auto-lysis:
art, engineering and circulating referents

by

Takis Zourntos

a thesis exhibition presented to OCAD University
in partial fulfillment of the requirements
for the degree of
Master of Fine Arts
in
Interdisciplinary Master's in Art, Media and Design

Djuna Day Studio
45 Chauncey Avenue, rear
Toronto, ON M8Z 2Z2
Canada
April 16-27, 2015

Toronto, Ontario, Canada, April, 2015

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I authorize OCAD University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

I understand that my thesis may be made electronically available to the public.

I further authorize OCAD University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Signature ____

auto-lysis: art, engineering and circulating referents, MFA, 2015
Takis Zourntos
Interdisciplinary Master's in Art, Media and Design,
OCAD University

abstract

I present an investigation into the merging of art practice and engineering. The study is conducted from a first-person perspective, in which I attempt to reconcile my engineering and research background with contemporary art. Through the use of an ongoing methodological dialogue, a comprehensive engagement between art practice and engineering results, producing a balanced (non-hierarchical) exchange of ideas. The works of the thesis exhibition blur the distinction between the aesthetic and the technical as well as the natural and the artificial, featuring mimetic-motion cybernetic machines, concept sketches, mathematical derivations, and an array of "workplinths." Sited in an industrial complex, the installation is itself a gesture of intervention, bringing the domains of art and engineering into close proximity.

acknowledgments

I feel a deep sense of gratitude to OCAD University for providing me with the opportunity to pursue this interdisciplinary degree. It has been one of the most intellectually stimulating times of my life.

Barbara Rauch has been a wonderfully supportive individual throughout my time here, and I cannot thank her enough for all that she has done. Doug Back has been a compassionate, good-humoured and inspiring PA. I am greatly honoured to have been his student. Dot Tuer has continually offered profound insights, and I am grateful to have worked with her and to have experienced firsthand her wit and wisdom. Caroline Langill has also offered invaluable feedback and guidance throughout the development of my thesis. I would like to thank Norm White for serving as my external examiner. Whenever I feel down about my work, surely the memory of Norm complimenting me and "the bright future" I have ahead of me will save the day.

I would also like to thank my comrades and fellow students whose help, insights and kind words made it possible for me to complete. I would especially like to thank Rawaa Bakhsh, Andy Fabo, Martha Griffith, Ana Jofre, Lucy Roussel, Ilias Toliadis and Marian Wihak.

And a special thanks to Mom, Deepa, Linus and Tolly (in descending chronological order :))— you all deserve so much better than what I have offered these past couple of years. Hopefully, I can make it up to you in the years ahead.

Contents

listing of figures

If the chain is interrupted at any point, it ceases to transport truth— ceases, that is, to produce, to construct, to trace and to conduct it. The word “reference” designates the quality of the chain in its entirety … *Truth-value* circulates *here like electricity through a wire, so long as this circuit is not interrupted.*

— Bruno Latour (1999, p. 69)

Chapter 1

introduction

This thesis proposes a hybrid practice based on a merging of art and engineering. These disciplines are placed in conversation, producing a dialogue which is at the core of my investigation. This dialogue is intimate in nature, with art and engineering accompanying each other throughout the process of making work, from the broadest conceptualization of a project to the minute details of fabricating parts. In a literal sense, I am testing the hypothesis put forward by philosopher Barry Allen, that "it is only when technology is practiced as art— when it is free to be practiced as art— that it can do its best work" (Allen, 2008, p. 6). At the same time, I am testing how engineering can influence artistic production by deepening the interaction with the medium of technology. In a society (or, as philosopher Bruno Latour would clarify, a *collective*[1]) described by Allen as "ineluctably technological,"[2] a responsive art practice needs a comprehensive engagement with engineering, science and mathematics. And while there is a significant history of various deliberate interweavings

[1]Latour defines *collective* as a group of interconnected human and non-human actants; the distinction between society and collective is relevant here since in order to confront the technological in art I employ a close examination of the interaction between human (user or viewer) and non-human (tool or machine). As discussed in the text, the ontologies of user and tool are not pre-determined, but emerge from interaction.

[2](Allen, 2008, p. 182)

of art and technology[3], what helps to distinguish this investigation is its first-person perspective. I work as both artist and engineer. I am an experienced engineering researcher-practitioner undertaking an intensive interdisciplinary program of graduate study in fine art. But why should we concern ourselves with the interplay of art and engineering, in the first place? Put another way, how well are collectives served by keeping the technical and the aesthetic in separate bins? Allen defines *technological* as "a steep rise in the scope and intensity of technical mediation, meaning machines that interface with other machines as much or more than with humans." He describes a system of ubiquitous blackboxing and overwhelming complexity made less evident through abstraction and specialization (Allen, 2008, p. 109). While this machinic dark matter pervades our lives, it has remained largely outside of contemporary art discourse. As art historian and critic Claire Bishop notes:

> *So why do I have a sense that the appearance and content of contemporary art have been curiously unresponsive to the total upheaval in our labor and leisure inaugurated by the digital revolution? While many artists use digital technology, how many really confront the question of what it means to think, see, and filter affect through the digital? How many thematize this, or reflect deeply on how we experience, and are altered by, the digitization of our existence?* (Bishop, 2012)

Bishop seems to be suggesting the need for a broadening of scope, and possibly, the integration of new media within the contemporary art canon. The mechanisms underlying the split between new media and contemporary art have been recently

[3]In the Renaissance, such an interweaving was seamless since there were no disciplinary boundaries as we have today. More recently, since the latter half of the twentieth century, there have been, for example, various early attempts at combining computer graphics and art (Dietrich, 1986). In the 1960s and 1970s, *Experiments in Art and Technology* (EAT) was a concerted effort at integration, founded by artists Robert Rauschenberg and Robert Whitman and engineers Billy Klüver and Fred Waldhauer (Klüver and Rauschenberg, 1998). EAT looked at technology critically and attempted to show the limits of our abilities to solve problems with engineering and science (Kuo, 2011). Modernist technocratic fervor reached a zenith by 1970 and rapidly waned as environmental and sociological concerns intensified (particularly over the ramifications of the Vietnam War, nuclear proliferation and pollution). EAT was largely dissolved by 1974.

described by art historian Edward Shanken, in the introduction of a special issue devoted to this divide (Shanken, 2011). Historically, new media has existed beyond the periphery of mainstream gallery culture, partly because of its non-traditional forms. Exposed wiring, electronics and pneumatics, are a distraction to the aesthetic experience. But what is germane to aesthetics? Certainly, conceptual art has done the work of shifting judgment from how an object merely appears to what the object implies beyond traditional aesthetic essentialism. Under consideration here is the object's functioning and design as a possible reframing of the conceptual apparatus. For this fusion of the artistic and the technological to take shape fully, a new aesthetic approach to technological production is needed. By contending with what Allen calls the "engineer's art ... of composition, combination, integration, systems, design," my aim is to discover parallels between art practice and engineering, developing insights into how art may further engage with the technological (Allen, 2008, p. 109).

Even in new media art, the role of technology has been more about special effects than inner workings. But technology is itself loaded with signifiers of our networked reality, with interacting electronic and mechanical components reflecting the interplay of aesthetics, function, militarism, labour and politics. These obscure associations encoded within technology are becoming more evident the more technology permeates contemporary life. Human beings who have grown up with computers and the Internet are developing an intuitive understanding of programming, digital communications and cybernetic interventions. Because of its pervasiveness and impacts, technology has become the primary medium of human expression and interaction, as relevant as paint or clay have been at any point in our history. And, in analogy with painting or sculpture, new media will develop systems of knowledge and rigorous approaches to its underlying technics within the context of artistic production. It is in this direction of developing the medium of technology itself in which this work strives to contribute.

Developing an aesthetic awareness within technological production has implications beyond the white cube. Technical mediation concerns *how* and *to what extent* we rely on machinery, and in our current situation, this reliance is substantial and increasing exponentially. Is this good or bad? While the quality of a work of art (or design or engineering) can be assessed by using various metrics, Allen emphasizes the human experience. He defines the beauty of a work as the extent to which the work embodies the anticipation of the viewer's (or user's) perception (Allen, 2008, p. 3). He suggests that technology ought to be developed with the aesthetic sensitivity of art, and, therefore, like an artist, an engineer must possess an expansive empathy not limited by narrow functional, spatial, or temporal parameters. For engineering practitioners to possess such an awareness is critical since, as recent examples demonstrate, an incrementally greater dependence on technology can produce a disproportionately large yield. For example, semi-autonomous drone technology, the result of combining existing aeronautical engineering knowledge with well-understood principles of teleoperation, comprises a new capacity to conduct large-scale killings with impunity (Byman, 2009). Or, consider the social-media-enabled obliteration of civilian dwellings, the gruesome combination of text messaging services and established laser-guided bombing technologies, representing a juxtaposition of what brings us together with what tears us apart (Blair, 2014). What are the engineers[4] in these contexts *not* thinking about?

The apparent division between the aesthetic and the technical is of principal concern here, a distinction which I hope to help to dismantle. It is the aim of the

[4]Even if we do not hold the military engineers of such projects responsible, what about the engineers behind the social media technologies or the equipment manufacturers who indirectly facilitate these outcomes? Are such uses of their work not anticipated in their imaginings? Where technology development is concerned, the layers of blackboxes can lead to an atmosphere of passing the buck, in which no one takes responsibility because, of course, no one possibly can.

artworks in this thesis to confront the viewer with the physics and metaphysics surrounding the interactions of tool, user and producer. The tools we use are not merely implements which are subordinated to us. What we are is determined by the interaction. Invoking what physicist-philosopher Karen Barad has termed *intra-action* (Barad, 2007), user and tool are ontologically indeterminate before an encounter, i.e., we *become* through technology. Should we not deliberate more about our own cyborg configurations? Of our many possible chimerical forms, why would we prefer one over another? How do we go about our choices and appropriations?

Chapter 2

contextualization

Since the Paleolithic Era, humans and technology have been in a state of co-evolution. We have, for approximately two million years, been dependent on the use of leveraging mechanisms that expand the capabilities inherent to our bodies and cognitive-exteriorizing implements (from stone tablets to digital storage equipment) that augment our mental faculties (Allen, 2008; Heidegger, 1977; Mitchell and Hansen, 2012). It is important to distinguish that for much of our association with technology, tools and machines have had much more significance than mere task facilitation— they have structured societies as units in fledgling economies (wherein materials, knowledge and the tools themselves are exchanged) and as instruments of change, in which they have even stimulated abstract thought and the formation of language (Uomini and Meyer, 2013). So while the specific configurations and implementations of tools have developed vastly over time, their substantial agency in the cultural evolution of humans is unquestioned.

While the human species has always led a technically mediated existence, where does the tool end and the human begin? Because the tool *propositions* the user, the dynamic interaction between human and technology describes a negotiation, an entanglement of agencies (Latour, 1999). As the encounter evolves, user and tool transition through various paired states of being. For example, consider the case of a human presented with a gun. The user and tool may find themselves assuming the respective roles of *passive observer and mechanism* followed by *participant and facilitator* followed by *shooter and accomplice*.[1] As cybernetic machinery increasingly influences or supplants human cognition, appearing in almost every aspect of contemporary life, from communications, healthcare, recreation, transportation and governance, what happens to us? If *sapiens* is characterized by its supreme capacity to solve problems, then there is irony in human ingenuity applied toward the creation of machines that reduce the need to think. We had expected that automated processes and dexterous manipulators would replace us in various so-called menial capacities, allowing more and more humans to pursue meaningful endeavours. But in spite of hopes for more free time and enjoyment of life since the emergence of the Information Age in the late twentieth century, human labour, whether on the assembly line or in the cubicle, has been corralled as never before into mechanistic modes of functioning.

Latour describes actor-network theory (ANT) as a method of inquiry, opposed to a set of rigid sociological models, for uncovering the hidden connections amongst entities (Latour, 2005). Taking things at face value, we may assume that an object is defined solely by its physical properties: dimensions, mass, aerodynamic coefficient, etc. What is more relevant within the *collective*— the network consisting of the humans and non-humans activated by the presence of the object (what sociologists would refer to as the local picture of "society")— is the influence of the object on its neighbours, its capacity for agency when mediating the flows of other actants. For

[1] Indeed, do guns kill people or do people kill people? For an in-depth look at this long-standing gun control topic, see Latour (1999, Chapter 8).

ANT, no thing— human or not— is an island and what things are depends on context. We abandon preconceived notions of societal structure and the use of "templates" to describe actants. Every collective is afforded the opportunity to relate a unique story.

While ANT provides a paradigm shift for studying social groups, it offers only a handful of methodological guidelines (Latour, 2005). It is akin to anthropological field work, requiring the intense scrutiny of actors and an appreciation for the reflexive role played by the observer. Controversies assist in the stimulation of the network, activating links and eliciting modes of behaviour which would otherwise go undetected. As a self-described positivist[2], Latour is clear about the scientific sympathies of ANT, where observation, modeling and mathematical techniques become amenable to ordinarily non-quantitative studies associated with the liberal arts. Latour has cited Tomás Saraceno's installation, *14 Billion*, whose webs of thousands of elastic cords are sufficiently dense to suggest a fabric, that is, a discrete topology which is nevertheless capable of describing what we perceive as a continuum, zones of entangled and nuanced reality (Latour, Feb. 2010). Indeed, this work captures in three dimensions the myriad relationships in a given collective, those which are usually invisible and unnoticed. The network must be unraveled through inquiry— by asking *how* things come to be— by tracing the impulses traveling along paths now illuminated by a distant but connected stimulus. However, while Saraceno reveals the network, the view is largely static (unless one is permitted to disturb the installation), belying the dynamism of real life.

The technical milieu in which we now find ourselves obscures the distinction between the natural and the artificial, a blurring that philosopher Donna Haraway

[2]"I am, in the end, a naive realist, a positivist."(Latour, 2005, p. 155).

describes as the fourth wound to human ontological narcissism[3] (Haraway, 2003a). While the future envisioned by Haraway in *A Cyborg Manifesto* accurately describes our current reality, how deeply has mainstream art confronted life in the hyper-technological collective (Haraway, 1991, Chapter 8)? Such a question seems quaint in these days of rampant early adoption. However, in regards to technical mediation, the stakes are high and matters are becoming increasingly complicated. Haraway's cyborg shares much in common with Latour's actants, in that its ontology is context-dependent; in fact, through its various affinities, the cyborg defies a precise ontology. It can be seen as the exception to the rule, a violation of categories and dualisms, straddling the boundaries of territories. In our grappling with reality, we construct representations, forming categories and dichotomies in the process. Cyborgs are themselves constructs which, occupying interstices and defying categorization, undo all of that representational effort. In this ironic sense, cyborgs are a glimmer of reality thwarting our attempts to understand reality through structure or representation.[4]

Philosopher Judith Butler proposed what she termed *performativity*, as a way to describe how a subject comes to be. In performativity, the ontology of a subject is dictated largely by iterative enactment. The subject becomes what it is (knowingly or not) principally through a process which reinforces an identity (Butler, 1993).

---

[3]The first wound being the Copernican revolution, or the heliocentric model of the universe replacing the geocentric view; the second wound being Darwin's Theory of Evolution, displacing the human from the centre of creation; the third wound being the Freudian tripartite structure of the human psyche, decentering consciousness from a whole, individual agency; the fourth wound being the realization that there is no separating humans and their "artificial" creations from the "natural" world, made especially clear through the ecological impacts of human technological advancements (Haraway, 2003a).

[4]The cyborg is not entirely a victim, it simply contends with its collective. Haraway has recently moved on from cyborgs to *companion species*, in which she presents more of an embracing of circumstances, a coming to terms or blending with one's context than suggested by cyborgs Haraway (2003b). But the cyborg itself is a mediated being in which the natural and organic find companionship with the artificial and technological. I prefer the darker implications of cyborgs to the furry, wet-nosed appeal of canines, but only slightly.

This insight helped to dismantle the structuralist notion of identity, linking ontology inexorably to context. Physicist-philosopher Karen Barad, recognizing the parallels between Butler's ideas and quantum mechanics, has broadened the scope of performativity beyond its original gender-oriented focus. Using the analogy of the scientific apparatus, she contends that both ontological and epistemological limits are determined by the nature of the experiment (context or network)— *is the electron a particle or a wave?*[5] Barad has developed a new philosophical branch in the process, an interdisciplinary tour de force known as *agential realism* (Barad, 2007). In agential realism, subjects and objects have no a priori essences. They are defined through interaction, whether the context concerns quantum mechanics or technical mediation (Barad, 2007; Latour, 1999, 2005). The ontological implications of technology are amplified through iterated, i.e., performative, technical mediation.

Consider, for example, the ubiquitous contemporary smartphone, which outwardly appears innocuous enough. It is, after all, small, and we give no thought to the fact that contained within this diminutive package is a computer more powerful than any building-sized mainframe system used in World War II and during NASA's moon missions. But rather than breaking enemy codes and computing trajectories, this powerful device is now deployed within a ruthless, economic (although sometimes literal) war between governments or corporate entities, which include espionage missions to infiltrate our electronic lives. How are we participating in these conflicts,

[5]It can be either depending on the context— a quantum-mechanical insight which shook the representational/structural foundations of physics. Although Barad employs quantum-physics analogies to disrupt representational conventions, deterministic nonlinear dynamics (the mathematics underlying system theory) also works, but is not as connected with Bohr's ideas. While quantum effects require substantial measurement sensitivity to detect at macroscopic scales, deterministic chaos, too, is a phenomenon associated with precision; it is only because of finite precision (possibly compounded by minute quantum effects) in practice that chaotic systems evade prediction, i.e., as with quantum mechanical systems, deterministic nonlinear dynamic systems exhibit similar epistemological limits. Also, we don't need quantum effects to realize ontological indeterminacies, as this is evident in the couplings of electrical circuit components and in non-trivial multi-body interactions.

by allowing the smartphone to mediate our activities?

Technical mediation is about affordances and the disruption of identity. The ontologies of users and tools dynamically change, momentarily converging to some transient state of being, through mutual (bilateral) couplings. Latour talks of humans and non-humans "folding ... into each other", describing the fluctuations induced by various means, owing to technical mediation (Latour, 1999, p. 176). The performative turn in philosophy responds to structural or representational tendencies, which have, for science, formed the foundation since the seventeenth century. By defining subjects and objects with sufficient accuracy, it had been thought, the outcome of any interaction could be predicted.[6] Since even "simple" systems comprised of three actants can defy prediction, what can we determine regarding systems comprised of several users, their tools and the multitudes of actants hidden in underlying networks supporting the interaction? It should not be surprising when such systems deviate from expected behaviours, producing seemingly emergent phenomena, and altering our perceptions of what things are.

We understand that our experiences are usually technically mediated, but in our technological collectives the sheer complexity of the network obscures the full ramifications of our interactions with machines. In addition, the connotation of *machine* also has indeterminacy: what is the function of a machine? What problem does the machine solve, when viewed beyond a narrow pre-defined scope, considered within a broader network which includes other machines, an ecology, flesh and blood? On the one hand, a machine is amenable to a positivist account by science and engi-

[6]We don't need the stochastic framework of quantum physics to disprove this. It has been discovered relatively recently that chaotic (unpredictable, though not random) behaviour can be produced by deterministic nonlinear dynamic systems of only third order. Nevertheless, we are still caught up in thinking in terms of objects, neatly defined by physical parameters alone, encapsulated by their faces and edges. And we still assume that each of these black boxes is, as Latour writes, "a matter of fact that is settled" (Latour, 1999, p. 304).

neering; the machine is a dynamic system, an interconnection of parts whose way of working can be defined with precision, e.g., as a set of equations or programs. On the other hand, the machine is an object of philosophical discourse defined as "a *system of interruptions* or breaks *(coupures)*," which describes production and flow (Deleuze and Guattari, 2004, p. 38). For philosophers Gilles Deleuze and Félix Guattari, once a machine is discovered, "what can it be used for?" An automobile is a machine, but so is the coupling of automobile and driver, or the collection of automobile, driver, ancient organisms and energy policy. Furthermore, through a process described by Deleuze and Guattari, a painting can be seen as an abstract machine, an apparatus through which subjects and objects are made (Zepke, 2005). In this manner, the machine integrates aesthetics and function, bringing into question whether the machine realizes a pre-determined purpose, or is defined performatively within a given context. A machine is a network of elements as well as a dynamic system, evolving in time as the nodes interact with one another along the links coupling them. When a subject views a painting, the experience can be described by what Deleuze and Guattari call *subjectivation*, in which, through *problematic affect*, the finite— the work itself— becomes the infinite: the set of all possible variations of cascading thoughts and experiences through which subjects are defined (Zepke, 2005; Deleuze and Guattari, 2004). In the engineering discipline of systems identification, the characteristics of a dynamic system can only be identified through a sufficiently rich excitation, a stimulus capable of exciting all possible modes of a network. Indeed, art *functions*. What is the function of a painting? A painting can be seen as a machine through which we discover ourselves.

Linking ANT with system theory (one branch of cybernetics) is a logical fusion, in which ANT determines the parameters of the collective, and system theory discovers a number of behavioural scenarios (based on initial conditions, external inputs, and disturbances). Cybernetics thus potentially provides ANT with a degree of predictive capacity, a means of quantitatively characterizing networks. In addition, there is considerable interpretative freedom for the development of machine-networks as analogues for social actor-networks with the potential to reveal insights into our ontological status within techno-scientific imbroglios. Cybernetics[7] is itself a hybrid discipline comprised of concepts from neuroscience, mathematics and physics. Mathematician and philosopher Norbert Wiener, a founder of the field, has defined *cybernetics* as the study of "control and communication in the animal and the machine" (Wiener, 1961). If one assumes perfect communication (or a complete understanding of the couplings) between parts or actants, then cybernetics reduces to system theory, which is one of my primary areas of focus within engineering. System theory offers both tools for analysis (to predict system behaviour) and synthesis (to design system behaviour). Haraway was quick to pick up on the ominous overtones of the latter capacity, envisioning a technological future of exploitation through cybernetic engineering of various societal controls, leading to the *Informatics of Domination* (Haraway, 1991, Chapter 8). In this thesis, I am re-appropriating Haraway's ironic appropriation of cybernetics for the purposes of artistic production. Not a reversal, mind you, since, after all, the jury is still out. What becomes of humans as we depend more and more on cybernetic interventions, those which replace our own cognition, in increasingly substantial ways? For example, if my car not only shifts its own gears but navigates on its own, are there mental capacities which will atrophy from disuse? Certainly, with increasing convenience we might

[7]The prefix "cyber" stems from Greek words associated with steering, piloting and governance, referencing control. The term "cyborg" is a contraction of the phrase *cybernetic organism*. In modern usage, the phrase cyber is associated with all things Internet-related, but this conflation of "cyber" and "digital" reflects the rise of the digital Turing/von Neumann machine as the dominant computing paradigm since the Second World War. Cybernetics concerns dynamical systems, and is amenable to either digital or analog forms of computing.

expect that the inclination to understand a machine (now layered with even more complexity) with which I have an intimate connection recedes. For many, the daily drive may constitute a primary stimulation of hand-eye coordination, potentially useful (perhaps even critical for survival) in other contexts. And while it can be argued that such conveniences free us up for other "more relevant" pursuits than dealing directly with technology, I have to ask, what is more relevant than being technical? The crux of Allen's argument is, after all, that being human *means* being technical. Are we outmoding ourselves through our own ingenuity?

The commodifying influence of modern technological production extends beyond the manufactured devices themselves, affecting the associated tools, methods and developers. The corporate engineer has become a commodified worker, possessing knowledge and a way of thinking that is standardized and largely indistinguishable amongst peers across many institutions.[8] The immateriality of knowledge labour has become increasingly blatant over the past two decades. Cultural theorist Tiziana Terranova writes:

> *... the "informatics of domination" that Haraway describes in the "Manifesto" is certainly preoccupied with the relation between cybernetics, labor, and capital. In the fifteen years since its publication, this triangulation has become even more evident. The expansion of the Internet has given ideological and material support to contemporary trends toward increased flexibility of the workforce, continuous reskilling, freelance work, and the diffusion of practices such as "supplementing" (bringing supplementary work home from the conventional office).* (Terranova, 2000)

[8]The needs of industry often influence curricula in educational institutions at all levels, effectively limiting the scope of programs, tailoring knowledge to facilitate production and generating virtually undifferentiated graduates; most engineering curricula, for example, provide few elective choices, with few provisions for liberal arts credits, which I have experienced firsthand as both an engineering student as well as a faculty member on curriculum planning committees. One has to go no farther than to examine the accreditation body ABET (http://www.abet.org/) which determines curriculum requirements for engineering and science programs in the United States (and a handful of nations in the Middle East and Asia); it is a non-governmental body which assesses public institutions. How ephemeral is knowledge in science and engineering if ABET deems it necessary to update its accreditation criteria *annually*?

Craft (or *techne*) has always been of central significance in art, even when repudiated. A Renaissance painting had a thick description, which included the acquisition of raw materials[9], the painstaking preparation of surface and pigments, the development of binders as well as the burnishing of gold leaf (The J. Paul Getty Museum, 2014). The artist's studio was also a laboratory, where aesthetic considerations informed not only a work's composing, but its composition. And, although invisible, the process— consisting of a multitude of painstaking steps— contributed to the work's affect and value. It was important that the ultra-marine was exotic and expensive, and that the studio had its own secret recipes for paints. Fast-forward to the art of the twentieth century, and we see a conspicuous disavowal of labour-intensive making. The ascendency of mass manufacturing was challenged with ironic uses of prefabricated elements in the avant-garde and in pop art. At this point, more than one hundred years after the creation of Duchamp's first readymade, *Bicycle Wheel*, the irony has perhaps run its course, and we are now faced with the consequences of industrialization: globalization and anthropogenic climate change. More recently the commodification of labour and the devaluing of craft have been addressed in the process and performance works of the 1960s and 1970s entrenched in the feminist movement. Employing undervalued handicraft or menialized labour, artists such as Eva Hesse, Jackie Winsor, and Mierle Laderman Ukeles greatly expanded the scope of the white cube, confronting institutional practices as well as gender and labour relations. The conspicuity of these works lies in their performative aspects (whether or not conducted in real-time), subordinating the actual output (art object) to process (Jones, 2014). Artists such as Francis Alÿs and Paul Donald are contemporary exponents of this school, introducing themes of globalization and its impact on art

[9]For example, the quarrying and importing of lapis lazuli from Afghanistan into Italy and Northern Europe in the fourteenth century.

practice as well as trade labour— the physical act of working has become emblematic of humans locked within a hegemonic system of extraction, production and disposal, approaching its limits.

2.1 summary of research questions

1. Within a given human-technological collective, of our many possible chimerical forms, why would we prefer one over another? How do we go about our choices and appropriations? Why don't we deliberate more about our own cyborg configurations?

2. Are "how" questions and the foregrounding of technical labour valid within contemporary art?[10]

3. How can an engineered system be presented to the viewer in a manner which is accessible as art and which conveys a sense of complexity and interconnectedness (for full engagement in the intended discourses), which may be subtle and embedded within technics?

4. What are the precedents which could anchor the prosaic activities of technology development within the art canon? What could the engineer do differently to fashion artworks rather than infrastructural works?

5. How does this hybrid practice inform both art and engineering? What can art practice and engineering learn from each other?

6. If describing technology as "advanced," "improved" or"benefitting" is problematic, can "sustainable" or "balanced" technologies be more in harmony with contemporary thought (postmodernism, metamodernism, etc.)?

[10]Especially if there is no single "correct answer."

7. If networks of systems provide a means to gain a broader understanding of technological impacts, can we identify fixed equilibria to strive toward, or is technological progress in the broadest conceivable sense an impossibility?

2.2 objectives

1. The creation of compelling body of art which causes the viewer to question human relationships with technology and the consequences of living within a large network of black boxes;

2. The development of a hybrid practice, bringing together engineering and practice-led methodologies, the aims of which include:

    (a) opening a sub-genre within new media art with a concern for knowledge labour and the influence of the Culture Industry on technology development and production;

    (b) helping to bring about change in the culture of engineering practice.

Chapter 3

methodology

I base my notions of engineering and fine art practice on what I gather from study and direct experience of these disciplines in academic and professional settings. In undertaking this thesis, I have often experienced an entanglement of practices, a simultaneity of art and engineering. So from the practitioner's standpoint, there really is no distinguishing disciplines, in the first place. Nevertheless, we must acknowledge an extant division between these fields as reflected in contemporary educational systems and professional practice, a de facto dichotomy within which we are always already.

By "engineering" I refer to the use of science or mathematics in the formulating and solving of a problem through the design and construction of a system or tool[1], the means by which technologies are produced. Engineering is the process, not the outcome, and, accordingly, subordinates material to the conceptual; what is technologically feasible is constrained by material limits, but even materials (or pressure- and temperature-regulating systems) can be invented. In its privileging of concepts,

[1]Please see Allen (2008) for a comprehensive anthropological characterization. Briefly, a tool is not simply a makeshift implement (e.g., a found rock or twig), but an object realized through a sophisticated economy which includes the exchange of ideas, networks of distribution, and sites of material acquisition.

modern engineering shares much with the avant-garde, but departs somewhat from contemporary art practice. Because it is steeped in scientific knowledge, engineering makes substantial use of *representation*[2], building models of some aspect of reality but not dealing directly with reality in its fullness until later stages of the implementation. Unlike idealized, hypothesis-driven science, there is no unique solution in engineering, but an infinitude of possible results, a fact about which engineers can sometimes lose sight.

By "art practice" I refer to the application of material and discursive understanding to the creation of objects or experiences through a reflexive and ludic process, optionally accepting and contending with unanticipated results or "failures" as part of a project (Philpott, 2007; Petelin, 2010-2011; Daniels and Schmidt, 2008; Alvesson and Skoldberg, 2000). Whereas engineers are often isolated within their cubicles, artists readily engage with the world around them, synthesizing interactions, global and local events, formal and informal investigations, as well as personal experience into work; a gallery opening or art show serves as a nexus conducive to the exchange of ideas and the stimulation of one's practice (Breitz, 2013). Contemporary art is sensitive to materials, and, much like the continental philosophy informing its leanings, often views representation with suspicion, and attempts to deal with reality without mediation. The Western artworld is concerned with audience; artworks are made to be viewed by the public. In engineering, accessibility is not a priority, although documentation is always helpful. I have noticed that artists, like engineers, are contin-

[2]Throughout the thesis, I distinguish between *abstraction* and *representation*; I use a version of the latter term found in science and technology studies (Latour, 1999). The distinction is partly a matter of degree, but also of emphasis. Abstraction is the use of symbols or signifiers, a means often put to use by artists. Representation is abstraction with the imposition of structures or models dictating the interactions of symbols, a step beyond abstraction which artists may be reluctant to employ because of its prescriptive overtones. In this thesis, the structures are developed from scientific theories or mathematical formalisms, but may be conjectured or synthesized (in what might be called artistic license) in order to achieve certain aims. Attending representation is often a subordination of material to structure, a view that while materials are interchangeable, structure is not.

ually solving problems, but unlike contemporary engineers, do not exhibit as much obsessiveness with narrowly-defined notions of uniqueness and optimality. In art, singular interpretations are considered cliché or merely illustrative— there cannot be a unique solution (Shannon, 2013; Shea, 2013).

Engineering is often practiced as a goal-oriented discipline, somewhat like design, concerned with solutions, but more rigidly attached to supposed unique and optimal outcomes. A desire for the one "correct answer" is, I believe, inherited from a long association with science, which engineering has long sought to emulate as a university-level discipline. Although science seems often concerned with discovering the simple truths to explain the universe, we are seeing evidence from cosmology, quantum mechanics and biology that simple explanations of phenomena are, at least part of the time, either elusive or non-existent; it is, after all, presumptuously anthropocentric to believe that the universe is totally amenable to conscious human understanding (Bogost, 2012). The reality is that engineering shares at least as much with art as it does science. There is no one solution for an engineering problem, no single truth to explain why a given design must be *right*. There is also a craft, an intuitive aspect to engineering problem solving, rarely experienced in training. Within engineering, and also within the hybrid practice under development here, there is a need to embrace craft and to find an equilibrium between intuitive and analytic ways of working.

Artist and researcher Rachel Philpott explains a process which aims to balance the freeplay of the mind with "serious" thinking which, while necessary to sift through the mind's creative output, often interferes with the development of original ideas (Philpott, 2007). She finds that successful ways of working necessitate an oscillation between analytic and divergent ways of thinking, what she terms *ludic methodology*. This approach seems natural for artists, who may often supplement creative studio time with journaling and reflection (Petelin, 2010-2011), but for engineers, a conscious effort is likely necessary to allow the imagination an opportunity to manifest inventive thoughts. Part of what gets in the way, I have found, is a reluctance or fear of straying too far from the representational tendencies which give engineering much of its "power."

Despite its indispensable status in engineering, representation is an obstruction to interdisciplinarity, making it difficult to be hands-on or solely empirical in one's approach. One does not dabble in science or engineering. One is required to operate through, and even pay homage to, representational conventions. But looking back, we might posit that fine art and engineering are not such distinct territories in the first place. During the Renaissance, the activities of what nowadays would be known by the disciplines of architecture, engineering, geometry, painting, science and sculpture, were intertwined and often conducted by a single individual, the polymath. Epistemological divisions would have seemed arbitrary (King, 2000). The talents of individuals like Brunelleschi and Da Vinci notwithstanding, the freeplay of ideas in the Renaissance was greatly facilitated by a unifying empirical approach[3]. Therefore, structures, like sculptures, were built from intuition informed by experience. Developments in mathematics, philosophy and physics by Descartes, Kant and Newton among others, laid the seeds of the representational tradition. No longer are we dealing directly with a falling object, but rather an idealized point mass m at a displacement x from an origin ("the ground") accelerating under gravity (idealized as

[3]The development of linear perspective by Brunelleschi occurred through his scientific, architectural and geometric exploration of ancient ruins. For the construction of the Dome of Florence Cathedral, Brunelleschi devised a number of machines, including the Great Hoist, used for the vertical transport of heavy loads. He was proficient not only in structural engineering, but in mechanical engineering as well, and he possessed none of the mathematical/representational tools of modern engineers. Da Vinci integrated his engineering prowess into his paintings, constructing figures from the inside-out, skeleton to flesh to skin, informed by his firsthand experience in the dissection of cadavers; he, too, lacked any sophisticated mathematical tools, but relied substantially on his skills of observation (Vasari, 2005).

a constant, $g = 9.81$ m/s^2). We represent the world with a diagram and mathematics, instantiating a domain of predictive capability. Who can argue with being able to know what will happen, being able to guarantee[4] that a structure won't collapse or knowing that a machine will function as intended? Since Newton, there has been an epistemological divergence of fields which were integrated under a Renaissance way of thinking. The shift is profound because it introduces a dichotomy. Whereas in the Renaissance, knowledge was knowledge, we now have a distinction: on the one hand, propositional knowledge (true and false statements) and intuitive knowledge (know-how or craft) (Allen, 2008). The former, equipped with an idealization of reality in the form of mathematical representation, provides us with the prospect of certainty and predictability, while the latter evades a straightforward account in terms of rules which can be written down. Attending this is the myth that science proceeds linearly in its elucidation of propositional knowledge, what the Greek term *episteme* describes as the straight path of reason. In reality, science proceeds along a much more convoluted trajectory, reminiscent of artistic process— the crooked path of knowledge, *metis*— tracing the thread of Ariadne weaving its way through the labyrinth, entailing a series of fluctuations between real and abstract (Latour, 1999).

In analogy with the material traces of performance art, representation can be a medium onto itself, distinct from the physical realization of the project, with its the waves of modeling, formalisms, tentative analyses, derivations and sketching, still constituting an aesthetic realm. There is much in the process itself which can be elegant or stilted, beautiful or abominable. These are, after all, the tools of the toolmaker, the means of producing the fabric of modern life, with all of its implications for labour, ecology, development and atrophy. In my own practice, representa-

[4]As long as reality and representation completely agree, which they never do.

tion is essential in achieving my aesthetic-functional aims. Such aesthetic goals have pushed the engineering methodology to extremes, as in art there are few limits to the imagination. At the same time, thinking representationally can be confining and unresponsive to what's going on, right now.

Artists are often comfortable as bricoleurs, and, in this regard, I find the greatest contrast with engineers. Deleuze and Guattari view engineering as the opposite of bricolage, which instead proceeds from detailed goal-oriented plans and utilizes so-called raw materials[5] (Deleuze and Guattari, 2004). Bricolage is performative making without intermediary, and while extreme, captures a capacity within most artists. In spite of the sacred territory bricolage represents, I view its valuing as a fetish, reminiscent of the classical privileging of speech over writing. Without any intervening structure or representation, we might infer a directness of expression or of transmission between artist and viewer. But there are many artists who apply labour-intensive making-from-scratch as well, at times necessitating the use of a well-staffed art-factory system[6]. Is such artwork less meaningful because of its deliberative nature? I do not see the rigorous and time-consuming methodologies of engineering per se to be at odds with art practice, but, in my experience, there is something persistent about engineering methodology which, if not entirely offensive, seems to rub many artists the wrong way. While the utilitarian nature of engineered objects poses a challenge to their interpretation as art, this is not in itself an insurmountable difficulty. Consider, for example, that each of Duchamp's famous readymades is an object of function— a bottle rack, an umbrella, a bicycle wheel, a shovel, a urinal. More contemporary examples would include the sculptures of Noriyuki Haraguchi (full-scale replicas), or Iñigo Manglano-Ovalle (objects with a ready-made feel). However, what

[5]Arguably still bricolage but at finer resolution.

[6]Well-known examples of which include the studios of Andy Warhol, Ai Weiwei, and Jeff Koons.

makes these objects art is their aesthetically-independent conceptual framing with respect to a given historical context, an intellectual advance requiring the relevant expertise, i.e., the knowledge and skills of an artist. Moreover, these objects demonstrate that, in contemporary art, the "readymade" has become not a signifier of mass manufacturing, but of the handmade, a rejection of the aesthetic nihilism of conceptual art.

To think of aesthetics and function as being mutually exclusive is irrational at this point in history. Conceptual art, pop art, performance art and new media have all greatly expanded the scope of aesthetic concern. My point here is to suggest that engineering, with its deliberative representational (and supposed utilitarian) ways, is not inherently in opposition to art practice, but representational means as well as utilitarian concerns must be inflected in order to produce art. And by integrating engineering methodology, art practice can expand, developing aesthetic concerns in regard to function and meeting our increasingly technological age on its own terms. Aesthetics and function are, at any rate, correlated. Allen has argued that the myriad uses of an object are implied by its aesthetic qualities (Allen, 2008). The sharpness of an edge, the sleekness of a profile or the weight in the hand suggest multiple uses of a thing. Beauty, he continues, is proportional to the degree to which the user's experience has been anticipated in the work. A bridge may be robust, but if its appearance betrays its stability, the design has failed obviously from an aesthetic standpoint but also in terms of its function, which includes the experience of safe crossing. From this idea of "functionless functionality" Allen blurs the line between function and aesthetics, showing that how an object looks, feels or sounds and how it works are inexorably linked.

Of course, as means, engineering methods can furnish the artist with options in terms of production. This collaborative model or "technology in the service of art" is a valid entry point for engineering into the artworld, but is much like the arrangement between architect and civil engineer. I am much more interested in how an art practice emerges from an engineer's reflexive participation in their own project. What are the precedents which could anchor the prosaic activities of technology development within the art canon? What could the engineer do differently to fashion artworks rather than infrastructural works? Consider, first of all, that without a comprehensive set of aesthetic concerns, contemporary technological production is a machine of advancement, driven by the force of economic expansion, producing systems with ever-increasing potency and the potential for irreversible change (Franklin, 2004; Haraway, 1991). As a way of thinking, art necessitates a formidable aesthetic sensitivity, and, if emulated within engineering, offers the possibility for technology making that is mindful, democratic and ecologically sound (Balsamo, 2011). In addition, as art becomes increasingly about doing and functioning both within and without the white cube, the development of a medium of function may be worthwhile. With its concern for function, engineering can offer art not just material means, but a way of conceiving of projects.

processes

In September 2012, I was taking the first studio class of my life taught by Professors Johanna Householder and Ian Carr-Harris, at OCAD University. I recall, during my first individual session with the professors, asking "what do I do?" because, except for various grade-school projects, I had never previously intentionally made a work of visual art. Johanna suggested that I begin with discourse, a word which I had— in my liberal-arts-starved engineering existence— not heard used often. But I took it to mean *reading*. Ian added that, as an engineer, I already had a way of making things, and that producing art should flow from this ability intuitively. My main concern was that engineering took a lot of time and resources. How could I create an engineered work in just two weeks (which was the time frame allotted for each major project in the class)?

In spite of the initial feelings of overwhelm, I began as Prof. Householder recommended. I read, attended shows and talks, and watched lectures on-line by critics and art historians. I journaled and did quite a bit of thinking. I was trying to grapple with what an artwork means. Although I have always found art fascinating and have enjoyed gallery visits, I had only an inkling of how art could connect with broader issues; it seemed to me that art only related to itself, that it was a closed world, a feeling that some of my reading tended to corroborate (Thornton, 2008).

But I had several important realizations while reading some of our assigned material (Kwon, 2004; Lakoff and Johnson, 2003). I started to understand how art was now (for the past hundred years) more about *ideas* than *objects* or *media*, and as a result, its ability to interface with any domain was virtually limitless. Also, the critical responsiveness which was embodied by artworks was exactly what I had felt had been lacking in engineering practice. I felt liberated because engineering could, through art, be about its very circumstances— the ecological destruction in which it was implicated, the unbridled capitalism driving it, the mindless consumerism bingeing on it, the knowledge workers exploited in the process— in a kind of parallel with institutional critique and performance art. This was a result of what I would later be able to later identify as *reflexive methodology*, assessing how technological production in its current manifestation facilitates the labour conditions and cultural tendencies which sustain it (Alvesson and Skoldberg, 2000).

Around this time I discovered systems art, and was quite taken by Hans Haacke's *Condensation Cube* (1965-2008)— simultaneously an aesthetic object and one that *worked*, responding to its external conditions— *feedback!* Imagine, artwork inspired by cybernetics, one of the branches of engineering in which I specialize![7] At least it was a start. With the cubes of Haacke and minimalist artists freshly in my mind, I came up with the location for a site-specific work— my first art project since high school— which seemed appropriate for its familiarity: an engineer's cubicle. Site-specific but not fixed to any precise location, the work had a nomadic sense to it, an impermanence suggesting a kind of potential, which appealed to me. I didn't want to make art that was entirely cynical, even though it was largely disillusionment with the engineering profession and academic world that made art school seem appealing. But I wanted to make something that worked, a contraption of some kind and thoughts of oppressive office environments brought to mind executive toys, like *Newton's Cradle*. An excerpt from my process journal, dated October 2012:

> *... this is a site-specific work, and the site I've chosen— the technology workers' cubicle— [is] an interesting site because of its indifference to actual physical location... it could be anywhere... but like more contemporary site-specific work, we know that "site" has become more about context than co-ordinates, about what you can't see but can experience... playing off of the idea of an "executive toy"*

To engage the cybernetic/systems-theory tools which were such a strong part of my engineering practice, I came up with the idea of a feedback-controlled gantry which, in principle, could be manipulated by viewers, allowing them to strike a row of pendula almost at will, except for the perceptible intervention of a control system. Reflecting on the use of control system technology, I wrote (also October 2012):

> *there is no "full manual" mode because technology (represented here by the embedded control/intelligence) is ever-present; there is no way to shut it off anymore, and (like Ursula Franklin [says]) it's not just the gadgets and machinery, our culture and our institutions are shaped by technology's influence, the values that promote industrialization (things like efficiency, repro-*

[7] Enthusiasm damped only slightly by my subsequent reading of the *The Cyborg Manifesto* (Haraway, 1991)

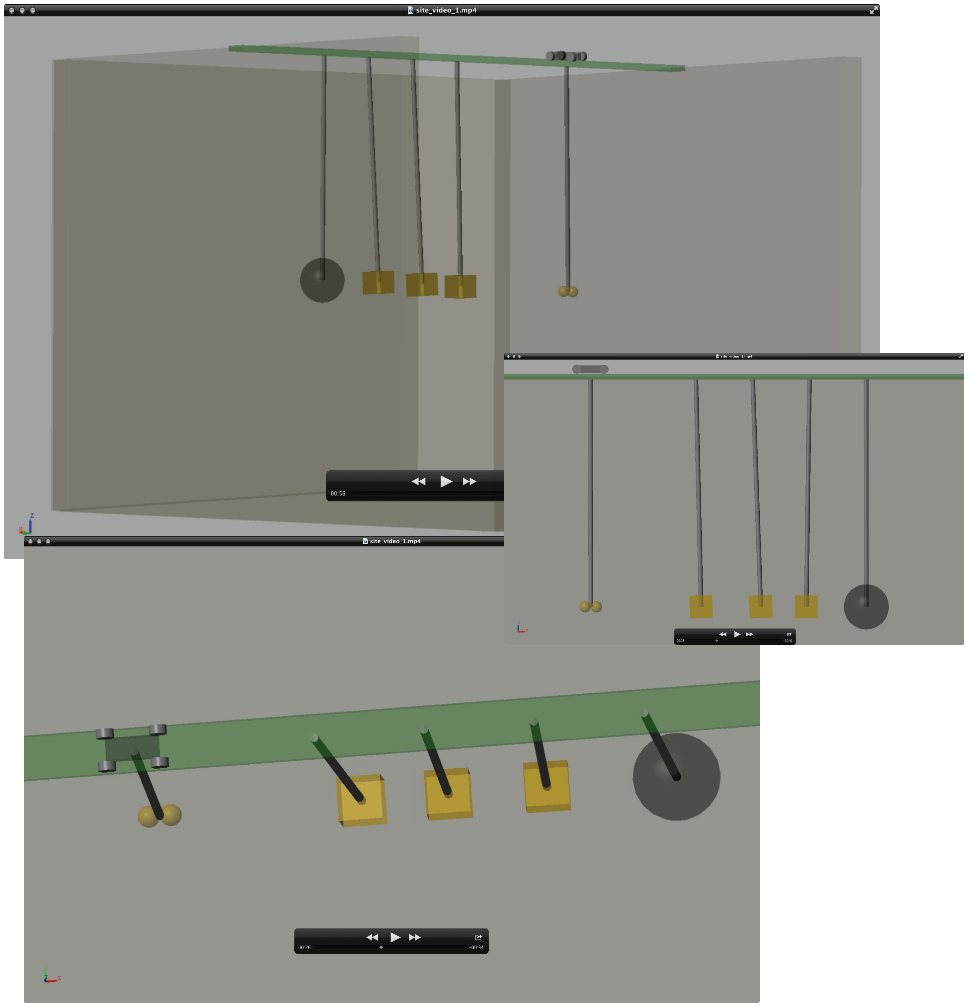

Figure 3.0.1: Screenshots of *i-Balls* (2012).

> *ducibility, performance, cost) seep into our way of life, in the things people “like” and “dislike”*

In part because of time constraints, the final implementation was a physics-based animation, rendered using the engineering computer-aided design software known as Matlab®, screenshots of which are shown in Fig. 3.0.1. I had also completed a substantial amount of conceptual sketches and derivations which, as a result of the parameters of the project, were, especially in Ian’s view, another creative dimension of the work, see Fig. 3.0.2.

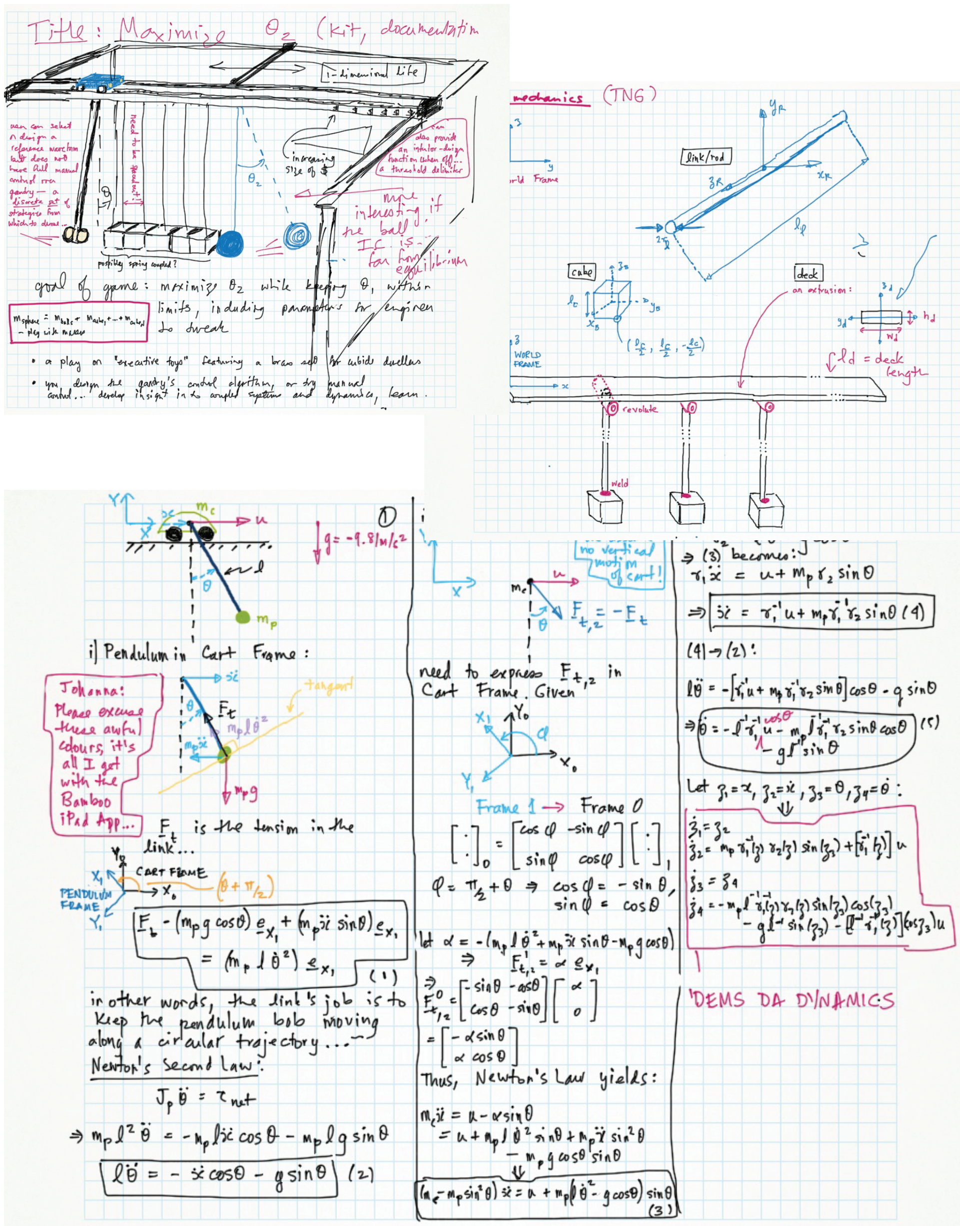

Figure 3.0.2: A sample of the development work (concepts, derivations) I did for *i-Balls* (2012).

Admittedly, I wasn't sure if this work was a game, a machine or a strange form of mathematically rigorous illustration. Some thematic aspects which emerged and would repeat themselves in much of the other work I was to do included technical mediation— especially in how cybernetics intervenes between a user and a task— and networks— how distinct areas of human activity are related within technological collectives. I had a desire to probe the systems constituting the fabric of societies, a tendency which made discourses like speculative realism appealing (Bogost, 2012). I was drawn to a way of interrogating works that seemed scientific, and I think, too, this influenced how I would like to engage a viewer, in a fundamental sort of metaphysical questioning. Also evident in this work is labour; the cubicle not only frames it but also foregrounds it. I later reprised the cubicle in physical form for the subsequent group exhibition, *Perspectives: Part I* in April 2013, Fig. 3.0.3.

Following the first semester of the MFA program, I wanted to hone my aesthetic sensibilities. I had been creating works which looked like "engineered systems," and, while this seemed to be a good direction, I had stumbled upon on it somewhat by default. I wanted there to be a stronger rationalization for my aesthetic choices. I was already getting looser with my illustrations, using comic-like depictions to inspire further machine production, as shown in Fig. 3.0.4. How could I also break out of my minimalist machine-making tendencies? While I searched for an improved machine aesthetic, I found that many contemporary conceptual artists seemed to be moving sympathetically, toward spare or "commonplace" aesthetics. The problem, I suppose, is that because I am an engineer, utilitarian is not ironic for me. It is, rather, a way of life. Conceptual art with its readymades, quasi-readymades and bricolage, was perfectly at ease with things looking utilitarian. Exhibitions around this time at the Art Gallery of Ontario by contemporary artists like Janet Cardiff, Georges Bu-

Figure 3.0.3: A physical object, *cubicle* (2013), made from construction lumber, plywood, mouldings, grey carpeting, latex paint, and various fasteners (original plans).

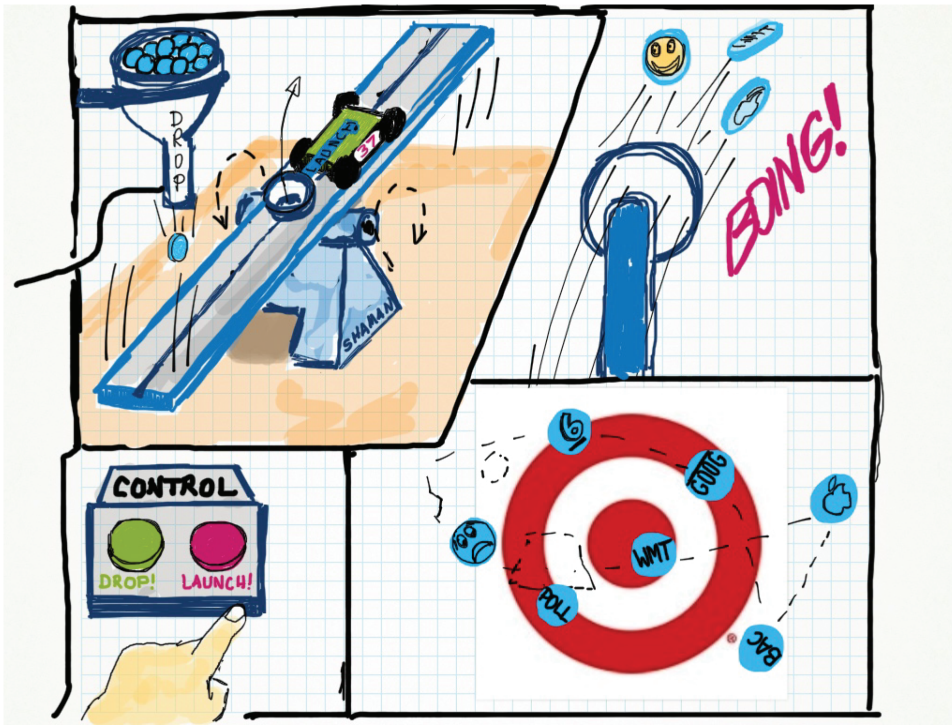

Figure 3.0.4: Conceptual drawing in planning phase of *i-Ching* (2012).

res Miller, Michael Snow and Ai Weiwei, seemed to embody aesthetic restraint, as if form had been subordinated to materiality, plurality or ideology. I thought that perhaps, because of my background, that I needed my work to be more aesthetically embellished. I experimented with a variety of forms (see Fig. 3.0.5), working at one point with random bits found in craft and surplus stores, supplementing made-from-scratch works with off-the-shelf pieces.

This aesthetic issue developed into a kind of existential crisis, and I began to question whether I was being authentic. Furthermore, I was not happy with my more aesthetic creations, some of which (shockingly) had no moving parts. They felt strange. Perhaps, I was not yet ready for a total departure from the utilitarian. At this time, I found re-reading Barry Allen's ideas conflating form and function quite helpful (Allen, 2008). How an object looks and feels is how it works. One could not hope for a better

Figure 3.0.5: Some examples of my aesthetic experimentation phase.

rationalization for a particular form. There are no aesthetic embellishments, but aesthetic features which relate to an object's ways of working. Even non-load-bearing features of bridges (e.g., towers, cladding) serve a perceptual function:

> *A bridge that is merely stable is like food that merely nourishes. Neither makes us want to come back. Neither gives us anything to live for. What's missing? Isn't it simply the good taste of art?* (Allen, 2008, p. 144)

which may seem like circular reasoning, as if Allen is saying that aesthetic properties of objects serve aesthetic functions. But Allen is referring to the *experience* of the bridge, in its totality, demanding of the designer nothing short of empathy toward users. Part of the experience of the bridge is the feeling of safety, especially if crossed regularly by commuters, and inspiration (rather than roller-coaster levels of exhilaration) in what the collective is capable of producing. The tricky part is to avoid thinking in dichotomous terms or to privilege function (form) over form (function). If anything, I surmised, this concern would likely enhance the "diffractivity" of the investigation.

zeroing in

Looking over the body of art work I have produced in the past couple of years, it is evident that machinery and process are recurring aspects for me. They are realms in which I'm looking for answers and, in this regard, feel like the right places to be for making art. I could not have foreseen this. I needed to experience it, to allow the practice to unfold, and I think art has to be this way. Art is a synthesis that happens largely at a level below conscious awareness. The same can be said for engineering when operating in an inventive mode.

Coming through the aesthetic struggle, I realized that I did not have to try to make engineered systems *look* like artworks. Rather, because my work is engineered to be art, it simply is art, by definition. There is the separate question: *how does one know that one is making art?* but this is an issue for every artist, not just one attempting to apply engineering techniques. As far as interdisciplinarity is concerned, this epiphany felt both profound and anti-climactic. There really aren't two disciplines. But there are. Rather than getting stuck in this paradox, I resolved to do what artists do when confronted with contradiction: proceed.

Chapter 4

my machines

> *A machine has to be constructed, and art as abstract machine will require an artist adequate to the task: a mechanic.*
>
> — Stephen Zepke (2005, Introduction)

Reality is fully appreciated only by taking into account its intricate dynamism and performativity. In the face of this unavoidable complexity, how do we make our lives embedded in such collectives? Systems engineering and cybernetics are not just about war machines and societal controls, but developing an understanding of how systems grow, decay and oscillate, the effects of network topology on system function, as well as the instrumental roles of feedback and nonlinearity in producing complex behaviour. Cybernetics offers a means by which we gain an understanding of dynamic interactions, discovering *how* actor-networks work. It is, for me, a medium through which I construct machines with metaphorical value. As far as the viewer is concerned, insights from the function and material traces of these works can, for example, suggest how we might be implicated in the causes of the circumstances in which we find ourselves, for, as Haraway notes, the cyborg is not innocent. Playing with such notions and inviting users into this world is part of my creative impulse. But is it art? In my practice, the questioning is more a matter of *how* than *why— I want the viewer to invent solutions, or, at least, attempt to do so.*

Asking *why* in technological collectives can lead us to short answers: *we seek instant gratification* or *we do not plan ahead*. After all, the leverage modern technology provides is considerable and increases seemingly without end. But it is through a complex web of interactions and feedback that the collective trauma of our immediate decision-making becomes apparent, so I do not see the question as *why*, but rather, *how* does this occur? This is a probing into the metaphysics of parallel chains of cause and effect, a speculative consideration of what is the nature of our action, and what our actions mean. This is not necessarily science fiction, but it has the air of science to it, as in a kind of thought experiment. As life in the matrix becomes increasingly complicated, we need an expanding literacy to survive it, perhaps partially achieved by introducing engineering into the art gallery, and, correspondingly, artistic ways of thinking into technological production.

Blending art and engineering can imply an inversion of aesthetic paradigm, in which what is ordinarily immaterial becomes central. My art practice is based on the foregrounding of technical labour— one means by which the network is revealed— through various material traces including sketches, derivations, mathematical manipulations, simulations and physical experiments. These elements constitute expressions of advanced engineering; simultaneously aesthetic objects onto themselves but also esoteric meanderings. Connecting this work to the finished products— underactuated balancing mimetic robots— suggests the impact of such technics, felt globally as a transformation into handheld lifestyle compounded by mounting piles of "well-made garbage" (Allen, 2008). Because how things are made now matters crucially, process art as well as performance art of immaterial labour capture our situation as never before (Jones, 2014). The current emphasis on making is a Renaissance-like movement, a lost tradition within the western canon finding relevance since (in what is ironic for me) the advent of industrialization.

In this thesis the machine functions as both artwork and metaphor. It is also a break in the flow of knowledge workers, who themselves are machines within a system of technological production which generates a flow of machines. The viewer is engaged in both process and function— within the artwork, the viewer is placed in the flow of technological production, to experience it and also, hopefully, to interrupt it. Whether or not technology's course is "good" or "bad," it powerfully influences culture and demands mindful consideration. Can we be mindful of technology without examining it? Technological growth is driven by a kind of delirium, for the expansion is not, for ecological considerations alone, rational. What then, is the nature of technological production as a machine, why and how does it operate?

The broad designation of *new media art* (NMA) which encompasses any artwork incorporating mechatronic or computing elements of any kind, problematizes a scholarly assessment of how a given work should situate itself amongst prior contributions in the mainstream art world (Shanken, 2009). More recently, however, robotic art is appearing with increasing frequency in major public galleries; as George Bures Miller has noted in a private chat with me "[high technology] is like the printing press," becoming commonplace and merely in the service of art. In historical terms, the collaborations between Klüver and artists like Warhol and Rauschenberg are the first examples of technological facilitation of an art project. However, arguably the abrupt end of the short-lived EAT was brought about by a failure to synthesize the negative ramifications of science and technology in the midst of the Vietnam War[1].

[1]Which is not to imply that EAT was not reflexive in regards to science and technology; indeed, the primary mandate of EAT was to conflate art and technology, to show that risk and uncertainty are as endemic to the hard sciences and engineering as they are to the visual arts (Kuo, 2011). However, in my opinion, EAT did not go far enough— viewers could still see science and technology as panacea— during a time of technology-enabled war.

The present work is no doubt *technological* and therefore may be cast within NMA. But more precisely it exists within a category of art which employs robotics as well as themes of industrial production and globalization, which is to say that technology is used reflexively rather than solely in the service of the aesthetic experience. Moreover the thesis works have a de-aestheticized character, i.e., each machine is developed sans façade as an "engineered work." The mimetic quality of the works in combination with motion also suggest a "performance by proxy," akin to a form of "second-order" performance art, a contemporary niche exemplified in the works by artists (to name a few): Lois Andison, Doug Back, Chris Burden, Janet Cardiff, Max Dean, Ken Feingold, Simone Jones, Laura Kikauka, George Bures Miller, Ken Rinaldo, David Rokeby and Norman White.

The material aspects of this art practice include the feedback-regulated underactuated machines themselves as well as the *material traces* of their developments embodied in sketches, writings, mathematical derivations and simulation results. The development process is of central concern in the thesis and is viewed as a performative dimension of the work. What elevates the making of machines itself to the status of art (apart from the aesthetic quality of the traces themselves) is firstly the use of relatively uncommon methods of making vis-á-vis the contemporary art canon which are currently implicated in an oppressive global materials economy, and secondly the intention to immerse the viewer in technological production as experienced by a worker.

4.1 installation

The venue selected for the exhibition was the industREALarts room, located at 688 Richmond St. in downtown Toronto[2]. With brick walls, concrete flooring and barred windows, the space is evocative of a knowledge-worker sweatshop or a small factory (see Fig.4.1.1), a setting appropriate to the foregrounding of process and labour.

The workbench, used extensively in the staging of the thesis exhibition, can be a site of sacred making, a repository of memory, or an instrument of subjugation. An art-historical precedent can be found in the oeuvre of contemporary artist Victor Grippo, who has employed the simple worktable to create installations, which suggest a lifetime of creation and experience haunted by adversity. The layout of the planned installation is shown in Fig.4.1.2, in which a labyrinthine configuration alludes to both Latour's writings on the "reality of science studies" as well as the ancient Greek mythological genius, Daedalus, whose fantastic machinations were both benefits and hazards to his patrons (Latour, 1999). The Minotaur and labyrinth are products of Daedalus's inventiveness, and the viewer is given the opportunity to navigate the crooked path of reason, should they dare.

The workbenches themselves are CNC cut and laser etched, then worked and assembled by hand. Each bench (minus an additional top) is made from a single 18-mm thick Baltic Birch plywood panel, measuring 4 ft. by 8 ft. (cutting diagram shown in Fig.4.1.3). Part workbench, part plinth, these objects retain a utilitarian appearance while conceding something to the gallery aesthetic (top, front and side views shown in Fig.4.1.4).

[2]Since the time of this writing, the thesis exhibition venue has been changed, however, the new setting shares many of the aesthetic qualities of the originally selected venue.

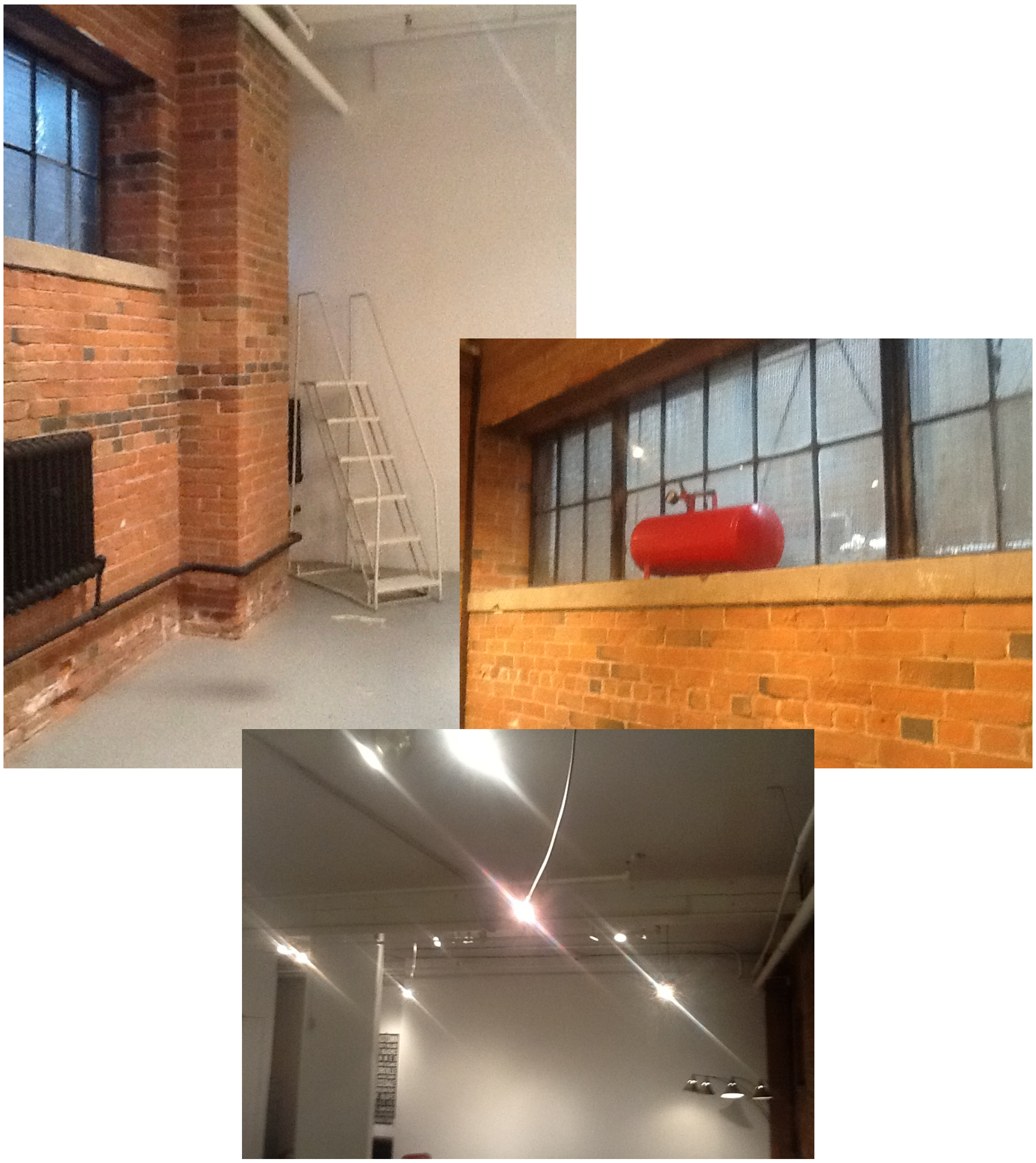

Figure 4.1.1: thesis exhibition venue: industREALarts room, interior shots, author's photos.

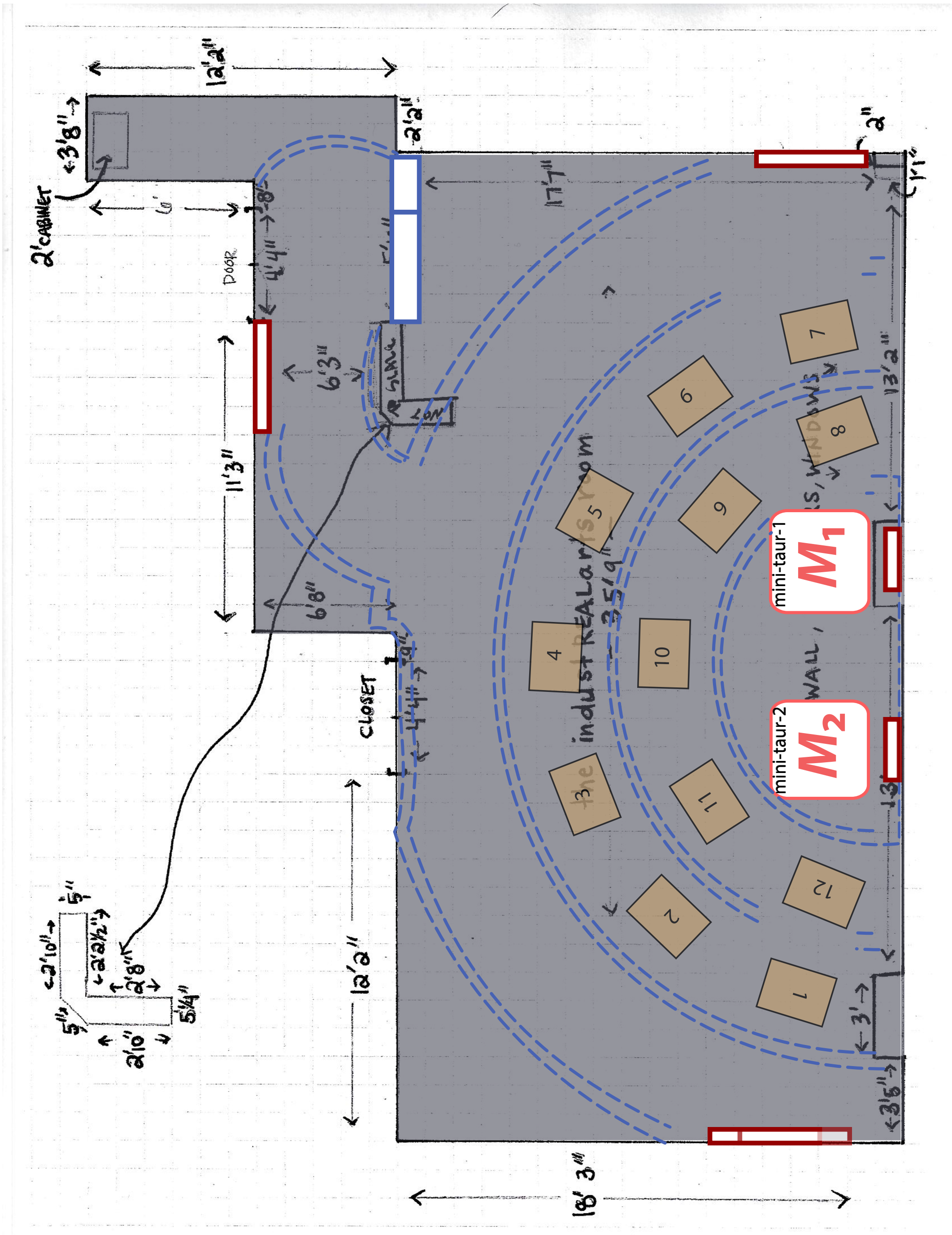

Figure 4.1.2: Floorplan of *auto-lysis* thesis exhibition. Workbenches are shown as numbered and are drawn to scale with respect to the floorplan (also to scale). Floorplan of the industREALarts Room courtesy Kirk Austensen and Cathy Mancuso.

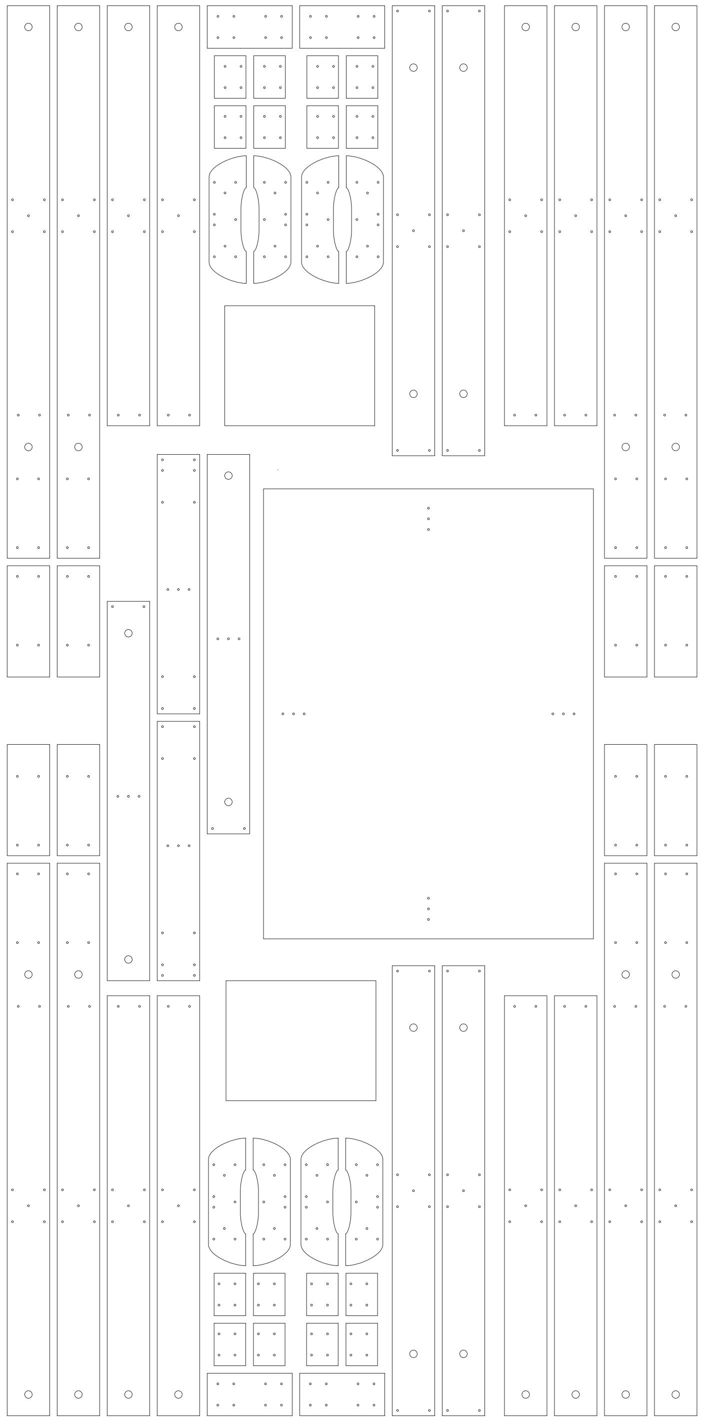

Figure 4.1.3: CNC cutting diagram for workbench design (by author). For scale reference, the workbench top (the large and unique rectangle in the plan) measures 30 in. by 22 in.

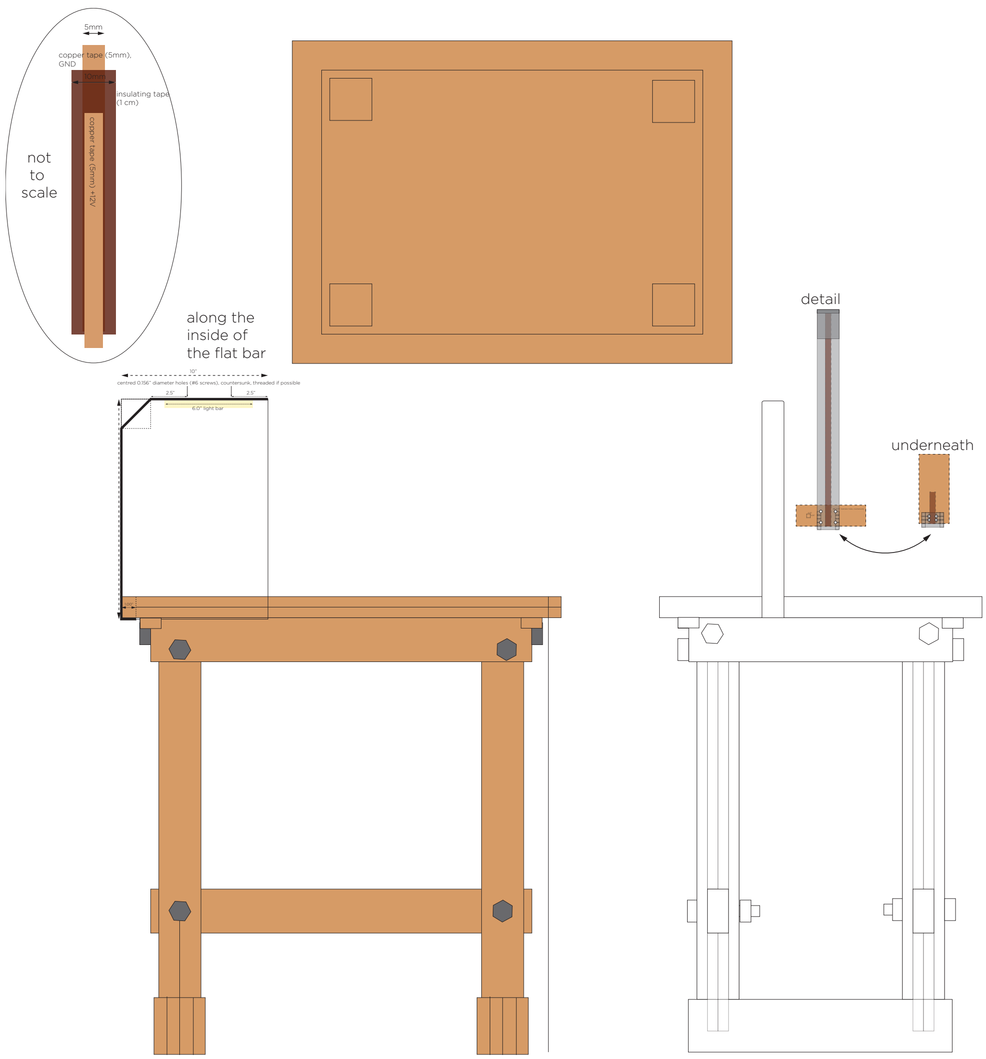

Figure 4.1.4: Top, front and side views of assembled workbench.

The actual work in developing the machines spanned a number of activities, including sketching, simulating, deriving, designing, prototyping and journaling. To capture the layering of work, moving between "real" and "representational" modes, and to suggest the diffractive use of methodologies ("seeing through one another"), I developed a series of palimpsest-like designs, each covering the entire work surface, which also serve to "transmute the equations"[3]. Layers of the palimpsest are distinguished with lighter or darker shades of grey, corresponding to lower and higher intensities of laser beam, framed by an iPad border hinting at the tool used to facilitate much of my creative thinking (and reinforcing a connection with technological production and labour). The laser beam embodies another layer of mediation, etching the palimpsest images (two of which are shown in Figs. 4.1.5 and 4.1.6) largely from hand-drawn work.

4.2 mimetic robots

The design and realization of underactuated machines is proposed as a methodological basis for my interdisciplinary art practice. A machine[4] is underactuated if it possesses more degrees of freedom (joints) than controls (actuators). Therefore, such a machine cannot be *directly* manipulated into a particular state or configuration[5]. While servo-driven robots tend to move *robotically*, with every motion determined explicitly by active means, underactuated systems capture the passive characteristics of animal locomotion and movement and therefore display a more mimetic quality

[3]As suggested by Prof. Dot Tuer during my first year at OCAD University.

[4]We define a *machine* as an assembly of rigid elements interconnected by joints which can be rotational (revolute) or linear (prismatic); each joint can represent more than one degree of freedom (DoF), and each degree of freedom corresponds to one configuration variable of the system.

[5]Unlike, for example, a "fully actuated" robotic arm possessing a motor at every joint which can be made immune to the effects of gravity and other known external forces.

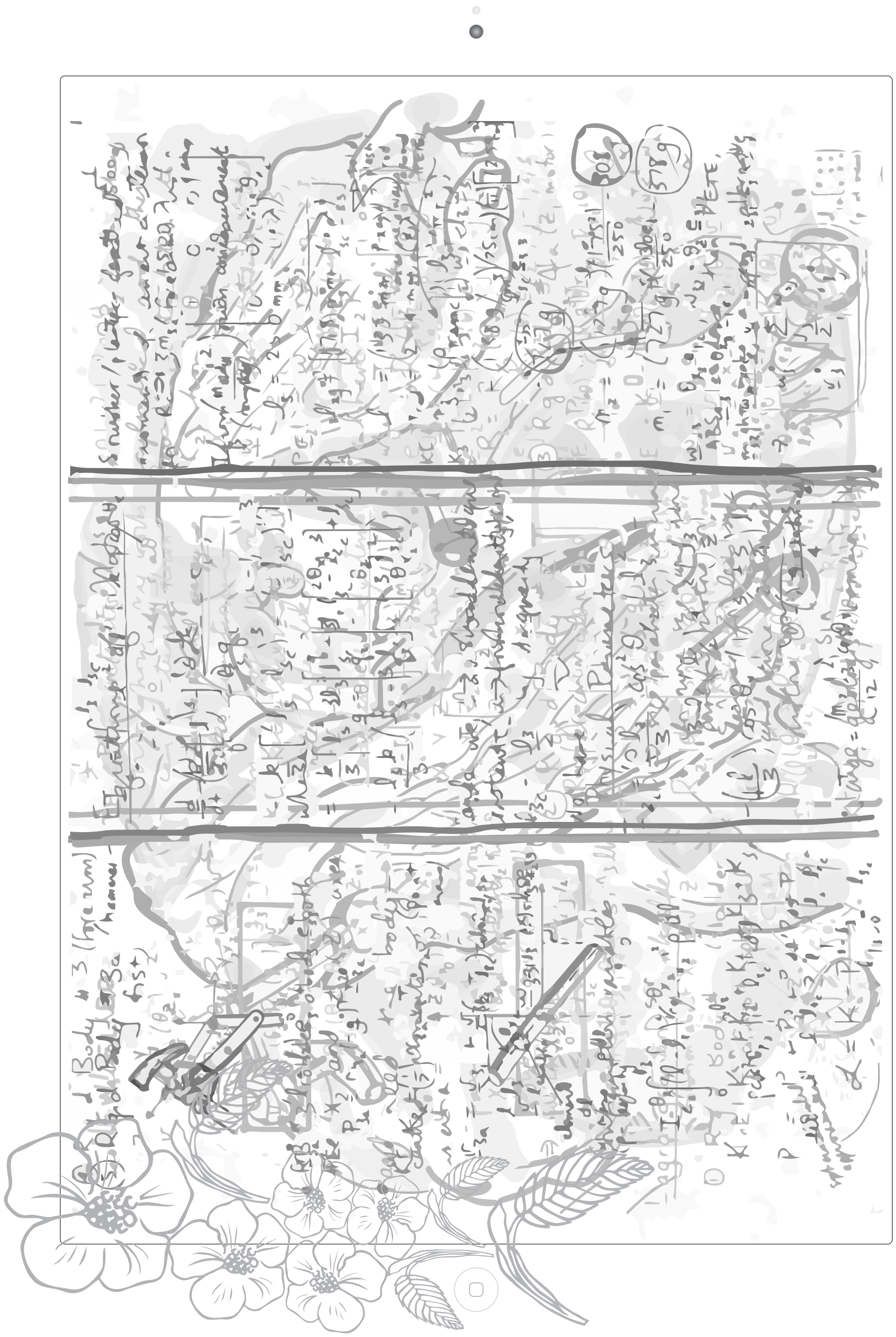

Figure 4.1.5: Laser-etched palimpsest design for workbench # 1, 30 in. by 22 in.

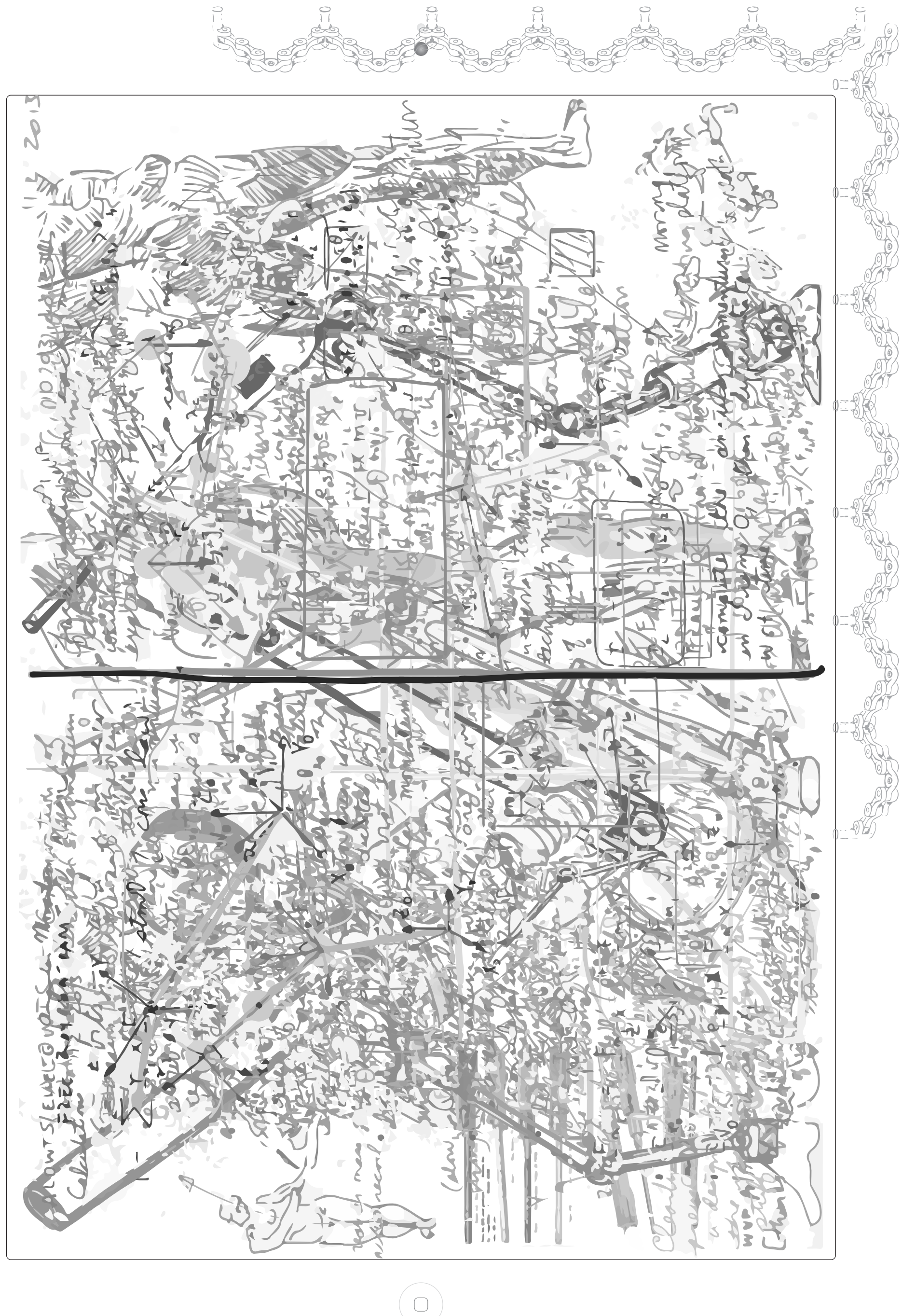

Figure 4.1.6: Laser-etched palimpsest design for workbench # 2, 30 in. by 22 in.

of behaviour. The significant challenge, however, is to elicit desired behaviours from an underactuated system. This requires a coordination of parts since we cannot unilaterally dictate the operation of each joint. There must be a blending of wills, the attainment of a moment-by-moment consensus of system and control. Such coordination is routinely performed by the human brain and nervous system for walking, which precisely coordinate muscle firings based on the vestibular sense, proprioception, etc., in order to achieve the stabilized bipedal gait.

To synthesize such a coordination requires both an understanding of the machine as a network of dynamically interacting elements and the use of feedback principles. Feedback control is the means by which systems— both animal and machine— autoregulate, and is widely employed in contemporary technologies[6]. Feedback control is an extreme form of technical mediation, not merely facilitating an activity as a passive implement functioning according to the user's will or as an exteriorization of the user's memory, but as a *decision-making* tool, a technology which supplants the user's judgment, issuing commands and taking actions on behalf of the user.

The art-machines developed in the thesis are *Elle Eg* and *El Bo*, shown in Figs. 4.2.1 and 4.2.2, respectively. The first machine features a completely passive two-DoF ankle and semi-passive knee (stabilized via elastic cords) along with a two-DoF actuated hip. The machine attempts to remain balanced through hip movements alone, moving its upper link (torso) about two orthogonal rotational axes, according to a controller algorithm develop using system theory. The second machine has a passive one-DoF

[6]Common examples would include temperature control (using thermostats), cruise control, anti-lock braking systems, traction control systems (sometimes referred to as "nanny mode"), auto-pilots and economic control via prime-lending-rate adjustment. The body contains many control systems which use a combination of electrical signals and hormones to regulate a wide range of autonomic functions; for example, the cardiovascular system adapts heart and breathing rate to demand and insulin controls the uptake of glucose to regulate blood sugar level.

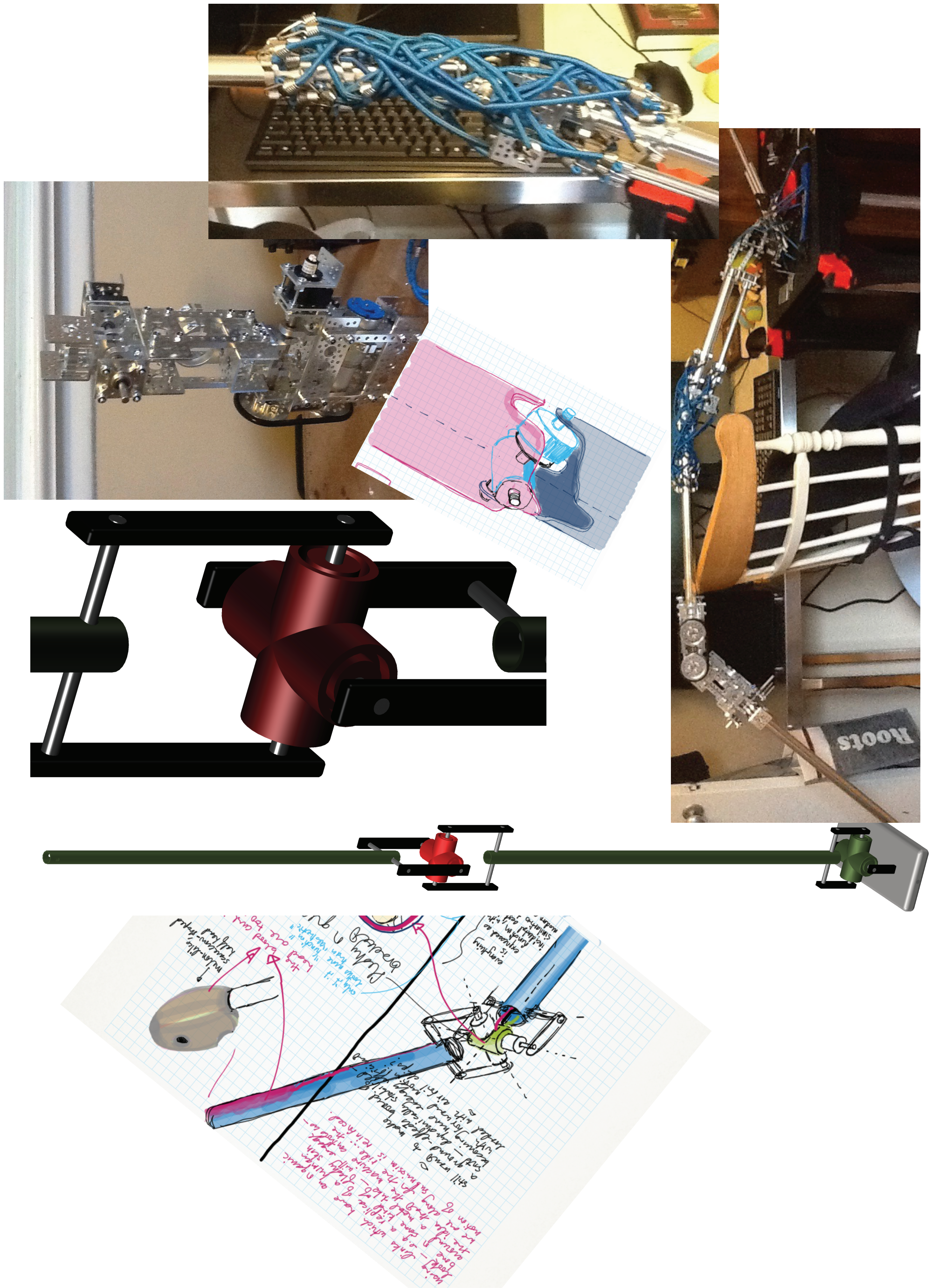

Figure 4.2.1: Art-machine *Elle Eg*, concepts sketches and photographs (2014).

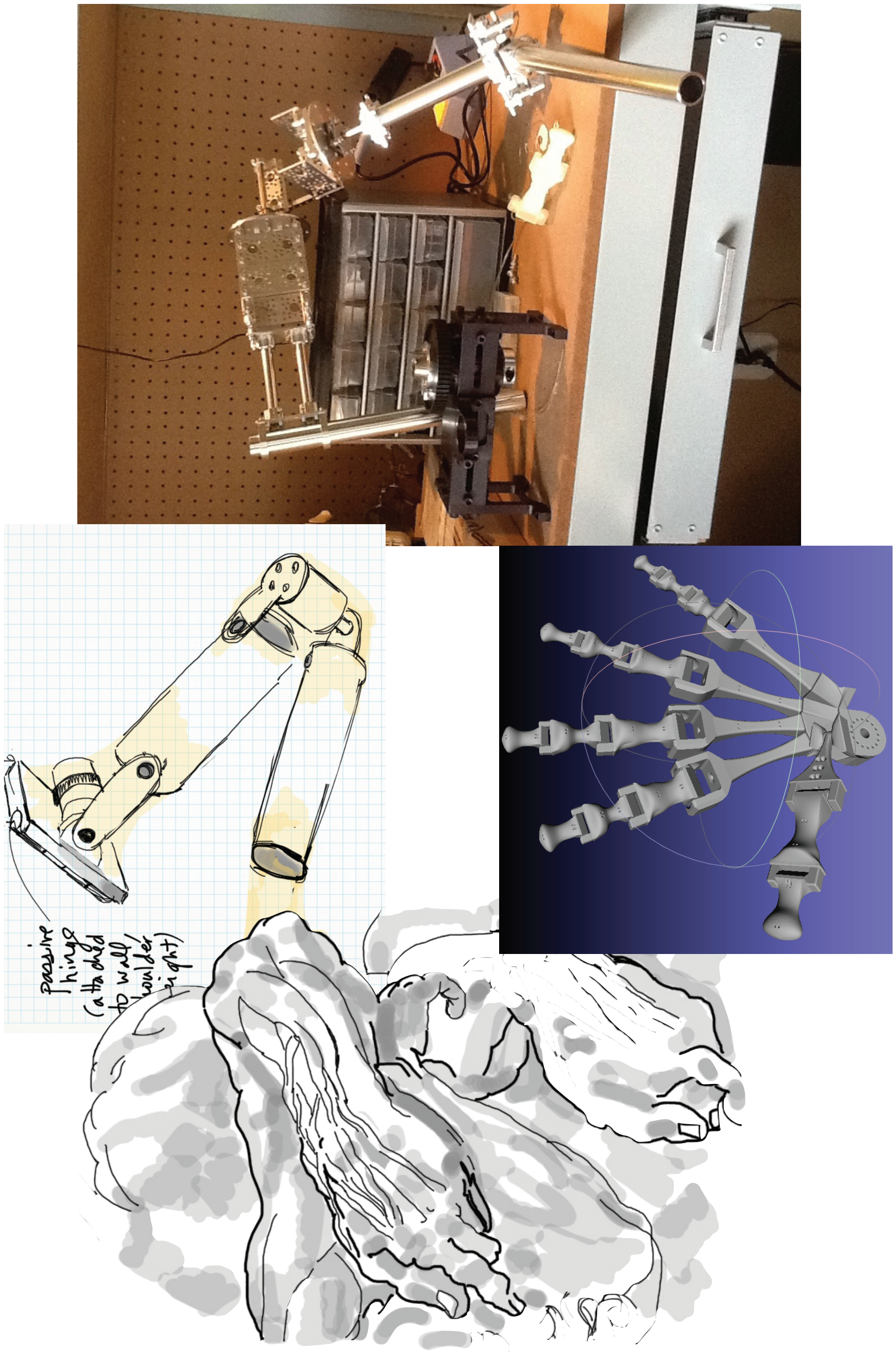

Figure 4.2.2: Art-machine *El Bo*, concepts sketches, solid model (STL image file) and photograph (2014).

elbow, and attempts to stabilize its arm in the upright position through shoulder movement. *El Bo* also features a fully articulated passive hand, as shown in Fig. 4.2.2, which can be threaded with nylon cord to allow grasping.

The underactuated property of a machine parallels the nature of complex and dynamic real-life networks. Whether a single actuator amongst many joints and links is able to effect change throughout the system is a matter of agency. Agency in such a network does not come straightforwardly through sheer force, but through special action. Latour states, "... action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled." In a similar fashion, in an underactuated system an *action* (in the sense of Latour) can be understood as a circuitous propagation of causes-and-effects which lead to a net result. Therefore, while the art-machines of this work are of comparatively low order by the standards of real-world networks in their "full realness" they are in themselves apparatuses of agency, providing a means of experimenting with what we can do from where we are given our constraints.

Chapter 5

conclusion

> *So technical people, objects, or skills are at once inferior (since the main task will eventually be resumed), indispensable (since the goal is unreachable without them), and, in a way, capricious, mysterious and uncertain (since they depend on some highly specialized and sketchily circumscribed knack).*
>
> — Bruno Latour (1999, p. 190)

As a thesis conducted within a fine arts educational institution but employing engineering methodology— a self-imposed constraint— a fundamental question reads as follows: *within the artworld context, does engineering have anything to say?* The scientific apparatus, as a platform of investigation, shares much in common with the work of art. As with conceptual or process art, the apparatus *performs*, engaging the viewer in an enactment, inviting the viewer to (re)consider "something we took for granted" (Monk, 2002). Like the experimental platform, art provides us with a focused context and the means to investigate, to discover new relationships amongst the familiar. As with the "synoptic tableau" of science, we can hypothesize and correlate our experience of the work with our thinking to arrive at new realizations (Latour, 1999).

The art-machines of this thesis employ technical mediation in the form of feedback control to coordinate motion, but the net motion comes from multiple agencies, including those of the humans who presumably designed the machine for a particular function, who organized its architecture and programmed its controller to operate in a particular manner. The machines and installation become an apparatus to consider the myriad possibilities by which the network is configured in the technological collective. How are the various human actants, from those who could have served as referents (possibly hundreds of years ago) to those who pieced together these creations, be implicated in the ensuing upheavals, within the network and beyond? How does the presence of various non-human mediators affect the network, dynamically shaping the ontologies of all actants? What do we become? The questioning is important but the answers are unknowable— the topology is not known, the parameters are not known— so the system evades prediction. The idea that we can't possibly know the outcome is good to know. Moreover, stimulating our speculative muscle is not only engaging, but necessary for informed agency within the collective. And I think that's all I could hope for in regards to my artwork.

The coupling between humans and technology is a dynamic one, which, in our times of rapid technological change, is persistently in a condition of non-equilibrium. That is, the circumstances are not static, and are likely subject to time constants on the order of a human lifespan, making a characterization of the dynamic coupling empirically difficult. What can we expect, then, in the long-term (or to invoke dynamical systems parlance: asymptotic) sense? My work can offer a coming to terms with our inexorable technological constitution, not a seeking of escape to an idealized nature somehow devoid of technology or a shedding of organicity for some purely mechanized existence, but a consideration of the myriad possibilities by which we might live as cyborgs.

5.1 future work

Whether or not the artworks produced in this thesis are considered successful, I know that I have benefitted tremendously in the attempt. There have been no more intellectually stimulating spans of my life than the past two and a half years spent as a graduate student at OCAD University. Above all, art serves no one. It is the freest domain of human expression. Like design— what I had thought I would be studying at OCAD U.— art observes. But unlike design, in which the application frames the observation, in art, the artist alone determines the parameters of their investigation. I can think of no other discipline so unfettered. Most of us are habituated to think within certain limits, even discouraged from thinking "too creatively," and I wonder if our collective condition is not the result of a kind of insanity— fixed in our thinking but expecting transformation. And I understand the need to keep things in check, why, for example, professions have regulatory bodies to ensure established procedures are adhered to in the interests of public safety. On the other hand, I have also experienced on too many occasions great obstacles to the creative impulse, in situations where new ways of thinking should be embraced. So I would like, somehow, for this interdisciplinary experiment to continue, to be reiterated by other individuals. I think more engineers need to experience what I have experienced. As much as I would like to believe that I have made progress in the hybridizing of art and engineering, I think the best result from my thesis is to have demonstrated that an engineer who receives training in fine art can experience a worthwhile transformation, even if the change comprises nothing more than a heightened capacity to empathize, the mustering of sufficient courage to take occasional chances outside conventional boundaries and an appreciation of to whom the engineer may be ultimately accountable.

Bibliography

Barry Allen. *Artifice and Design: Art and Technology in Human Experience*. Cornell University Press, Ithaca, NY, 2008.

Mats Alvesson and Kaj Skoldberg. *Reflexive Methodology: New Vistas for Qualitative Research*, chapter On Reflexive Interpretation: the Play of Interpretive Levels, pages 238–257, 288–292. Sage Publications, 2000.

Anne Balsamo. *Designing Culture: The Technological Imagination at Work*. Duke University Press, 2011.

Karen Barad. *Meeting the Universe Halfway: Quantum Physics and the Engtanglement of Matter and Meaning*. Duke University Press, Durham & London, 2007.

Claire Bishop. Digital divide. *Artforum*, 51(1):434–441, September 2012.

David Blair. *The Israeli laser-guided bomb strikes Gaza with the speed and menace of a dagger*. URL: http://www.telegraph.co.uk/news/worldnews/middleeast/israel/11006911/The-Israeli-laser-guided-bomb-strikes-Gaza-with-the-speed-and-menace-of-a-dagger.html, August 2014.

Ian Bogost. *Alien Phenomenology, or What It's Like to Be a Thing*. University of Minnesota Press, Minneapolis, MN, 2012.

Candice Breitz. *From A to B and Back Again*. OCAD University President's Speaker Series Lecture, September 2013.

Judith Butler. *Bodies that matter: On the discursive limits of "sex"*. Routledge, New York, NY, 1993.

Daniel L. Byman. *Do Targeted Killings Work?* URL: http://www.brookings.edu/research/opinions/2009/07/14-targeted-killings-byman, July 2009.

Dieter Daniels and Barbara U. Schmidt. *Artists as Inventors / Inventors as Artists*. Hatje Cantz Verlag, Ostfildern, Germany, 2008.

Gilles Deleuze and Félix Guattari. *Anti-Oedipus*. Continuum, London, 2004.

Frank Dietrich. Visual intelligence: The first decade of computer art (1965-1975). *Leonardo*, 19(2):159–169, 1986.

Ursula M. Franklin. *The Real World of Technology*. House of Anansi Press, Toronto, ON, 2004.

Donna Haraway. *From Cyborgs to Companion Species: Dogs, People and Acquiring Genomes in Natureculture (2003-2004 Avenali Chair in the Humanities Lecture, Presented by The Doreen B. Townsend Center for the Humanities, UC Berkeley)*. URL:https://www.youtube.com/watch?v=Q9gis7-Jads, September 16 2003a.

Donna J. Haraway. *Simians, Cyborgs and Women: Reinvention of Nature*. Routledge, New York, NY, 1991.

Donna J. Haraway. *The Companion Species Manifesto: Dogs, People and Significant Otherness*. University of Chicago Press, Chicago, IL, 2003b.

Martin Heidegger. *The Question Concerning Technology*, pages 3–35. Harper & Row Publishers, New York, NY, 1977.

Amelia Jones. *Material Traces: Time and Gesture in Contemporary Art*. OCAD University Lecture, February 2014.

Ross King. *Brunelleschi's Dome: How a Renaissance Genius Reinvented Architecture*. Penguin Books, Toronto, ON, 2000.

Billy Klüver and Robert Rauschenberg. *Experiments in Art and Technology: A Brief History and Summary of Major Projects (1966-1998)*. Experiments in Art and Technology, Berkeley Heights, NJ, 1998.

Michelle Kuo. *Test Sites: Experiments in Art and Technology (Festival of Art, Science and Technology, MIT150)*. URL: http://video.mit.edu/watch/michelle-kuo-test-sites-experiments-in-art-and-technology-7744/, February 2011.

Miwon Kwon. *One Place After Another: Site-Specific Art and Locational Identity*. The MIT Press, Cambridge, MA, 2004.

Geoge Lakoff and Mark Johnson. *Metaphors We Live By*. University of Chicago Press, Chicago, IL, 2003.

Bruno Latour. *Pandora's Hope: Essays on the Reality of Science Studies*. Harvard University Press, Cambridge, MA, 1999.

Bruno Latour. *Reassembling the Social: an Introduction to Actor-Network Theory*. Oxford University Press, Oxford, 2005.

Bruno Latour. International Seminar on Network Theory Keynote: *Networks, Societies, Spheres: Reflections of an Actor-Network Theorist*. URL: https://www.youtube.com/watch?v=Bj7EDMRJrbU, Feb. 2010.

W.J.T. Mitchell and Mark B.N. Hansen. *Critical Terms for Media Studies*. The University of Chicago Press, Chicago, IL, 2012.

Philip Monk. *Ian Carr-Harris: Works: 1992-2002*. The Power Plant, Toronto, ON, 2002.

George Petelin. It's research but not as we know it! *Scope (Art & Design)*, 5&6:8–16, 2010-2011.

Rachel Philpott. Studies in Material Thinking. *Inside Making*, 09(05):1–16, April 2007.

Edward A. Shanken. *Art and Electronic Media*. Phaidon Press, New York, NY, 2009.

Edward A. Shanken. Introduction: New Media, Art-Science and Contemporary Art: Towards a Hybrid Discourse? *Artnodes*, 1(11):65–67, 2011.

Bill Shannon. *Private Communication*. Studio Visit, OCAD University, September 2013.

Geoffrey Shea. *Private Communication*. OCAD University, February 2013.

Tiziana Terranova. Free Labor: Producing Culture for the Digital Economy. *Social Text*, 18(2):33–58, Summer 2000.

The J. Paul Getty Museum. *Gold-Ground Panel Painting*. URL: http://www.getty.edu/art/gettyguide/videoDetails?segid=440, 2014.

Sarah Thornton. *Seven Days in the Art World*. Granta Publications, London, 2008.

Natalie Thaïs Uomini and Georg Friedrich Meyer. Shared Brain Lateralization Patterns in Language and Acheulean Stone Tool Production: A Functional Transcranial Doppler Ultrasound Study. *PLoS ONE*, 8(8):e72693, August 2013.

Giorgio Vasari. *Lives of the Artists*. Dover Publications, Inc., Mineola, NY, 2005.

Norbert Wiener. *Cybernetics: Or the Control and Communication in the Animal and the Machine*. The MIT Press, Cambridge, MA, second edition, 1961.

Stephen Zepke. *Art as Abstract Machine: Ontology and Aesthetics in Deleuze and Guattari*. Routledge, New York, NY, 2005.