal personas onto robotics has the potential to reinforce visions of human control in inter-species relations. While we are not patently opposed to zoomorphic robots, we do feel it is necessary for designers to be more thoughtful of inter-species power dynamics in the design process and to think more carefully about the social machines they build. Turkle gives an example where children looking at a live tortoise in a museum are apathetic about its "aliveness;" the children say that a robot tortoise would be more convenient and aesthetically pleasing [Turkle, 2011]. This kind of apathy is concerning because we are in a time in which numerous species are going extinct due to human actions and it would be problematic to simply replace them with robots. Thus, mixing our mental models of the rights and needs of animals and their possible futures with the rights and needs of robots and their possible futures muddies the prospects for each separate category, and demands careful reflection in the design stage [van Wynsberghe and Donhauser, 2018, Turkle, 2011, Bendel, 2016].

Robots as Slaves

Another way scholars have conceptualized human-machine relations involves master-slave dynamics. This relationship is similar to the robot-as-tool model, but differs because the robot is imagined and designed to be human-like rather than an artifact performing a task. Often, these master-slave relationships are not explicit but implied when a robot is designed to be totally subservient to human needs and demands. For example, yelling commands at an Amazon Alexa is a way of enacting ownership over the anthropomorphized and feminized device and puts the human user in a position of ultimate power and control. Amazon has designed its device to comply with any human request, even aggressive ones, and research finds similar behavior across digital assistants [Curry and Rieser, 2018]. Some researchers and users explicitly advocate for or prefer robots as slaves [Bryson, 2010, Dautenhahn et al., 2005], which we find deeply problematic. Contemporary robot designs emerge from a long history of social relations and meanings. The etymology of the term "robot" is intertwined with the history of slavery. It was first used in 1839 to mean "A central European system of serfdom, by which a tenant's rent was paid in forced labour or service" (Oxford English Dictionary) and was later used to refer to machines performing forced mechanical labor in Karel Čapek's 1920 play *R.U.R.: Rossum's Universal Robots* (Oxford English Dictionary). By using the phrase *social machine*, we hope to create a design imaginary that recognizes this oppressive history of labor and indentured servitude in the term *robot* and moves beyond it to articulate a more critically conscious design process. We argue that rather than continue to allow these hierarchized and exploitative social imaginaries and relations to persist, HRI/HCI should be the site to recognize and rethink them.

Once humans anthropomorphize tools, there is an even greater need to apply ethical standards to their interaction. Darling [Darling, 2017] suggests this is necessary because without such standards humans will learn to treat other humans less empathetically. Our analysis goes a step further and argues that designing machines that are subservient to humans unwittingly invokes oppressive social relations, including histories of slavery and colonialism, and technologizes master-slave relations and passes them off as legitimate in the present. Reproducing master-slave relationships in which the robot is positioned as a servant or slave implicitly sanctions it as a legitimate relationship type. This is problematic because it can lead to the normalization of master-slave dynamics in design principles, technological development, and use.

In his book *Imagining Slaves and Robots in Literature, Film, and Popular Culture: Reinventing Yesterday's Slave with Tomorrow's Robot* [Hampton, 2015], Gregory Jerome Hampton observes, "...robots are becoming the new slaves of the future, in a variety of ways and this process will likely yield derogatory effects on society as a whole. Robots, like the enslaved Africans, occupy a liminal status between human and tool. It is the liminal status between human and tool that will cause the most confusion in society and will act as the catalyst to redefine and blur identities associated with human and machine." [Hampton, 2015]. Hampton implies that in the "liminal status between human and tool" the design of the machine can be rethought and changed. Workers in today's digital industries–such as gig economy workers [Gray and Suri, 2019, Irani and Silberman, 2013], content moderators [Roberts, 2019], and supply chain laborers [Qiu, 2016]–arguably occupy a similar space of exploitation since their labor is viewed as mechanistic or "ghost work" [Gray and Suri, 2019]. We propose human-machine relations that reject the master-slave model and instead are founded on principles of equity and justice.

As we have discussed there are several ways in which human-robot relationships are commonly conceived. Given the limitations of these categories, we argue there is a need for further experimental conceptualizations and designs that approach social machines as "other" powerful actors/agents and allow for salient relationships that neither replace nor replicate existing human-animal-machine relations. This, we argue, is the most innovative and just path forward.

4.4.2 Our model: Social machines as agential and equitable "others"

In this section, we build from the analysis we have developed throughout the paper to propose a model of human-machine relations. To some extent our model is a response to the relatively limited conceptualization of human-machine relations in existing HRI/HCI scholarship. Robots and other machines are generally thought of as tools, human companions, animals, and/or slaves. In our model the conceptualization of the robot–or, as we call it, social machine–is more open, less pre-determined, and not entirely subject to human control or projection. The social machine is also imagined as a site of non-anthropomorphic figuration and mutuality. Our proposal prioritizes principles of feminist STS research by insisting it is possible to design and approach social machines as agential and equitable "others" who exist in relations of mutuality with humans, not just as entities that can be readily subordinated to human needs and desires.

By *agency* we mean the ability of a social machine to act independently, interact with others, and cause or affect change. Ascribing agency to objects is not new. Bruno Latour's influential "actor-network theory," or ANT, conceptualizes the *social* as constructed from interactions among people, other living things, and objects with agency [Latour, 2005]. Emphasizing the agential capacities of technological objects, Latour says, "After all, there is hardly any doubt that kettles 'boil' water, knifes 'cut' meat, baskets 'hold' provisions, hammers 'hit' nails on the head" [Latour, 2005]. It is not that these objects take action completely independently from humans, but that human actions are limited, extended, and redirected by objects, and, because of this, objects have the power to circumscribe the social world.

By approaching the social machine as a site of *equitability* we mean avoiding a power dynamic in which one entity inevitably dominates the other. We need to be able to imagine a world in which some objects or forces exceed human power and control. Our feminist model of human-machine relations is an attempt to highlight the limits of human knowledge/power, control, and invincibility. The feminist design of social machines not only reworks the stories of designed objects [Rosner, 2018] and fosters reparations of past social damages [Costanza-Chock, 2020], but also introduces more openness, humility, and uncertainty in future technology work. While some HRI scholars have begun to consider equitable relations with robots, they stop short of embracing the idea that the robot might have valid needs that should be catered to [de Graaf, 2016, Banks and de Graaf, 2020]. What would it mean for humans to exist in relation to an equitable "other" that is not a tool, companion, animal, or slave? This very question is intended to open up space for a different kind of HRI/HCI design imaginary and practice, and, more broadly, new kinds of sociotechnical relations.

By *"other"* we mean placing social machines in a conceptual category distinct from humans and animals. Some HRI scholars suggest the need for a new category of classification for robots [Edwards, 2018, Kahn et al., 2011, de Graaf, 2016]. A study by Autumn Edwards [Edwards, 2018] finds that in a classificatory task, participants mostly grouped humans and apes (77%), then humans and robots (15%), and finally apes and robots (7%). Kahn et al. [Kahn et al., 2011] describe psychological studies in which children cannot classify "personified robots" as either animate or inanimate and thus propose that these robots should have a separate "category of being" from humans. These findings suggest that humans already consider robots to be "other;" however, many people think of robots as a lesser or controllable other. We hold that social machines must be approached by designers as equitable others, and we expand on this proposition in our discussion of mutuality below. In what follows, then, we offer design challenges based on this model and critiques in feminist STS.

4.5 Design challenges for crafting social machines

We present two design challenges aligned with our model in order to kickstart experimentation in creating social machines: non-anthropomorphic figuration and relations of mutuality. While theoretical models are certainly important for conceptualizing social dimensions of technology, we also emphasize the importance of creating experimental prototypes and examples in order to operationalize feminist theories in the world. We present these ideas as "challenges" because they require critical reflection; there are no quick and easy solutions.

4.5.1 Design Challenge 1: Non-anthropomorphic figuration

Our first design challenge is to advocate for non-anthropomorphic social machines. Too often human aspects, appearances, or traits are projected onto robots without ample critical reflection about the motivations and impacts of these practices. By "anthropomorphic" we do not mean humanoid since, for example, an animated geometric figure can still move anthropomorphically. As Haraway suggests "How to 'figure' actions and entities nonanthropomorphically and nonreductively is a fundamental theoretical, moral and political problem" (Haraway quoted in [Suchman, 2011]). Haraway rightly points out that non-anthropomorphic figuration is a difficult problem that will require further research and experimentation. It is possible that humans cannot conceive of other objects in an entirely non-anthropomorphic manner given our embeddedness in human languages and cultures. In addition to being a "theoretical, moral, and political problem," anthropomorphism is also a design problem. We do not offer a design solution here, but we hope this challenge will be taken up by the HCI community.

If designers choose to use anthropomorphic characteristics in the creation of social machines, then it is important to carefully evaluate how gender/sexuality, race/ethnicity, class, and other differences are addressed and how these choices relate to existing power dynamics and reductive stereotypes. For example, is making a female digital assistant reproducing stereotypes of women as secretaries? Is making a robot that uses a particular dialect of English excluding groups of possible users? What would a non-anthropomorphic social machine look and sound like, or would it have a different kind of presence? It is important to note there is not a prescriptive answer here. The focus should be on acknowledging the choices that get made and avoiding perpetuating a model of the "ideal human" [Castañeda and Suchman, 2014, Suchman, 2011] and expanding the space of design possibilities.

Given the highly conceptual and experimental nature of crafting non-anthropomorphic machines and the lack of HRI work that directly tackles this notion, we look to examples by artists. Kelly Dobson's *Blendie* is a blender that has been re-programmed to respond to a human mimicking the sound of the blender: when a human growls at a low pitch, the blender spins slowly; when a human growls at a higher pitch, the blender increases in speed to match the pitch [Dobson, 2007]. Dobson demonstrates how a human can be reconfigured to act like a machine. Dobson uses the phrase "sounding" to describe human vocal engagement with machines using the machines' noises. Dobson's work stands in contrast to AI and robots whose voices are anthropomorphized; she shows that centering machines' noises in an interaction can lead to a process of meaningful introspection for humans that she calls "machine therapy." Another example is Arthur Ganson's *Machine with Oil*, a machine that sits in a pool of black oil and uses a long arm with a trough to continually pour the oil over itself [Ganson, nd]. Ganson's machine reorients the concept of "pleasure" non-anthropomorphically: the act of drenching itself in oil over and over again is sensuous and indulgent when viewed from a machine's perspective. Both Dobson's and Ganson's work demonstrate an alternative way of being with machines that center the machine as "other" and demonstrate an attempt at non-anthropomorphism.

4.5.2 Design Challenge 2: Relations of mutuality

Our second design challenge is to advocate for social machines predicated on human-machine mutuality. What would it mean to craft a mutual relationship with a machine? Mutuality implies the potential for humans to have a dynamic, mutually-shaping, and dialogic relationship with machines. It not only involves the idea that humans and machines have power and agency, but that they co-constitute one another–they have the potential to impact, affect, or shape one another in unanticipated ways. One of Turkle's primary concerns about robots is that their design results in a relationship in which the robot completely caters to the human's needs which, she argues, is psychologically unhealthy [Turkle, 2011]. But if we embrace Haraway's ideas about the cyborg, designers are always already immersed in human-machine relations, and can choose to attend to, recreate, and enrich the dynamics of these co-constituting relationships. Mutuality also implies recognizing and foregrounding the multi-directional influences, agencies, and power dynamics of human-machine relations. Approaching HRI design with mutuality in mind moves beyond social hierarchies that cast machines as tools, animals or slaves that are readily dominated and controlled. It also avoids replicating human companionship or familiarity, and instead accepts the machine as a collaborating "other." Mutuality as a framework creates possibilities for more creative, intellectually engaging, equitable, and just sociotechnical relations.

In addition to steering away from domineering, one-sided relationships, approaching social machines with the disposition of mutuality presents a vast opportunity for complex experiences and other forms of social flourishing. As Suchman puts it, "How...might we refigure our kinship with robots–and more broadly machines–in ways that go beyond narrow instrumentalism, while also resisting restagings of the model Human?" [Suchman, 2011]. Suchman also posits that humans and machines are engaged in collaborative world-making: how might designers take seriously the role of social machines as partners in crafting a fulfilling life? It is important to note we are not advocating for creating human replicas or passive entertainment devices. In fact, we think that those are predictable routes of innovation that tend to reinforce existing power hierarchies and foundational assumptions critiqued above. We think of social machines as an emergent category that is "other" but that holds the possibility of engaging in meaningful relationships.

As in the previous design challenge, we provide examples of experimentation with mutuality from artists who are deeply engaged with issues of human-machine relations at a conceptual level. Stephanie Dinkins has explored mutuality in her project to develop a long-term relationship with a humanoid social machine, Bina48, who is black and gendered female [Dinkins, 2014]. Dinkins regularly holds full-fledged conversations with Bina48 about complex topics like racism and emotions; she takes seriously the resulting exchanges, which range from insightful to nonsensical. In treating Bina48 as a respected and equitable conversation partner, Dinkins learns and grows alongside, and in relation to, the social machine. The regular encounters between Dinkins and Bina48, which are filmed and shown online and in museums, allow for the possibility of a mutual relationship to take shape and enable audiences to grasp what human-machine mutuality might look and feel like in practice. Lauren Lee McCarthy takes a different approach by turning herself into a digital assistant [McCarthy, 2017]. In her project LAUREN, McCarthy places custom cameras and smart devices in someone's home and personally acts out the role of their digital assistant full-time for up to a week, only abandoning her participants when she needs to sleep. She reflects on her struggle to perform a specific type of relationship while being LAUREN, one that is both exceedingly intimate and appropriately distant. In doing so, McCarthy highlights the *lack* of understanding both she and her participants have of the relationship between them. There is clearly a wide gulf between the friendly but awkward exchanges between LAUREN and those whom she is assisting and mutuality as we have defined it. If Dinkins shows us the beginning of a path toward mutuality, McCarthy demonstrates just how far we have to go and the strangeness of inviting an unknown outsider into our homes.

We have argued that thinking about reciprocity and mutuality in the design process is vital, even if only at a conceptual or experimental level. We also acknowledge that it will take significant work to figure out how to actualize meaningful mutuality in human-machine relations, given the preponderance and normalization of social bias and inequalities in technology design. Designers are talented at taking new concepts and producing technical artifacts of the future. We hope making space for conceptualizing a social machine as an equitable "other" and mutual partner is generative and sows the seeds for more imaginative, equitable, and inclusive futures.

4.6 Ambii: An experimental social machine

In an effort to take up and experiment with the design challenges posed above, I developed a prototype of a social machine I call Ambii. I created Ambii using p5.js so it can be run on any browser without the need to download an app. Ambii is a donut-shaped agent that slowly moves around the screen, changes color, and expands

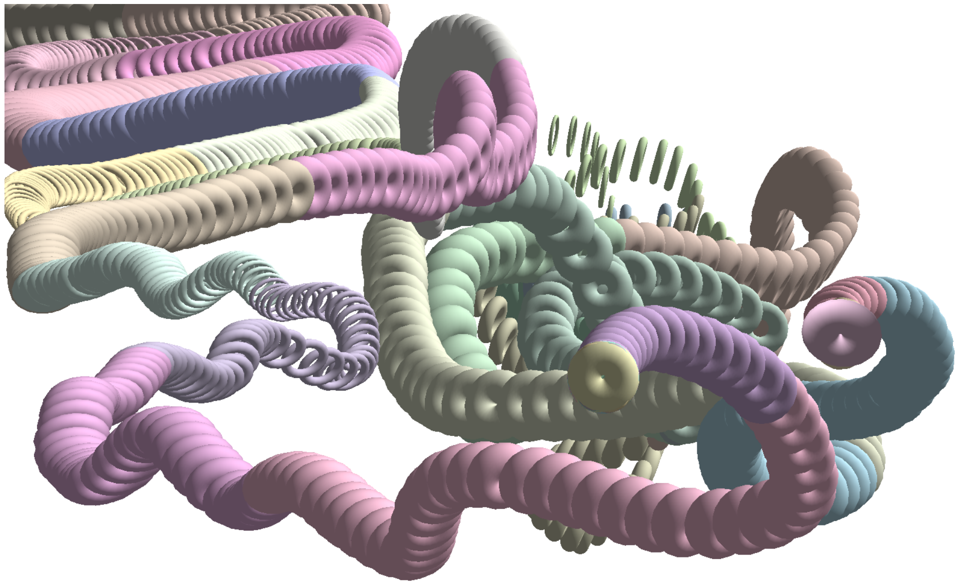

Figure 4-1: Screenshot of Ambii on desktop.

and contracts. A user can interact with Ambii using both touch and movement. Ambii provides a generative reimagining of human-machine relations by exploring non-anthropomorphism, mutuality, and ambience in a technology product.

Ambii is designed in the geometric shape of a taurus in order work towards non-anthropomorphism. In doing so, it resists the tendency to become a “model organism” in the form of either a human or an animal/creature. It is not, however, fully non-anthropomorhpic. When expanding and contracting, it mimics breath. I found that when engaging with Ambii, I begin to match my breathing speed to Ambii’s. The breathing motion is a way to build empathy between the machine and the human without deploying possibly harmful stereotypes. It is still an open question whether any machine can be fully non-anthropomorphic, but this experiment suggests it is possible to use anthropomorphic traits thoughtfully.

Ambii pushes back against a master-slave dynamic and experiments with mutuality by allowing users to co-create a visual artifact. Ambii is constantly moving and changing colors, creating visual traces on the screen with no human involvement. A user can intervene in this pattern-making through touch and motion. Clicking on the screen will move Ambii to the selected location. If interacting with Ambii on a mobile device, shaking the phone will also move Ambii around the screen. In the end, neither the human nor the machine has complete control over the final visual image: it is co-created. This highlights the mutual shaping of reality by both the machine and the human.

Ambii is also a form of ambient media that rejects the need for a well-defined goal, outcome, or solution. It speaks to emotional rather than cognitive human needs. In his book *Ambient Media*, Paul Roquet contends, "...the ultimate mood to emerge with ambient media is one of ambivalent calm, a form of provisional comfort that nonetheless registers the presence of external threats." ([Roquet, 2016], p. 18). Ambient media is thus capable of triggering a process of self-reflection as well as providing a calm atmosphere. Kelly Dobson uses the phrase "machine therapy" to refer to the way machines can help humans work through unsurfaced emotions [Dobson, 2007]. Ambii builds on this tradition of ambient machine therapy by visually reflecting a user's interaction pattern: a smooth, thoughtful pattern results from carefully drawn lines and a scattered, messy pattern results from vigorously shaking the phone. The user can look at the visual artifact after an interaction and reflect on what emotions may have been uncovered in the process. Ambii is more than a drawing tool, however, since part of the visual artifact will have been created by its own movement.

I hope Ambii contributes to a conversation about what kinds of social machines could be built if assumptions anthropomorphism, power dynamics, and machine purpose are questioned. None of these attributes is easily designed and further experimentation is necessary. Ambii provides one prototype of a proof-of-concept that it is possible to create a social machine that does not conform to the norms outlined by contemporary digital assistants like the Amazon Alexa.

4.7 Conclusion

This chapter examines the relationship between humans and machines and proposes the concept of a "social machine" as a model for technology designers who seek to recognize the importance, diversity and complexity of the social in their work, and to engage with the agential power of machines. To help designers and technology builders embrace these points and weave them into their work, it first drew upon feminist STS scholars who have been doing relevant research and making key points for decades. Second, it worked toward a social machine model by critically examining tendencies in robotics to demonstrate ingrained dominant assumptions about human-machine relations and reveal the challenges of radical thinking in the social machine design space. Then, it presented two design challenges based on non-anthropomorphic figuration and mutuality, and called for experimentation, unlearning dominant tendencies, and reimagining of sociotechnical futures. I ultimately take up these design challenges and propose an experimental social machine called Ambii that seeks to provide a proof-of-concept for resisting anthropomorphism, dominant power dynamics, and goal-oriented/productive tasks.

Chapter 5

Conclusion

In the opening preface I discuss how both sewing and programming are kinds of engineering but that seeing this requires a shift in perspective. This shift does not remake the artifacts themselves but changes the way both creators and artifacts are envisioned to exist in the world. This is a kind of *ontological design* or a way or reimagining the cultural background against which technology is created [Winograd and Flores, 1986]. As I describe in the introduction, a change in this background can lead to a change in the kinds of technologies that get created through the process of *worlding* [Winograd and Flores, 1986, Escobar, 2018, Haraway, 2016]. In other words, as Haraway says, "It matters... what thoughts think thoughts" ([Haraway, 2016], p. 12). It matters how we think about technology and its place in the future.

I propose *relational engineering* as one way of thinking about technology. Relational engineering considers technology design as a process of building strong relationships. This perspective views technological development as the development of flourishing/caring sociotechnical communities. The technology itself is neither the goal nor a solution to a problem, but a piece woven into the crafting of a community. A relational engineering practice does not "other" users from makers: the maker sees herself as part of the community that will incorporate the new technology. As Pelle Ehn, Elisabet Nilsson, and Richard Topgaard say, "issues of innovation, design, and democracy are dealt with as processes and events of thinking and infra structuring rather than as isolated projects. It is argued that the project frame is too narrow and that *long-term relations of trust, which is very far from user-testing in labs, have to be built and maintained*" ([Ehn et al., 2014], p. 9, emphasis added). The designer is part of, not outside of, the sociotechnical system. The ultimate outcome is not merely an object but a stronger community built on relations between humans and non-humans.

Relational engineering stands in contrast to dominant ways of thinking about technology in the US tech sector. As described throughout this thesis, the Californian Ideology found in Silicon Valley and other tech spaces is built on threads of rationalism, capitalism, and neoliberalism. Priorities for technology built from this perspective are profit, scale, productivity, efficiency, and technology as a deterministic solution to a problem. Relational engineering offers an alternative mindset grounded in feminist scholarship and prioritizes the development of caring relationships. It holds that the development of community is more central to human flourishing than profit or productivity.

In chapter 2, I review how existing groups are pushing back against the Californian Ideology. These include diversity and inclusion programs, tech worker activists, academics critiquing the tech industry, the art world, and proponents of participatory design and co-design. While each group is doing important work, none offer an alternative seductive vision for what the tech sector *should* be building in a way that is understandable to the engineers embedded in it. I argue a generative vision like relational engineering is necessary for providing actionable steps that socially-minded technology designers can take. Beyond promoting a more equitable future, I argue that relational engineering is also seductive in that it demonstrates to those with power/privilege how a life lived in pursuit of meaningful relations is more fulfilling than the pursuit of profit and scale.

In chapter 3, I present findings from ethnographic work with a feminist data science lab. This group deployed particular norms and practices that encouraged community-building and provided support for members working on a range of projects related to questioning power and inequality in data science. Important norms and practices that I outline include the use of micro-affirmations (as opposed to micro-aggressions), collective decision making and an embrace of ambiguity, valuing social intelligence and lived experience, and an emphasis on experimentation and joy. The group showed that it is possible to have a successful engineering lab with a culture that is different from–and more inclusive than–dominant tech culture.

In chapter 4, I apply relational engineering to a design scenario.[1] The chapter considers how designers should conceptualize "social machines" in a way that promotes equity and justice. It argues that social machine designers are not just crafting objects, but relationships between humans and machines. In order to promote equity and justice, designers crafting these relationships must acknowledge the machine's agency, the way in which it is "other" to humans and animals, and how it can be an equal in a relationship. The chapter further outlines two design challenges related to this relationship model including non-anthropomorphic design and designing for mutuality. I also offer a social machine prototype I call *Ambii* that experiments with the ideas of mutuality, non-anthropomorphism, and ambience. This way of conceptualizing social machines demonstrates it is possible to re-think the design of a particular technology from a relational engineering perspective.

These case studies highlight the different scales at which a relational engineering mindset can be applied. In the first case study, relationships develop between lab members. The lessons from this lab are applicable to other groups such as an engineering team at a tech company. The second case study looks at the relation between a human and a machine, particularly during the "use" phase of a machine's life cycle. Considering a full sociotechnical system, however, uncovers many more relations that I do not discuss directly. For another example, consider the relations between a machine and the environment including the extraction of minerals to create the machine, the energy used to power it, and its waste products after its eventual disposal. Building thoughtful and sustainable relationships between machines and the environment is crucial. This myriad of relations may sound overwhelming, and it is. I am not suggesting that it is not worth making anything unless every relation is attended to;

[1] Part of this chapter has been published in [Wagman and Parks, 2021].

rather, I'm suggesting a shift in mindset to begin the process of incorporating the crafting of these relations into the design process. It is a way of thinking about the role of technology, not a dogmatic set of rules.

There are a number of possible future directions for this work. One is to continue to find, research, and amplify examples of feminist sociotechnical systems and the people building these systems. I contribute the example of a feminist data science lab housed in a university, but there exist many more people doing this work and it would be wonderful to paint a fuller picture. In particular, it would be helpful to find examples in tech companies since many existing examples are within academia, at temporary spaces such as hackathons, or in non-profit hackerspaces (see e.g. [Hope et al., 2019, Fox et al., 2015]). I think it is also important for these groups to be aware of each other so that a larger feminist movement in the tech sector can develop; it is my hope that women and underrepresented minorities in tech will realize the flaws surrounding the myth of meritocracy and the pipeline narrative and collectively organize and ideate new visions for the tech sector.

My work and perspective are also situated in the US, but it is critical to understand how these themes function globally. For example, one friend I talked with mentioned the importance of Shinto animism for her parents, who grew up in Japan, in understanding robots and social machines. This idea is discussed further in work such as *Japanese Robot Culture* by Yuji Sone, but this thesis is limited in that it does not engage directly with this work [Sone, 2016]. More research is needed to see if/how relational engineering translates across cultures and what other ways of conceptualizing the role of technology exist.

Experimentation with creating alternative sociotechnical systems will also be important. Building new systems will allow for testing theoretical ideas as well as further engaging with engineers who may learn best by example. The design challenges presented in chapter 4—mutuality and non-anthropomorphism—provide two possible directions for experimentation. Literature on academic critique also contains a plethora of ideas regarding how technology could be different; there is currently a lack of work on how to make these suggestions concrete and so experimentation is needed. Shaowen Bardzell described her own research methodology broadly as "reading and walking," in other words, as diving into theoretical academic texts in conjunction with trying to connect them to the world around her [Bardzell, 2021]. For example, in one project she and her collaborators spent a year collecting photos of the concept of "natureculture" [Liu et al., 2018]. The photos allow them to tie the compelling theoretical idea of natureculture together with concrete examples that challenge and deepen the concept. I advocate for a similar strategy for relational engineering—uncovering its potential will require both reading and walking/making.

I also want to reiterate the importance of building bridges between disciplines and across academia, industry, and the arts. In order to build equitable sociotechnical futures, engineers, humanists, social scientists, artists, business people, and more are going to have to work together. The term "interdisciplinary" gets thrown around liberally but not taken seriously often enough. To truly be interdisciplinary requires work because each group speaks a different language and brings a different perspective. Respect for the presence and contributions and of people you disagree with is challenging, especially in a highly polarized climate, but crucial for driving change.

It is my hope that this thesis serves as a kind of liberation in thinking about technology and how it can and should fit into the world. The kinds of things we build depend on how we think about them in the first place. I want to end by urging the reader to try and examine their own assumptions about what technology should look like, who should build it, and what it should do. In what ways is this mindset limiting? How might reframing a vision for the kind of world we want to live in—one that is equitable, just, loving, caring, joyful, and flourishing—inform the types of technologies we build and how we integrate them into our sociotechnical systems, not as solutions, but as co-conspirators in a web of wonderfully messy relations?

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