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# Machines for Living

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**Abstract**

Machines for Living

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This thesis describes *A Machine for Living In*, a digital media artwork using newly available computational and sensing tools to study the home as a site of intimate life. The title invokes Le Corbusier's modernist framing of the house as a machine to interpret the promise of contemporary smart home technologies. The project has two distinct phases: the construction and inhabitation of a functional smart home system, followed by an exhibition of processed data as a multi-part digital art installation. In a process of joint human-machine authorship, this system produces a complex portrait of the home: as a space of language, intimacy, bodily practice, and quotidian narrative. Compositionally, it contrasts utopian illusions of beautiful, frictionless utility with artistic strategies generating insight into the messy, material realities of the everyday.

The thesis begins with three key frames of reference for the work in Bachelard's topoanalysis, critical engineering design, and site-specific and systems-oriented arts production. It describes early projects pursuing the psychological study of intimate life, leading to the current work. It recounts the conceptual and technical development of *A Machine for Living In*, and discusses the composition of the resulting exhibition. The thesis concludes with a speculative framing of this research as a kind of introspective design: a hybrid practice of targeted inquiry to provide insight about both human and machine.

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## **DEDICATION**

To my parents, for starting my education,  
and to Leah and Jasper for seeing me through to the end.

## Chapter 1. INTRODUCTION

### 1.1 OVERVIEW

This thesis describes *A Machine for Living In*, a digital media artwork using newly available computational and sensing tools to study the home as a site of intimate life. The title invokes Le Corbusier's modernist framing of the house as a machine to interpret the promise of contemporary smart home technologies. The project has two distinct phases: the construction and inhabitation of a functional smart home system, followed by an exhibition of processed data as a multi-part digital art installation.

In a process of joint human-machine authorship, this system produces a complex portrait of the home: as a space of language, intimacy, bodily practice, and quotidian narrative. Compositionally, it contrasts utopian illusions of beautiful, frictionless utility with artistic strategies generating insight into the messy, material realities of the everyday. The project was first exhibited in the Foster Art Gallery at Westminster College in New Wilmington, Pennsylvania, in August of 2017.

Le Corbusier's valorization of the machine—the product of engineered utility—is resonant with a contemporary utopian spirit founded on the potential of ubiquitous sensing, embedded computing, and machine learning. Where the airplane and automobile were the models of his time, the computer has become our dominant metaphoric and idealized machine.

In my doctoral studies I have explored diverse modes of human-computer interaction through digital art, creating poetic intersections of human and machine perception. Delving further into my history as an artist, I have often sought to engage the intimate circumstances of life through my work: whether exploring relationships, family structure, studio processes, or systems of

communication and exchange. My dissertation continues these twin threads of technical exploration and intimate investigation. I build on Bachelard's topoanalysis—the systematic psychological study of sites of intimate life—striving for similar goals through technological means in a process of technological topoanalysis.

The purpose for my project is two-fold: to use emerging technologies to study the home as an intimate site; and in so doing, to interpret the qualities and implications of those new techniques. My goal is to produce a reciprocal diagnosis of human and machine. Accordingly, I combine methods from engineering design, psychological exploration, and art production. This work is a meeting of systems art, poetic topoanalysis, and machine design.

In summary, the larger arc of my research considers how evolving technologies impact our most personal lives. As we live in increasingly intimate codependence with our technologies, our understandings of ourselves must change. This state of technological cohabitation, with all of its immanent potential and unforeseeable consequence, is the subject of my research for the foreseeable future. The practices documented in this paper point towards that broader investigation of machine living. I advocate for the design of introspective machines that harness the potential and reveal the limitations of new technologies, while bringing insight into the intimate conditions of the everyday.

## 1.2 STRUCTURE

This paper is divided into five chapters.

Chapter 1 introduces my project, potential contributions to the field, and the structure of this document.

In Chapter 2, *Art, Technology, and Intimate Life*, I articulate three key frames of reference for my work: engineering design, art production, and psychological exploration. I discuss the most relevant theories and practices for each domain.

Chapter 3, *Strategies and Explorations*, illustrates my practice through early projects leading to the current work. I discuss formal strategies of model-limited experience, opportunistic systems, digital surrogacy, machine observers, joint human-computer authorship, and machine as metaphor as they have been developed in these past works. Each project engages different modes of intimate experience.

Chapter 4, *A Machine for Living In*, describes the dissertation project in five sections.

In "Arriving at Home," I describe my interest in the home as a subject in all of its experiential complexity: as a space of language, intimacy, bodily practice, quotidian narrative, and as the focus of contemporary smart home enthusiasm.

In "Le Corbusier and Machine Living," I introduce Le Corbusier's affinity for the machine and his modernist conception of the house as a machine for living. I identify echoes of this spirit in the contemporary idealization of ubiquitous sensing, embedded computing, and machine learning, particularly as they combine in popular enthusiasm for the smart home.

In "House-Machines" I establish a formal context for this project through other house works and art to be inhabited: architectural (Le Corbusier), cinematic (Keaton), fictional (Bradbury, Casares), and technoscientific (Roy).

In "Site Observation" I describe the hardware and setup for the site-specific phase of the project. I identify the key experiential layers of domestic space, and match them with effective technologies for capturing domestic activity. I describe the sensing apparatus built, the parameters of site observation, and the scope of collected data.

In "Constructed Home" I describe the structure of the inaugural exhibition of this work at the Foster Art Gallery at Westminster College. I relate the forms and composition developed to key artistic references for the work. I consider the compositional problem of working with complex, multi-modal data: how to synthesize diverse machine observations into a singular, cohesive viewer experience. I describe my approach to temporal composition. I also discuss the dynamics of shared agency in this process of joint human-machine authorship.

Finally, in Chapter 5, Conclusions and Future Directions, I describe new horizons for the work: new forms for the *Machine for Living In*, and future directions for the broader research practice. The paper concludes with a speculative framing of my work as kind of intimate science: a hybrid art and technology practice designing introspective technologies to provide insight about both human and machine.

## Chapter 2. ART, TECHNOLOGY, AND INTIMATE LIFE

My research is devoted to the domain of intimacy, to the domain in which psychic weight is dominant.<sup>1</sup>

–Gaston Bachelard

I have at various times worked as a neuroimaging researcher, experimental game designer, circuit designer for consumer electronics, and as a painter in a studio. This paper describes multiple years of digital arts research into the smart home. What unifies these diverse activities?

Like Bachelard in his *Poetics of Space*, I would claim my research operates in "the domain of intimacy." Though the forms change from project to project, with their particular subjects and material engagements, I consistently return to a desire to understand and interpret the intimate circumstances of the everyday. This has led me to artistic explorations of the constituents of human identity such as language, cognition, relationships, and the body. I have built projects around speech recognition, mechatronic automation, physical sensing, computer vision, and machine learning, as these technologies increasingly shape our interactions and experience. Artistically, I am informed by the rich history of artists' responses to and interventions in their own intimate lives.

Theoretically, I seek to situate these diverse modes of research and production within a unified frame of inquiry. This chapter details the key references for my work. Investigating the circumstances of intimate life, my practice resonates with Bachelard's topoanalysis in analytic intent, psychological interest, and poetic method. In art production, I utilize strategies of site specific engagement and systems construction to produce art to be inhabited, informed by models drawn from literature, speculative fiction, and the history of art and technology. Treating

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<sup>1</sup> Gaston Bachelard, *The Poetics of Space* (Boston: Beacon Press, 1994), 12.

technology as both tool and subject, freighted with sociocultural meaning, my work aligns with Critical Engineering Design, and practices of the Bureau of Inverse Technology (Jeremijenko and Rich) and Machine Therapy (Dobson).

The projects discussed in this paper build on the tradition of art to be inhabited. They are sites studied through constructed intervention. They seek poetic insight through technical means, juxtaposing mechanisms of human and machine. They pursue a psychological understanding of the space of everyday experience.

## 2.1 TOPOANALYSIS

Of course, thanks to the house, a great many of our memories are housed... A psychoanalyst should, therefore, turn his attention to this simple localization of our memories. I should like to give the name of topoanalysis to this auxiliary of psychoanalysis. Topoanalysis, then, would be the systematic psychological study of the sites of our intimate lives.<sup>2</sup>

-Gaston Bachelard

The house, for me functions as “a simple localization” of themes, material, and technical possibility. It is a complex site. In his *Poetics of Space*, Bachelard uses the house as the structuring image through which he examines the poetry and psychology of intimate space. His topoanalysis, described above, is an apt frame for my work as an art and technology researcher: engaged in “the systematic psychological study of the sites of our intimate lives.” Trained as a painter and engineer, experimental in my forms and methods, my development as an artist has been a gradual sharpening of focus onto these sites of intimate human experience, exploring the consequences of emerging technologies. Given the widespread adoption of tech into our intimate lives, a study of embedded, situated, “smart” technology is, for all intents and purposes, a study of intimate life. What I find

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<sup>2</sup> Ibid., 8.

compelling in Bachelard's work is his method combining a systematic analytic approach, psychological interest, anchored to real sites, with a seriousness about the significance of poetic imagery.

I was introduced to Bachelard's ideas during my MFA studies at University of California, San Diego, through the animation work of Carl Burton, particularly his short film *Shelter* that dwells in a Bachelardian notion of intimate, inhabited space.<sup>3</sup> I was reintroduced to Bachelard's ideas and became more invested in them as a doctoral student at the Center for Digital Arts and Experimental Media at the University of Washington, through discussions with my faculty Juan Pampin, Richard Karpen, and James Coupe. I was particularly struck by the General Exam prompt they authored for my colleague Ha Na Lee out of Bachelard's *Poetics of Space*: "The great function of poetry is to give us back the situations of our dreams."<sup>4</sup> Lee's resultant work, *Vestiges II*, itself a dreamlike exploration of space, can be viewed online.<sup>5</sup>

In *The Poetics of Space*, Bachelard takes a systematic approach to his study of intimate space. He takes the reader through discussions of houses, rooms, nests and shells, inhabitation, the dialectics of large and small, and the dialectics of within and without. These discussions are anchored to real sites: the home, the attic, the cellar, the living room, the cave, or the city apartment. For each, he analyzes those spaces as evocative sites, as locations of memories, and as images in particular works of poetry or art.

Bachelard attributes a specific potency to the poetic image: "the reader of poems is asked to consider an image not as an object and even less as the substitute for an object, but to seize its

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<sup>3</sup> Carl Burton, *Shelter* (accessed March 15, 2018); available from <http://carlburton.io/index.php?/anim/shelter/>.

<sup>4</sup> Bachelard, 15.

<sup>5</sup> Ha Na Lee, *Vestiges II*, 2013, (accessed March 14, 2018); available from <http://hanalee.me/projects/projects/vestiges.html>.

specific reality.”<sup>6</sup> According to him: “By its novelty, a poetic image sets in motion the entire linguistic mechanism.”<sup>7</sup> There is a radical transsubjectivity in the poetic image for Bachelard. Poetry supersedes language: the poet’s invented images spark a sympathetic creative genesis in the reader’s mind. Poems operate through “resonances and repercussions”: resonating with our life in the world, repercussions awakening new depths in the reader.<sup>8</sup> “At the level of the poetic image, the duality of subject and object is iridescent, shimmering, unceasingly active in its inversions.”<sup>9</sup>

Where Bachelard aims for a poetic interpretation of built space, I extend his idea of "intimate sites" to include any of the systems, relationships, and contexts where we find intimacy in life. For instance, my grandmother’s diagnosis with Alzheimer’s is explored through the creation of an interactive chatbot and my dialog with the system in *Megahat Grandmommy*.<sup>10</sup> Similarly, an imaginary daughter is the conceptual machine to unpack my fantasies of parenthood in the *Father-Daughter Art Show*.<sup>11</sup> Language, drawing, and mirrored self-image are similarly addressed as moments of intimate exchange engaged through well-constructed art systems. On a closer reading of Bachelard’s work, I began to see his ideas as a natural frame for my art. I too am concerned with the psychological study of these intimate sites, using new computational and sensing techniques in a kind of technological topoanalysis.

Significantly, Bachelard focused much of *The Poetics of Space* on the home as a subject. He describes the house as a vertical and concentrated being, and establishes a system of meanings for

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<sup>6</sup> Bachelard, xix.

<sup>7</sup> Ibid., xxiii.

<sup>8</sup> Ibid., xxii.

<sup>9</sup> Ibid., xix.

<sup>10</sup> Robert Twomey, *Megahat Grandmommy*, 2005; available from <http://roberttwomey.com/megahat-grandmommy>.

<sup>11</sup> Robert Twomey, *Father-Daughter Art Show*, 2007; available from <http://roberttwomey.com/father-daughter-art-show>.

spaces in the house along those axes: rationality for the roof, irrationality for the cellar.<sup>12</sup> The house becomes “a tool for analysis of the human soul.”<sup>13</sup> It is defined by its enclosure, a simple encapsulation of space in opposition to the surrounding nature. Its primary function is shelter, and its primordial form is the cave. For Bachelard the house is a kind of spatialized representation, creating a diagrammatic relationship between the physical arrangement of rooms and the psychological organization of the individual: “On whatever theoretical horizon we examine it, the house image would appear to have become the topography of our intimate being.”<sup>14</sup> This casts the house as an intimate, psychological spatial diagram.

## 2.2 SITE SPECIFICITY

By drawing a diagram, a ground plan of a house, a street plan to the location of a site, or a topographic map, one draws a "logical two dimensional picture." A "logical picture" differs from a natural or realistic picture in that it rarely looks like the thing it stands for. It is a two dimensional analogy or metaphor—A is Z.

The Non-Site (an indoor earthwork) is a three dimensional logical picture that is abstract, yet it represents an actual site in N.J. (The Pine Barrens Plains). It is by this three dimensional metaphor that one site can represent another site which does not resemble it."<sup>15</sup>

- Robert Smithson

The first major frame for my arts production is site specificity. *A Machine for Living In* establishes a descriptive relationship between observations of an actual, inhabited house site, and a condensed representation of that space in the gallery exhibition. As such, it is participating in the

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<sup>12</sup> Bachelard, 18.

<sup>13</sup> Ibid., xxxvii.

<sup>14</sup> Ibid., xxxvi.

<sup>15</sup> “A Provisional Theory of Non-sites,” in Robert Smithson, *Robert Smithson, The Collected Writings*, ed. Jack D. Flam (Berkeley: University of California Press, 1996), 364.

tradition of site specific art: artists who develop work out of intense engagements with particular geographic and conceptual sites. Specifically, Robert Smithson's seminal non-site artworks are a key model for the two-part process of this project.

In his *Nonsites*, described in the passage above, Smithson establishes an abstract relationship between a real site and its gallery representation, the "three dimensional logical picture." He portrays this conceptual pairing of crafted object and observed site as a spatial metaphor. The constructed site does not resemble the actual site, but describes it through some abstract process other than likeness.

There is space in this definition for computational production: data driven representations are abstracted, derived from observation, and function through visual means beyond resemblance. The most powerfully operative strategy here is the idea of metaphor: "Between the *actual site* in the Pine Barrens and *The Non-Site* itself exists a space of metaphoric significance." Rather than poetic metaphor, Smithson argues for "an entirely new sense of metaphor' free of natural or realistic expressive content."<sup>16</sup> In Figure 2.1 we see this abstract mapping between the aerial map of Pine Barrens and the constructed sculpture in the gallery space. Rather than working with conventional visual metaphors, he establishes a new aesthetic vocabulary inspired by science fiction, photography, and born out of the administrative aesthetic of conceptual art.<sup>17</sup>

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<sup>16</sup> Ibid.

<sup>17</sup> For more on the administrative aesthetic, see H. D. Buchloh Benjamin, "Conceptual Art 1962-1969: From the Aesthetic of Administration to the Critique of Institutions," *October* 55 (Winter 1990), <http://dx.doi.org/10.2307/778941>.

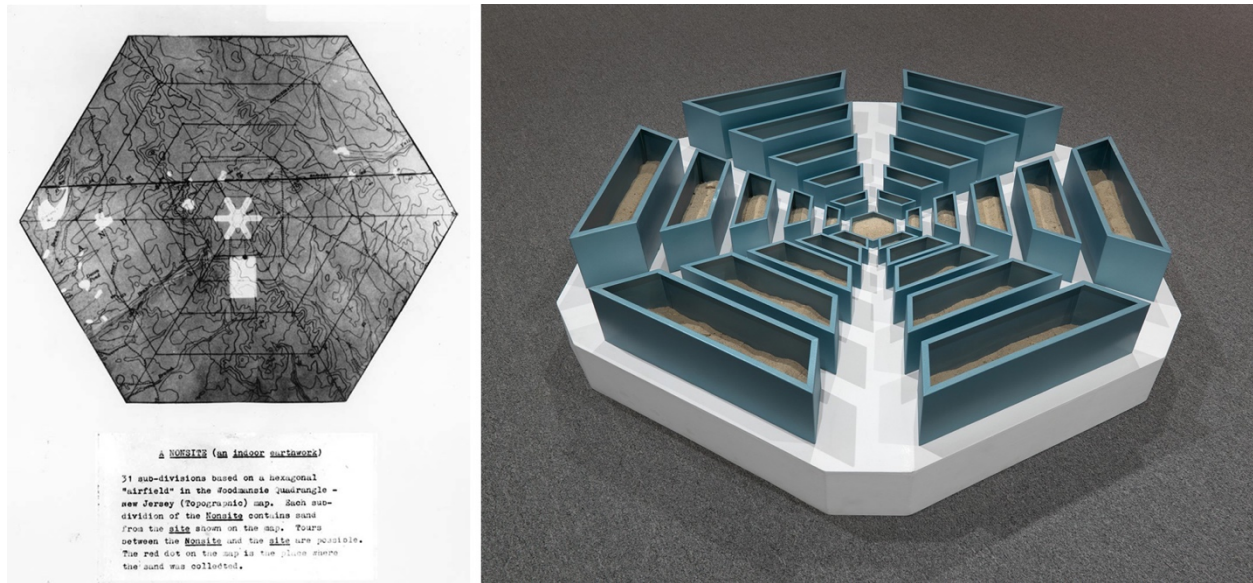


Figure 2.1. Robert Smithson *A Nonsite, Pine Barrens, New Jersey*<sup>18</sup>

In non-sites such as the Pine Barrens, Smithson focused on collapsing space and distance through his representations of remote sites. However, Smithson was also interested in the ontological categories of place and their semantic meanings. His text *Untitled (Site Data)* is "an attempt to locate structural meanings by observing building sites within a kind of abstract anthropology."<sup>19</sup> Spaces discussed include the urban apartment, the artist's studio or loft, the suburban house, the art gallery (since the late 50s), the art museum (modern), the urban office building, and the industrial site (dams and spillways, power plants, flood control and irrigation works, tunnels bridges roads and parking lots, and air terminals). Work with that last category— industrial sites—became his most well-known subject, as in *Monuments of Passaic*, where he brings an archeologist's interest to them as ruins of modern society.<sup>20</sup> *Untitled (Site Data)* is an

<sup>18</sup> Robert Smithson, *A Nonsite, Pine Barrens, New Jersey*, 1967, Photostat of map., and Robert Smithson, *A Nonsite, Pine Barrens, New Jersey*, 1968, Sculptural nonsite.

<sup>19</sup> "Untitled (Site Data)," in Smithson, *Robert Smithson, The Collected Writings*.

<sup>20</sup> Robert Smithson, *Monuments of Passaic*, 1967, (accessed March 15, 2018); available from [https://www.robertsmithson.com/photoworks/monument-passaic\\_300.htm](https://www.robertsmithson.com/photoworks/monument-passaic_300.htm).

inventory of places and their meanings. I find Smithson's descriptions entirely charged with potential, as spaces for action or production.

Georges Perec accomplishes a similar structural reading of space through more diverse textual strategies in his *Species of Spaces*.<sup>21</sup> In a slow zoom out, he travels from the page, to the bed, the bedroom, the apartment, the apartment building, the street, the neighborhood, the town, the countryside, the country, Europe, the world, and Space. With Perec there is no deferred artistic production and no future site-specific artwork: the text is the work.

My work embraces an expanded notion of site specificity. Where Smithson deal with concrete, geographical sites, in my work I am interested in Bachelardian sites: broadened from concrete locations to abstract loci of content and meaning. Family as a site of drama. Studio as a site of creative work. Sites are concrete nuclei of meaning whether spatial, psychological, or cultural.

### 2.3 SYSTEMS CONSTRUCTION

Conceptual focus rather than material limits define the system. Thus any situation, either in or outside the context of art, may be designed and judged as a system.<sup>22</sup>

–Jack Burnham

The second major frame for my art production is systems construction. In 1950 Ludwig von Bertalanffy outlined his *General Systems Theory*, a science of wholes, studying "systems of various orders not understandable by investigation of their respective parts in isolation."<sup>23</sup> He

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<sup>21</sup> Georges Perec, *Species of Spaces and Other Pieces*, Rev. ed. (New York, N.Y., USA: Penguin Books, 1999).

<sup>22</sup> Jack Burnham, "Systems Esthetics," *Artforum* 7, no. 1 (September 1968): 32.

<sup>23</sup> Ludwig von Bertalanffy, *General Systems Theory; Foundations, Development, Applications* (New York: G. Braziller, 1969).

distinguishes between two types of systems: "open" and "closed" depending on whether they admit energy and material from their environments or stand apart in isolation. Once, systems thinking was the purview of military scientists and academic specialists, but today systems have become a commonplace frame for understanding any complex, multicomponent circuits of communication and exchange.

In 1968, sculptor and critic Jack Burnham published "Systems Esthetics" in *Artforum*. In that article, he proposes systems thinking as the dominant paradigm of the time, articulating a societal transition "from an object-oriented to a systems-oriented culture."<sup>24</sup> This claim is more complicated today, as we seem suspended somewhere between the two. Increasingly we imbue our objects with agency, perception, and intelligent response through computational technologies. Smart, internet-connected things function as both.

Burnham situated contemporaneous art practices in relation to those systems theories, articulating a precedence for systems over objects: "art does not reside in material entities, but in relations between people and between people and the components of their environment."<sup>25</sup> From these new theories grew new conceptions of the artist's role as "a perspectivist considering goals, boundaries, structure, input, output, and related activity inside and outside the system."<sup>26</sup> Contemporary artists, cognizant of the network of possible contexts, communities, and information channels for their work, adopt similar global systems perspectives on the function of their work.

Burnham engaged a broad scope of sites through his systems analyses, concerned with "the creation of stable, on-going relationships between organic and non-organic systems, be these neighborhoods, industrial complexes, farms, transportation systems, information centers,

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<sup>24</sup> Burnham, 31.

<sup>25</sup> Ibid.

<sup>26</sup> Ibid., 32.

recreational centers, or any of the other matrixes of human activity."<sup>27</sup> The house functions as one such “matrix of activity,” and is particularly dense in numbers of human and non-human agents, relationships in motion, and layers of material accretion.

Beyond the construction of pure, functional technologies, there is a rich ecosystem of possible forms at the periphery of systems art. I’m most interested in applying systems paradigms to interpret these non-technological sites: installation artworks as networks of signifying objects, as narrative systems and linguistic systems; cybernetics and systems perspectives on artist-object-viewer relationships; ways to situate non-technical, non-canonical Systems Artists who engage with complex human phenomena.

What would a non-technological systems art look like? For instance, consider Mary Kelly's *Post-Partum Document* (1973-79)<sup>28</sup> as a work of systems art, portraying the first years of her child’s life as a complex psychological, familial, and linguistic system. What is a systems art engaged with the real, lived conditions of human experience in all of its messy materiality? My work explores multiple parallel systems strata: both complex functional technologies and the soft human structures they engage with.

Mary Kelly’s *Post-Partum Document* (Figure 2.2) is an analysis of parenthood / child rearing as a systems of communication and exchange. It explores layers of consumption and waste (“dirty nappies”), language and communication, and psychoanalytic theories of child development through lived experience as a parent. The resulting artwork is also a configurable network: a signifying system of objects, images, and text that can be reconfigured to adapt to exhibition

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<sup>27</sup> Ibid., 31.

<sup>28</sup> Mary Kelly, *Post-Partum Document*, 1973-1979; available from [http://www.marykellyartist.com/post\\_partum\\_document.html](http://www.marykellyartist.com/post_partum_document.html).

scenarios and alternate print media form. Kelly's book "Post-Partum Document"<sup>29</sup> adapts and expands upon the project through multiple additional channels of communication. She writes supplementary text, reframes images, and establishes a new textual ordering of the materials produced through the project. *Post-Partum Document* becomes a diffuse cluster of activities, a system of meaning, producing diverse experiential artifacts.



Figure 2.2. Mary Kelly *Post-Partum Document*

Mary Kelly's project is a personal inventory of intimate experience, assisted by the child as catalyst and anchoring subject. Birth and parenting provide frames to examine theories of language, development, psychoanalysis. Simultaneously, the project is a means to document intimate life. Where the child is Kelly's device and conceptual lens, for me the machine is other.

## 2.4 CRITICAL ENGINEERING DESIGN

The significant artist strives to reduce the technical and psychical distance between his artistic output and the productive means of society.<sup>30</sup>

- Jack Burnham

<sup>29</sup> Mary Kelly, *Post-Partum Document* (Berkeley, Calif.: University of California Press, 1999).

<sup>30</sup> Burnham, 31.

The third frame for my work is critical engineering design: practitioners who create work to use and interpret new technologies. As Burnham describes above, there is a currency in engaging technically and psychically with “the productive means of society.” These critical engineering practices capitalize on the capabilities of new technologies, but simultaneously reveal their limits and human consequences. This is part of critical, cultural sense-making — provoking informed perspectives on the uses, meanings, and transformative potential of new technologies.

Anthony Dunne and Fiona Raby popularized the term Critical Design in the late 90s, first using the phrase in their book *Hertzian Tales*. Critical Design encompasses a number of practices that “use design as a medium to stimulate discussion and debate ... about the social, cultural, and ethical implications of existing and emerging technologies.”<sup>31</sup> Speculative designs “challenge narrow assumptions, preconceptions and givens about the role products play in everyday life.”<sup>32</sup> In part, this is a bid for cultural and technical relevance, “significance” as Burnham describes it above. Critical Design is “one of the many mutations design is undergoing in an effort to remain relevant to the complex technological, political, economic and social changes we are experiencing at the beginning of the 21c.”<sup>33</sup> Dunne and Raby invest in the central importance of designed products as mass media and consumer interfaces, imbuing product design with the criticality of other avant-garde cultural practices.

Oliver, Savičić, and Vasiliev provide a technologically focused update to Critical Design in 2011 with their *Critical Engineering Manifesto*. “The Critical Engineer considers Engineering to be the most transformative language of our time, shaping the way we move, communicate and

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<sup>31</sup> Dunne and Raby, *Biography* (accessed March 15, 2018); available from <http://www.dunneandraby.co.uk/content/biography>.

<sup>32</sup> Dunne and Raby, *Critical Design FAQ* (accessed March 15, 2018); available from <http://www.dunneandraby.co.uk/content/bydandr/13/0>.

<sup>33</sup> Ibid.

think. It is the work of the Critical Engineer to study and exploit this language, exposing its influence.”<sup>34</sup> This belief in the centrality of engineering in determining sociocultural behavior and values is shared with the next practice I discuss in detail: *The Bureau of Inverse Technology*. Where Critical Engineering differs is in expressing a skeptical and somewhat paranoid worldview. In addition to the need for technological literacy, they speak of the “challenge and threat” of technological dependence, a desire to “incite suspicion,” “exposing influence” and “moments of imbalance and deception.”<sup>35</sup> This is a language of resistance to power, exposing hidden mechanisms of control, and the user constraints built into the formal strictures of engineered design.

The authors identify a reciprocity in the constitution of engineering and its subjects: “each work of engineering engineers its user.” I identify a similar reciprocity in the knowledge gained through my experimental human-computer interactions: they effect a reciprocal diagnosis of human and machine where we learn something about each. In terms of practical medium, the critical engineers seek to observe and operate in “the space between the production and the consumption of technology,” adopting strategies from “art, architecture, activism, philosophy and invention.”<sup>36</sup>

Finally, Critical Engineering arrives at a systems perspective: “The Critical Engineer expands ‘machine’ to describe interrelationships encompassing devices, bodies, agents, forces and networks.” This generalization of the category of machine is one Le Corbusier makes implicitly though his mechanized theories of architecture, one I adopt in my own work and research, and

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<sup>34</sup> Julian Oliver, Gordan Savičić, and Danja Vasiliev, *Critical Engineering Manifesto* (accessed March 14, 2018); available from <https://criticalengineering.org/>.

<sup>35</sup> Ibid., see items 1, 3, and 4.

<sup>36</sup> Ibid.

serves to connect Critical Engineering practice to the long discourse and heritage of the machine in industry and culture.

#### 2.4.1 *Inverse Technologies*

Natalie Jeremijenko and Kate Rich's Bureau of Inverse Technology (BIT) bills itself as "an information agency servicing the Information Age."<sup>37</sup> Their reflexive approach turns the products of technical innovation to examine the systems and structures that produced them. As I see it, the practice has three key ideas: that data has values (particularly in what is and isn't measured), that artists and designers importantly render things legible, and that cultural producers operate both through experimental prototyping and mediagenic spectacle.

Their project *Suicide Box* (1996) demonstrates these strategies.<sup>38</sup> This was an autonomous computer vision system monitoring the Golden Gate bridge, at the time the most common site for suicide attempts in the Bay Area and the country. Installed on site with a view of the bridge, the system looks for vertical motion in a camera feed and records those events to disk, creating "public, frame-accurate data of a social phenomenon not previously accurately quantified."<sup>39</sup> This project raises questions of what information counts, what we choose to observe, and what jobs we task our technologies with. Site specific and locally engaged, this project complicates our understanding of the context and culture of San Francisco and the Bay Area as "Information capital and Suicide capital of the USA."<sup>40</sup> Additionally, the piece makes corporations involuntarily

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<sup>37</sup> Bureau of Inverse Technology, (accessed March 14, 2018); available from <http://bureauit.org/bitindex.html>.

<sup>38</sup> Bureau of Inverse Technology, *Suicide Box*, 1996, (accessed March 14, 2018); available from <http://bureauit.org/sbox/>.

<sup>39</sup> Ibid.

<sup>40</sup> Ibid.

complicit, citing sponsorship from Silicon Graphics, Microsoft, NBC, Genentech, Fox, Failure Analysis, and Disney.

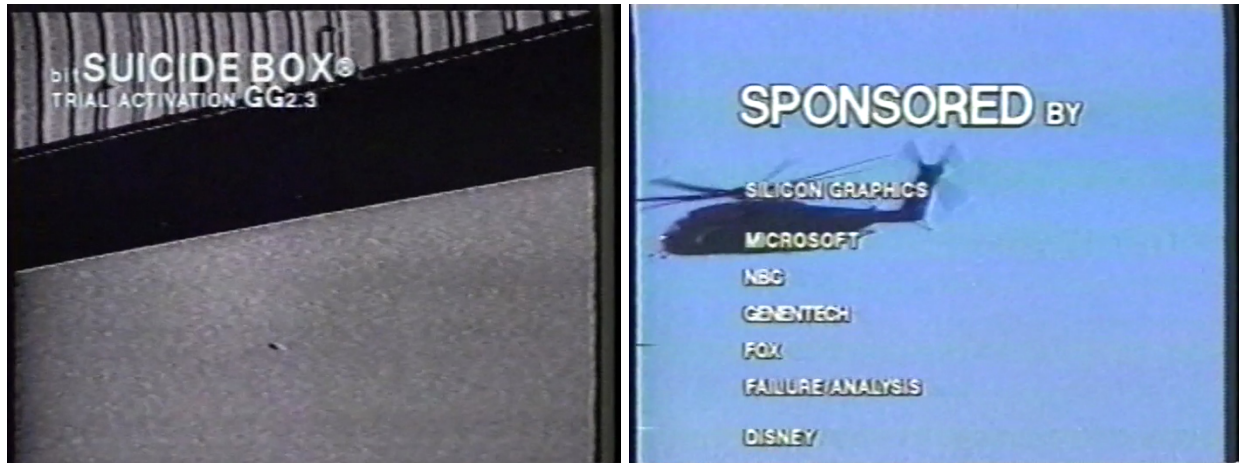


Figure 2.3. Bureau of Inverse Technology, *Suicide Box* (1996)

Through the corresponding video produced about the project (and later exhibited), BIT renders visible the issue of suicide, questions the social and governmental response to this known problem, and conveys some of the complicated ethical terrain underlying the creation and deployment of advanced technologies. The video of the project (and indeed videos of other BIT related projects) exists as a mass media communication that can circulate widely. While a smart use of media technology and a clever manipulation of the conventions of mass commercial communication, my critique of BIT's methods has to do with what I consider an experientially impoverished result for the viewer. It's all about the corporation, the technological apparatus, and a critical examination of the forces "out there." The work's cold, technical surface cuts it off from the domain of intimacy. But perhaps that is the point.

I am interested in using similar techniques to related ends: achieving a reciprocal diagnosis that examines the nature of the human as well as the nature of the machine, and how they construct one another.

If BIT was the appropriate pseudo-corporate entity to service the information age, what is the necessary entity to service ours? Jeremijenko now operates the Environmental Health Clinic,<sup>41</sup> providing prescriptions for improving our wellness (and the planet's), developing mutualistic systems engaged with our ecological environment. I believe there is still a need for inverse technologies: we are living through a second machine age built on machine perception and machine learning, defined by these new applications of computational technology.

I will end with some provocation from Natalie Jeremijenko on the relation between art and technoscience, New York Magazine from 2000:

The art world is a very prissy little thing over in the corner, while the major cultural forces are being determined by technoscience. The whole way we imagine ourselves is being redefined, and the art world is still talking about gender politics or whatever without taking on big corporate biotechnical advances. Technology is a language that is much less about privilege, it's much less intimidating conceptually than art criticism—one knows how to use a computer keyboard.<sup>42</sup>

#### 2.4.2 *Machine Therapy*

A more intimate approach to critical engineering, Kelly Dobson's Machine Therapy is a “parapraxis of machine design,” creating connections with machines through their visceral side-effects “in ways that are revelatory and potentially therapeutic for people.”<sup>43</sup> In Machine Therapy, “it is not the main functions that the machines are designed to carry out that matter most, but rather it is the side elements of their designs and actions that matter to people in deep yet unconscious

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<sup>41</sup> Natalie Jeremijenko, *Environmental Health Clinic* (accessed March 14, 2018); available from <http://www.nyu.edu/projects/xdesign/clinic/>.

<sup>42</sup> Natalie Jeremijenko, interview by Courtney Eldridge, 2000, *The New York Times Magazine*.

<sup>43</sup> Kelly Dobson, “Machine Therapy” (Ph.D. diss., Massachusetts Institute of Technology, 2007), 20.

ways."<sup>44</sup> A hybrid art and technology practice, Dobson's work is visceral, psychological, and potentially therapeutic. It is also acutely personal. Dobson frames her practice as arising from personal experiences communing with industrial machines.

Like Bachelard, Dobson's work is inherently psychological. Invoking therapy, she suggests that one or both parties (human and machine) is in need of a cure. This relates to my own idea of reciprocal diagnosis of human and machine: that through unexpected encounters we reveal something about the nature of each. In 2005, Dobson conducted a series of "Machine Therapy Sessions" with her interactive devices and documented participants' responses to their experience.<sup>45</sup> Many sought to prolong their engagements, and found near-total immersion in their experience.

Dobson's projects focus on "visceral, cathartic, and reflexive expressions and communication".<sup>46</sup> Rather than denying the sonic, haptic, and visual qualities of machines, she connects them to processes of human expression. For instance, *Blendie* is "a modified mid-1940's Osterizer blender that foregrounds the guttural sounds of a blender in action."<sup>47</sup> *Blendie* analyzes sound with its embedded microphone and signal processor to detect human vocalizations matching its own "guttural" blender voice. It uses the dominant pitch of the user's voice to modulate the speed of its motor, creating a sympathetic re-embodiment and establishing a visceral empathy.

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<sup>44</sup> Ibid., 19.

<sup>45</sup> Ibid., 71.

<sup>46</sup> Ibid., 3.

<sup>47</sup> Ibid., 79.

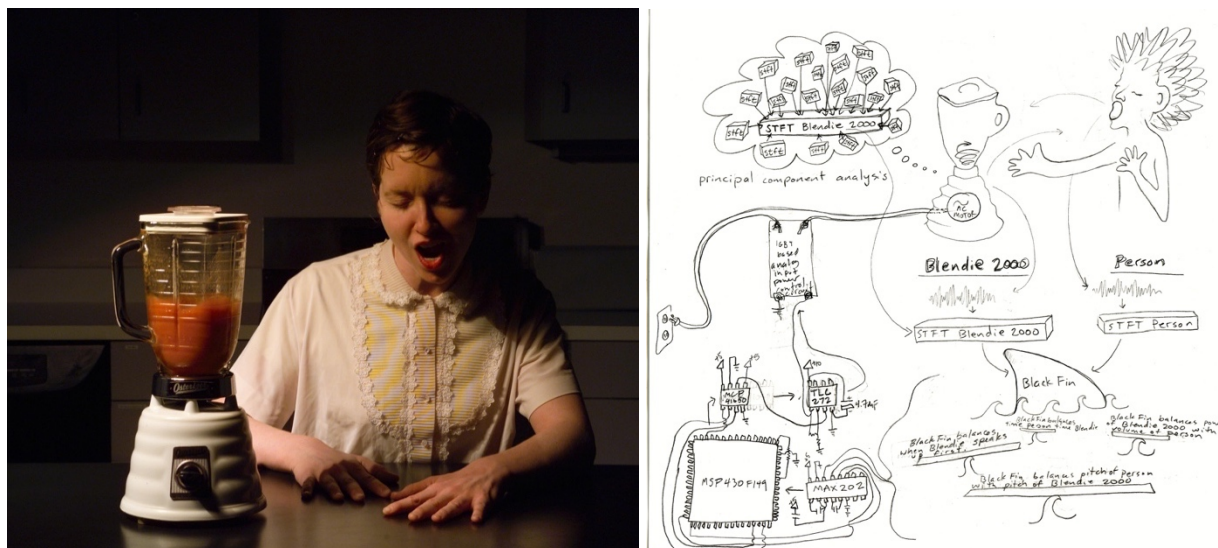


Figure 2.4. Kelly Dobson, *Blendie* (2004)

This dynamic of human-computer interaction relates to the contemporary practice of visceral design, producing situated, embodied experience of immaterial data. In Luke Stark's article "Come on Feel the Data (and Smell It)", he finds that "users prompted to engage viscerally will have a well-rounded sense of their own intellectual, emotional and physical stance on the matter at hand."<sup>48</sup> A visceral engagement draws on the full range of sensory perception, rather than privileging dominant channels of visual and auditory experience.

Visceral engagement places users in an intimate, embodied position. This focus on the body of both human and machine agents is a strong counterpoint to the rhetoric and design choices expressed through Le Corbusier's modernist practice, particularly works such as Villa Savoye, his flagship modernist "machine for living."<sup>49</sup> As she describes it, a "parapraxis", Dobson's work dwells in the "slip of the tongue, thought to reveal a repressed motive."<sup>50</sup> In psychoanalysis this is

<sup>48</sup> Luke Stark, "Come on Feel the Data (and Smell It)," *The Atlantic* May 19, 2014 (accessed March 14, 2018); available from <https://www.theatlantic.com/technology/archive/2014/05/data-visceralization/370899/>.

<sup>49</sup> The epitome of Le Corbusier's New International style, his "machine for living."

<sup>50</sup> Dobson, 54.

a revealing breakdown of the conscious machine, or in systems terms it is evidence of the unscriptable human subject.

## 2.5 ART TO BE INHABITED

The function of inhabiting constitutes the link between full and empty. A living creature fills an empty refuge, images inhabit, and all corners are haunted, if not inhabited.<sup>51</sup>

A house that has been experienced is not an inert box. Inhabited space transcends geometrical space.<sup>52</sup>

-Gaston Bachelard

*A Machine for Living In* belongs to a tradition of art to be inhabited. These are projects that take a hybrid approach to their subjects as sites and systems. They occupy real spaces, whether architectural or psychological. They enact a Bachelardian notion of site-specificity. Whether examining existing sites (Oldenburg's lower east side bodega) or manufacturing new ones (Lynn Hershman Leeson's invented *Roberta Breitmore* persona), they confuse the distinction between simulation and the real. Invariably, as work both constructed and inhabited by the artists, they are personally psychological topoanalytic studies of intimate space. They are also diffuse projects functioning as systems, not objects.

Lynn Hershman Leeson's *Roberta Breitmore* project (Figure 2.50) began in 1973 with her arrival in San Francisco, taking up residency at the Dante Hotel.<sup>53</sup> Over the next 5 years, she developed an alternate persona named Roberta Breitmore. Strategies included renting a room, registering for a driver's license, signing up for bank accounts, and developing palettes for clothing

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<sup>51</sup> Bachelard, 140.

<sup>52</sup> Ibid., 47.

<sup>53</sup> Lynn Hershman Leeson, *The Roberta Breitmore Series*, 1973-1978; available from <http://www.lynnhershman.com/roberta-breitmore/>.

and makeup choices. Additionally, she advertised for roommates, went on dates, visited a therapist, and at one point hired a private detective to document her daily activities, providing consequential “proof” of this new persona. Later she multiplied this performative identity, hiring multiple actors to inhabit the role for particular events, art openings, etc. Leeson’s work tweaks the mechanisms of institutionally constituted identity (driver’s license, therapist sessions, newspaper want-ads) and thus critically engages the real social systems supporting personal identity. Simultaneously these gestures pursue a personal exploration and fantastic play.

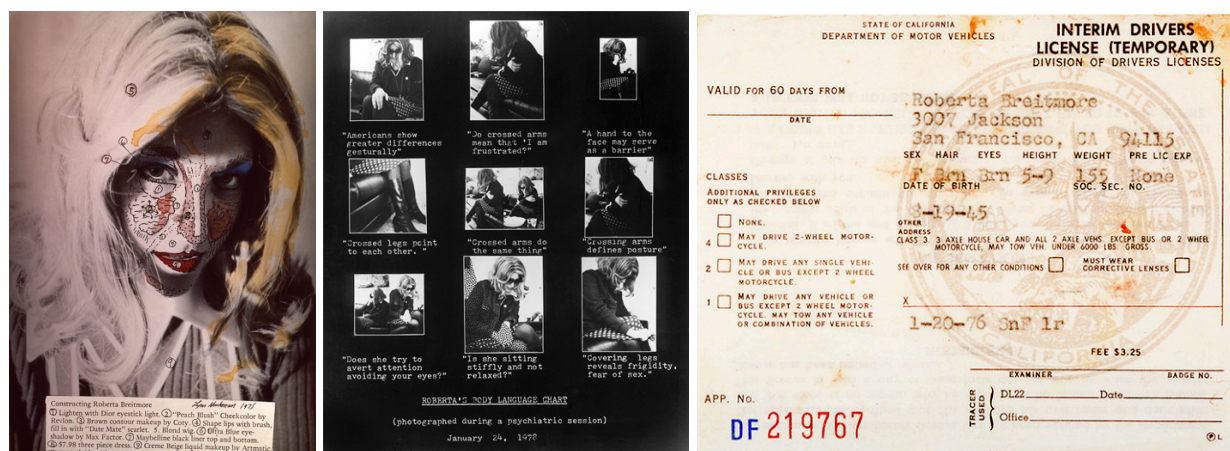


Figure 2.5. Lynn Hershman Leeson, *Roberta Breitmore* (1973-1978)

Claes Oldenburg’s *Store* similarly blurs the boundaries between the representation and the real. Originally proposed to his gallery as a commercial artistic enterprise,<sup>54</sup> Oldenburg occupied a store front on the Lower East Side of Manhattan for 2 months in 1961. His *Store*, in a commercial storefront, would in fact operate as a store:

In the front half, it is my intention to create the environment of a store, by painting and placing (hanging, projecting, lying) objects after the spirit and in the form of popular objects of merchandise, such as may be seen in stores

<sup>54</sup> See “The Store Described & Budget for the Store” in Claes Oldenburg and Emmett Williams, *Store Days: Documents from The Store, 1961, and Ray Gun Theater, 1962* (New York: Something Else Press, 1967).

and store-windows of the city, especially in the area where the store is (Clinton St., f.ex., Delancey St., 14th St.).<sup>55</sup>

Functionally, this piece constructs and inhabits an essentially ambiguous place between reality and representation. His initial proposal included an estimate of costs including rent, renovations, and materials for art production, as well as expected operating hours, public events, etc.<sup>56</sup> His “Preliminary Report on the Store” tallies total sales, tax collected, cost of rent, utilities, and supplies, and calculates profits and costs to split between Oldenburg and his gallery.<sup>57</sup> This project both constructs a site and inhabits an existing one: a doubling of roles and representations, creating a pseudo-commercial doppelganger gallery mimicking its commercial brethren.

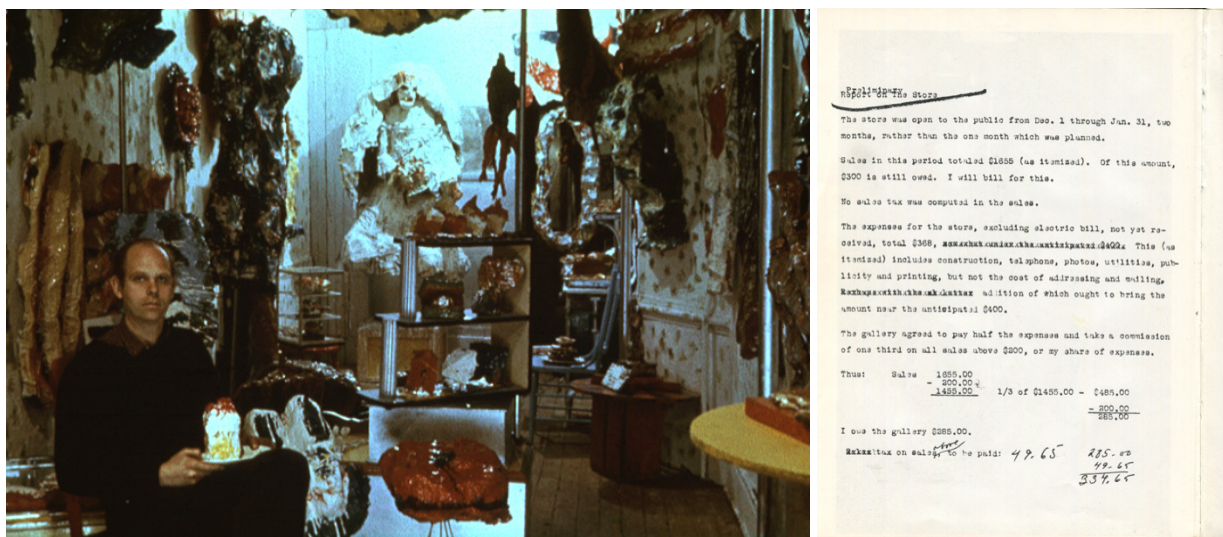


Figure 2.6. Claes Oldenburg, *The Store* (1961)

Near the end of his life, between 1819 and 1823, Francisco de Goya painted a set of darkly compelling images on the walls of his house near Madrid, the “Quinta del Sordo” (Villa of the Deaf Man). Though his home named after a previous occupant, Goya, too, was deaf and nearly

<sup>55</sup> Ibid.

<sup>56</sup> Ibid.

<sup>57</sup> See “Preliminary Report on the Store” in *ibid.*

blind when he moved into the house, having recovered from a bout of near fatal illness.<sup>58</sup> Colloquially known as the Black Paintings, and dark in both subject matter and tone (reflecting the circumstances of his personal health), these works are a particularly private example of art to be inhabited. There are fourteen paintings in all, seven each in two rooms, one on each floor of the house. These were painted directly onto the walls of the house, and were never intended to travel or be exhibited. Goya did not discuss the works during his lifetime, thus titles and dates are mere speculation. They only rose to widespread public knowledge nearly fifty years after his death, in 1873-74, when they were transferred to canvas and relocated to the Museo del Prado in Madrid. This is a rare case of a major work by a major artist serving largely private functions during the course of his life, when there was any chance of getting direct explanation.



Figure 2.7. Francisco de Goya, *Black Paintings* (1819-1823)

Goya literally surrounded himself with his painted images. Each of two rooms in the house had paintings mounted on all available wall space. Photographer Jean Laurent documented these images *in situ* prior to their relocation to the Prado. In his photographs of the works (for instance Figure 2.8 below) you see the wall paper, wainscoting, and decorative wooden trim of the

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<sup>58</sup> Depicted in his painting Francisco de Goya, *Self-portrait with Dr. Arrieta*, 1820.

architecture of the home. What accounts for this directness of gesture, and this construction of immersive pictorial space to reside in? Interpretations of the work tend towards the autobiographical, reading preoccupations with aging and mortality in the work, as well as Goya's habitual themes of superstition, organized religion, and the power of the mob. Since he did not discuss them in his lifetime, all readings are mere speculation. The only thing known for sure is that these images serve some private symbolic and expressive function for the artist, that he chose to paint them directly in the intimate lived space of his everyday life.



Figure 2.8. Goya's *Duelo a garrotazos* (Fight with Cudgels) *in situ*.<sup>59</sup>

<sup>59</sup> Goya's *Duelo a garrotazos* (Fight with Cudgels), photographed by Jean Laurent, *Duelo a Garrotazos*, 1874.

Goya constructed an image space to literally dwell within. This is similar to Hershman Leeson's invention of the *Breitmore* persona to inhabit, and Oldenburg's creation of the *Store* to operate as both proprietor and artist/craftsman. All of the projects construct ontologically ambiguous sites straddling self-consciously artistic production and everyday contexts, roles, and activities. My own works pursue a similar strategy of construction and inhabitation. They are machines for living, intimate psychological spaces to be inhabited, operated by human and machine.

## Chapter 3. STRATEGIES AND EXPLORATIONS

This chapter outlines the creative strategies and technical terrain for my research through early projects leading to *A Machine for Living In*. I describe my technical domains of engagement. I highlight the essential sites of meaning explored. I describe the formal strategies operating in the work and the particular systems constructed. Finally, I consider these projects as examples of introspective inquiry into human and machine. Each project deals with different modes of technologically mediated human experience.

### 3.1 TECHNICAL DOMAIN

I work in a diverse landscape of contemporary electronic technologies, grouped under topics of physical computing, creative coding, and experimental human computer interaction. My early digital projects targeted single technologies for exploration and use: for example, automatic speech recognition in the project *Solipsist*,<sup>60</sup> conversational chatbots in *Megahal Grandmommy*,<sup>61</sup> and face recognition in *Everyone as Someone I Know*.<sup>62</sup>

Recent projects combine multiple modes of technical production in service of larger descriptive goals. *Searle's Room* (and the follow up, *The Serious Business of Children*) used a

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<sup>60</sup> Solipsist used the Carnegie Mellon University speech recognition framework pocketsphinx. This is a part of the project *CMUSphinx* (accessed March 14, 2018); available from <https://cmusphinx.github.io/>.

<sup>61</sup> “Megahal” in this title comes from the chatbot software I used to create the piece: Jason Hutchens, *MegaHAL* (accessed March 14, 2018); available from <https://megahal.alioth.debian.org/>.

<sup>62</sup> The early version of this project used a simple Principal Component Analysis (PCA) algorithm to match viewer's faces with static images in a database. The newer version, shown as “Face Swap”, tracks viewers faces in live video using a constrained linear model (CLM) based on facial landmarks written by Jason Saragih, implemented in the *ofxFaceTracker* package: Kyle McDonald, *ofxFaceTracker* (accessed March 14, 2018); available from <https://github.com/kylemcdonald/ofxFaceTracker>.

mechatronic drawing machine, motion encoders, *k*-means clustering, concatenative synthesis, and speech recognition to explore machine intelligence through children's protolanguage.<sup>63</sup> *Rover* used a mechatronic camera platform, structure from motion algorithms, light field synthesis / computational photography techniques, GLSL shaders, audio feature extraction, clustering, and granular synthesis to create a dreamlike cinematic exploration of place.<sup>64</sup> My dissertation project continues in this vein of multi-process research and development. Each of these has been in a sense a "machines for living."

My material engagements are these technologies of the self: domains where technologies purport to represent or capture the constituents of identity. These include receptive technologies for machine perception of sound, vision, speech and language. They also include expressive synthesis of human legible sound, image, drawing, speech and language. Other topics deal with digital fabrication, embodied experience, computational portraiture, and personal analytics.

These domains stake a terrain of machine living, our contemporary condition where computers are the machines we dwell in and amongst. The bulk of contemporary experience is mediated through electronic media and computational sensing technologies. Thus, my work with them is an attempt at a critical embrace of Burnham's "productive means of society." Projects that engage the conditions of machine living are the meeting point between critical engineering design practice, technological topoanalysis, and psychological investigation.

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<sup>63</sup> Robert Twomey, *Searle's Room*, 2015; available from <http://roberttwomey.com/searles-room>.

<sup>64</sup> More information is available in our SIGGRAPH 2017 paper: Robert Twomey and Michael McCrea, "Transforming the Commonplace through Machine Perception: Light Field Synthesis and Audio Feature Extraction in the Rover Project," *Leonardo* 50, no. 4 (2017), [http://dx.doi.org/10.1162/LEON\\_a\\_01458](http://dx.doi.org/10.1162/LEON_a_01458).

My affinity for technology is rooted in my own history as an artist and engineer. I started programming in MS Basic some time in elementary school, and taught myself C++ when I was 13. I have built circuits for as long as I can remember, starting with the Radio Shack electronics inventors kit my grandma gave me, also during elementary school. I designed and programmed my first embedded microcontrollers and fabricated and populated my first printed circuit boards in high school. I have a deep technical and intellectual affinity for these techniques and modes of production. It is only in my mature career as an artist that I have situated them in a unified conceptual field with other more traditional artistic media and content concerns.<sup>65</sup>

### 3.2 SITES OF MEANING

Beyond technical exploration, my projects are structured around particular human engagements. Specific subjects vary from project to project, but as described in the previous chapter, they are unified in their engagement with sites of everyday life. A partial list of previous subjects for my work includes Alzheimer's disease, parenthood, guns, drawing, speech, language, studio practice, art school, family members, and art world heroes.

These spring from a conceptual extension of Bachelard's "sites of intimate life": similarly drawn from the domain of the intimate; equally poetic and replete with history, memory, and imagination; but broader than mere geometric space. Some are actual temporospatial sites (the home, the studio, the art school). Others are social relations, kinships, or common cultural experiences. All of these are defined by some readily identifiable and simply articulated nucleus

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<sup>65</sup> Not to say that I am not adapting to an emergent technological landscape: in recent work and instruction I have employed digital fabrication, cloud-based computing, embedded systems, machine learning, and GPU programming. Future horizons for my work include neural and somatic interfaces, augmented reality, and autonomous robotics.

or locus of meaning. My work is anchored to the experience of the everyday, through these commonplace subjects, and thus readily accessible.

### 3.3 FORMAL STRATEGIES

My work develops a number of formal strategies. The first, *model-limited experience*, has to do with the functional expression and constructed experience of the inherent limits of algorithms and data as filters for experience. The next, *opportunistic systems*, are the active counterparts to the first: systems that act to achieve desired results rather than passively filtering the world. The next, *machine observers* and *digital surrogates*, substitute machine perception and autonomous agents as placeholders for absent others in traditionally human roles. Finally, the idea of the *machine as metaphor* reframes the stakes of these previous strategies to focus on meta-practices of representation and analogy between human and machine.

#### 3.3.1 *Model-Limited Experience*

Model-limited experiences are interactions where participant experience is curtailed (and potentially frustrated) by the algorithmic parameters and implicit values in the data producing that experience. These systems are designed to give viewers direct, working understanding of algorithmically inbuilt rules of interaction; prompting reflection on the nature of those rules and values.

My project *Solipsist* exemplifies this dynamic.<sup>66</sup> In it, a small wooden room with a microphone and receipt printer establishes a finite world of language. Speaking to the “intelligent” printer that transcribes their words, viewers quickly learn that the system (and its choice of

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<sup>66</sup> Robert Twomey, *Solipsist*, 2011; available from <http://roberttwomey.com/solipsist>.

language model) directly determines what is heard, what counts, and thus what can be said. The system's values determine the space of expression. Poetically, this illuminates the inherent boundedness of our contemporary reality of always-on speech recognition, and resonates with the idea of language as a closed system. These lessons project outwards to inform our understandings of the parameters of commercially available personal voice assistants.<sup>67</sup> This also resonates with the essential Jeremijenko/*BIT* interest in the idea "that data has values," and that a task of the artist is the render them legible.

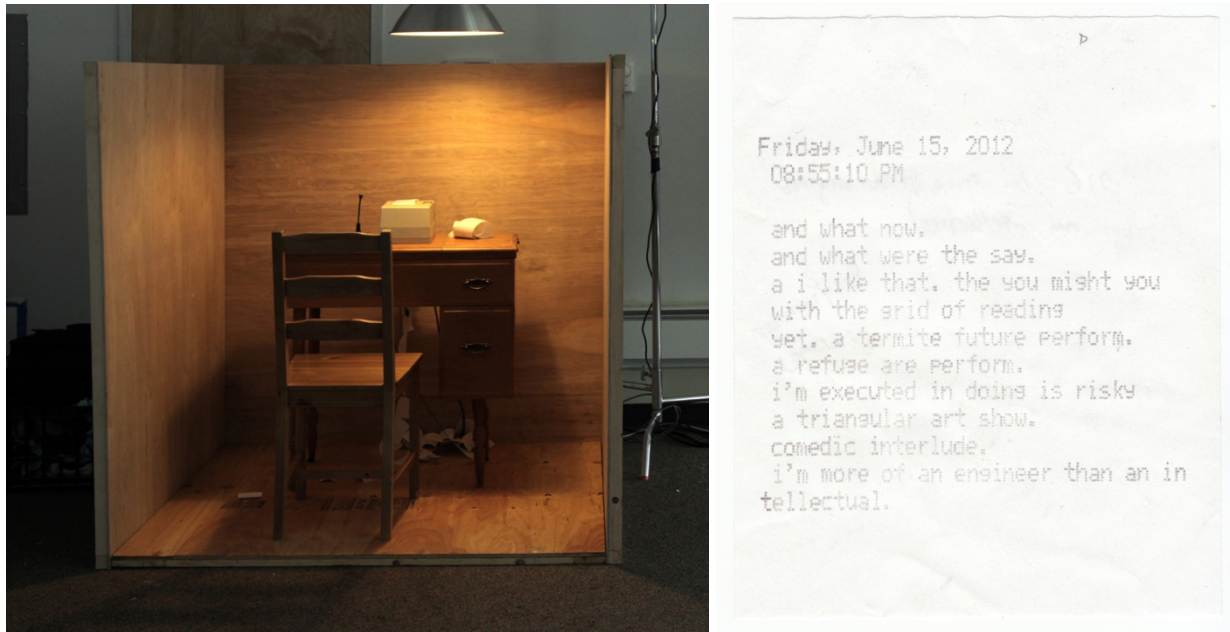


Figure 3.1. *Solipsist* (2011)

*Solipsist* was born out of a close reading of Mel Bochner's "Serial Art, Systems, Solipsism."<sup>68</sup> In it, he invokes the character of the solipsist to describe the aesthetic characteristics of a number of contemporary art practices, circa 1967:

<sup>67</sup> Apple's Siri, Amazon's Alexa, and Google's eponymous Google Assistant.

<sup>68</sup>Mel Bochner, "Serial Art, Systems, Solipsism," *Arts Magazine*, no. Summer (1967).

For the solipsist reality is not enough. He denies the existence of anything outside the self-enclosed confines of his own mind. Viewed within the boundaries of thought, the random dimensions of reality lose their qualities of extension. They become flat and static. Serial art in its highly abstract and ordered manipulation of thought is likewise self-contained and nonreferential.<sup>69</sup>

There are two moves at play in this passage: a flattening of reality through the boundaries of thought (as language), and a declaration of self-containment and nonreferentiality. These same formal principles operate in my piece: a flattening of experience into language, and the development of a self-contained, closed system of speech. Viewers of the piece are situated in an isolated, closed world of language.

The second reference for this piece is David Markson's novel *Wittgenstein's Mistress*.<sup>70</sup> In it, the protagonist, Kate, is similarly suspended in a finite space of language. This enclosure is compounded by a seemingly finite well of experience, historical reference, and language that she cycles through in the book. In the form of the book, a printed textual medium, the reader and author similarly have no recourse to reference or information outside of the text.

Each of these creative works functions as a model-limited experience and finite system, where the rules of the game establish the space of possible interaction and expression. The character of these systems is strangely flat and unexpressive. As Bochner describes:

Some may say, and justifiably, that there is a "poetry" or "power" or some other quality to this work that an approach like the above misses. But aspects like those exist for individuals and are difficult to communicate using conventional meanings for words. Others may claim that given this they are still bored. If this is the case, their boredom may be the product of

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<sup>69</sup> Ibid.

<sup>70</sup> David Markson, *Wittgenstein's Mistress*, First edition ed. (Elmwood Park, IL, USA: Dalkey Archive Press, 1988).

being forced to view things not as sacred but as they probably are—autonomous and indifferent.<sup>71</sup>

### 3.3.2 *Opportunistic Systems and Projective Identity*

While similarly finite in their data and rule sets, opportunistic or coercive systems act on their environment to produce desired goals. Here, beyond simply expressing the limits of data and algorithms, systems proactively author their intended effects on the external world.

In my project *Everyone as Someone I Know*, viewers' video mediated bodies are the contexts on which the system manifests a database of stored personae, grafting pre-computed identities in place of the viewers' own faces.<sup>72</sup> Functionally, this system excises and re-edits identity through facial appearance, expression, mouths and words. Representational effect is no longer due to viewer's volitional contribution to an interactive experience, but rather to an involuntary re-edit of their identity through computer vision and face tracking technology.

This project speaks to the mechanics of computational attribution of identity as broadly practiced by computing giants such as Google and Facebook, and dwells in potentially sinister consequences of voluntary or semi-voluntary participation in these systems. Who oversees or verifies these computational judgments? This is a pressing contemporary issue in machine learning and computer vision communities, with a growing public focus on the bias built into naturalistic recognition and perception technologies.<sup>73</sup>

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<sup>71</sup> Bochner.

<sup>72</sup> Robert Twomey, *Everyone As Someone I Know*, 2013; available from <http://roberttwomey.com/face-swap>.

<sup>73</sup> Recent press including Dina Bass and Ellen Huet, "Researchers Combat Gender and Racial Bias in Artificial Intelligence," *Bloomberg* December 4, 2017); available from <https://www.bloomberg.com/news/articles/2017-12-04/researchers-combat-gender-and-racial-bias-in-artificial-intelligence>., or Will Knight, "Forget Killer Robots—Bias Is the Real AI Danger," *MIT Technology Review* October 3, 2017); available from <https://www.technologyreview.com/s/608986/forget-killer-robotsbias-is-the-real-ai-danger/>.



Figure 3.2. *Face Swap / Everyone as Someone I Know* (2013)

In audiovisual content, this project explores ideas of public/private personae and interpersonal desire. The faces and identities programmed into the system, stored in its database, were pre-selected by the artist based on entirely personal criteria of attachment and desire, appropriating identity irrespective of actual social distance. The bulk of the “characters” in the piece are artists or theorists that the artist feels particularly attached to. Examples include William Pope.L, Marina Abramovic, Marcel Duchamp, and Rosalind Krauss. In this sense, the project becomes a sort of aspirational wish fulfillment: a system for projective identity using advanced computational techniques to instantiate idealized others through the presence of viewer/participants.

This project collapsed boundaries of space, time, and context, unifying a collection of absent others based on their value to some esoteric individual fantasy. It is solipsistic, in its own way.

### 3.3.3 *Digital Surrogates*

A third major artistic strategy in my work is the creation of digital surrogates. Similar to the dynamics at play in the model-limited and opportunistic systems described above, observers and surrogates differ through their relative passivity and agency.

Much of my work (including pre-digital projects such as *The Father-Daughter Art Show*<sup>74</sup>) operates through the construction of affective surrogates. In engineering research and consumer product design, attention has been devoted to efforts such as affective computing,<sup>75</sup> social robotics,<sup>76</sup> and companion robots.<sup>77</sup> These are systems that capitalize on the inbuilt human abilities to sense and express emotions, harnessing those capabilities through expressive and receptive machine perception techniques. Kelly Dobson's *Machine Therapy* projects (discussed in Chapter 2), offer a unique perspective on affective computing focusing on embodied, visceral interactions, but still concerned with the reception and expression of human-legible emotion.

Working from the position of a studio artist, I take a broad view of affective surrogacy. Machines or computational systems can be surrogates, but so can objects. A surrogate is anything that stands in as place-holder or invented foil. They function variously as observers, translators, interlocutors, partners, replicas, doppelgangers, or simulations. For example, *The Father-Daughter Art Show* (2007) is a body of work built around the idea of an imaginary child.<sup>78</sup> This conceptual device was a mechanism to explore fantasies of parenthood and family absent any real

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<sup>74</sup> Twomey, *Father-Daughter Art Show*.

<sup>75</sup> See for instance *Machine Perception Lab (MPLab) at the University of California, San Diego* (accessed March 14, 2018); available from <http://mplab.ucsd.edu/wordpress/>. The central researchers founded emotional analysis company Emotient, later acquired by Apple: Doug Ramsey, *Apple Acquisition of UC San Diego Startup Paves Way for Further Robotics Research at UC San Diego* (accessed March 14, 2018); available from [http://ucsdnews.ucsd.edu/pressrelease/apple\\_acquisition\\_of\\_uc\\_san\\_diego\\_startup\\_paves\\_way\\_for\\_further\\_roboti](http://ucsdnews.ucsd.edu/pressrelease/apple_acquisition_of_uc_san_diego_startup_paves_way_for_further_roboti).

<sup>76</sup> See the social robotics work of Cynthia Breazeal, *Kismet* (accessed March 14, 2018); available from <http://www.ai.mit.edu/projects/sociable/baby-bits.html>. And her research group at the MIT Media Lab, *Personal Robotics Group* (accessed March 14, 2018); available from <http://robotic.media.mit.edu/>.

<sup>77</sup> Breazeal's commercial product, Jibo, "the first social robot for the home": *Jibo* (accessed March 14, 2018); available from <https://www.jibo.com/>.

<sup>78</sup> Twomey, *Father-Daughter Art Show*.

child. The works produced were crafted studio objects (paintings, drawings, sculpture) and video art, functioning as an expressive system in an art installation: an object-based visual essay.



Figure 3.3. *Father-Daughter Art Show* (2007)

In a digital project such as *Megahal Grandmommy*,<sup>79</sup> the constructed system (a text-based chatbot) was a direct replacement for a living individual: my grandmother, recently diagnosed with Alzheimer's disease. Conversations with the chatbot potentially displaced or replaced conversations with my actual grandmother, and the whole system became an affective psychological feedback loop. My interactions with the surrogate, contextualized through actual events, generated a unique meditation on and portrait of my grandmother's declining mental state.

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<sup>79</sup> Twomey, *Megahal Grandmommy*.

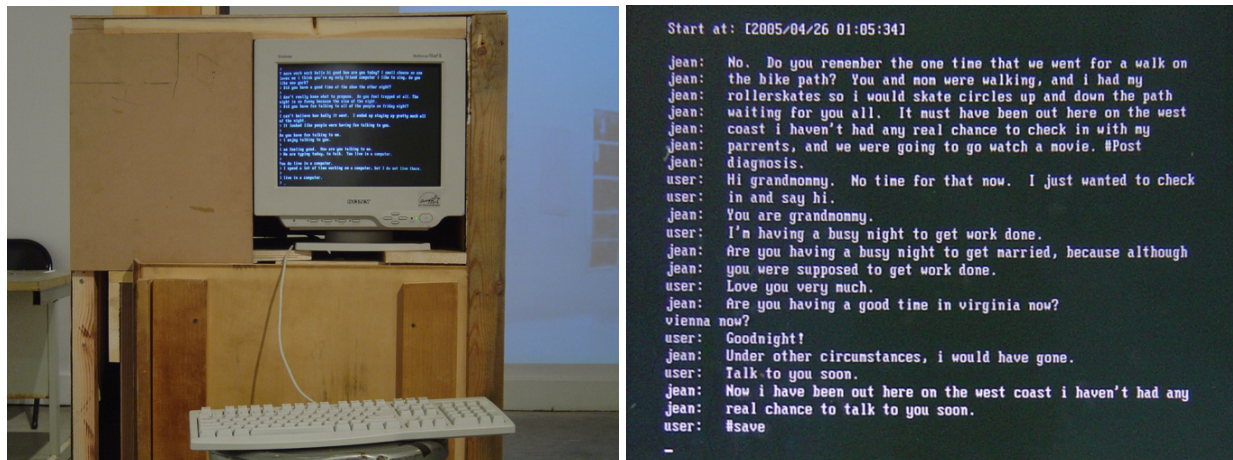


Figure 3.4. *Megahal Grandmommy* (2005)

Surrogates operate through this displacement of affection of attachment onto the constructed other. From an artistic perspective, surrogates serve as a third agent/actor, triangulating meaning between artist, viewer, and crafted object. The artist interacts with the crafted surrogate, and the viewer interacts with that same construction with some additional comprehension of the artist's use and history.

From a cybernetic perspective, surrogates serve as psychological feedback devices, catalyzing emotion or interaction. Dobson conceived of *Blendie* and her later projects *Umo*, *Omo*, and *Amo*<sup>80</sup> in this sense: as cathartic and therapeutic on an emotional, visceral, bodily level. This is a frontier for engineering design: creating affective devices that sense and respond to emotional expression. My own projects pursue poetic aims through similarly psychological / topoanalytic engagement. Increasingly, personal robots such as Cynthia Breazeal's *Jibo* are being adopted into intimate space, for instance serving as companions for children and the elderly in the home. Breazeal's MIT colleague, Sherry Turkle, succinctly articulates the dangers of this approach to forming "real" emotional bonds with machines in her article from the *Washington Post* from December 2017:

<sup>80</sup> Dobson.

These machines are seductive and offer the wrong payoff: the illusion of companionship without the demands of friendship, the illusion of connection without the reciprocity of a mutual relationship. And interacting with these empathy machines may get in the way of children's ability to develop a capacity for empathy themselves.<sup>81</sup>

### 3.3.4 *Machine Observers*

Machine observers are the passive versions of active surrogates. They operate as mute witnesses and narrators, sensing and describing aspects of observed experience. *Solipsist*, *Convex Mirror*,<sup>82</sup> and *Rover*<sup>83</sup> all function in this vein: registering external events with no real capacity to influence them. *Solipsist* transcribes speech to text to produce machine-mediated representations of spoken words.

*Convex Mirror* is a site-specific drawing machine and computer vision system creating compressed temporal representations of time and space. Substituting computer vision and precision automation for the human hand and eye, this project operates with a superhuman physical precision and temporal duration. Each drawing is produced over the course of three weeks, for twelve hours a day, as the system dogmatically records its computational perception, resulting in densely rendered images such as Figure 3.5 below. Named after Parmigianino's self-portrait in a convex mirror, this project implicitly contrasts the scope, scale, and temporal duration of human and machine labor, producing its own portrait in the process.

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<sup>81</sup> Sherry Turkle, "Why these friendly robots can't be good friends to our kids," *The Washington Post*, December 17, 2018.

<sup>82</sup> Robert Twomey, *Convex Mirror*, 2013; available from <http://roberttwomey.com/convex-mirror>.

<sup>83</sup> Robert Twomey, *Rover*, 2015; available from <http://roberttwomey.com/rover>.

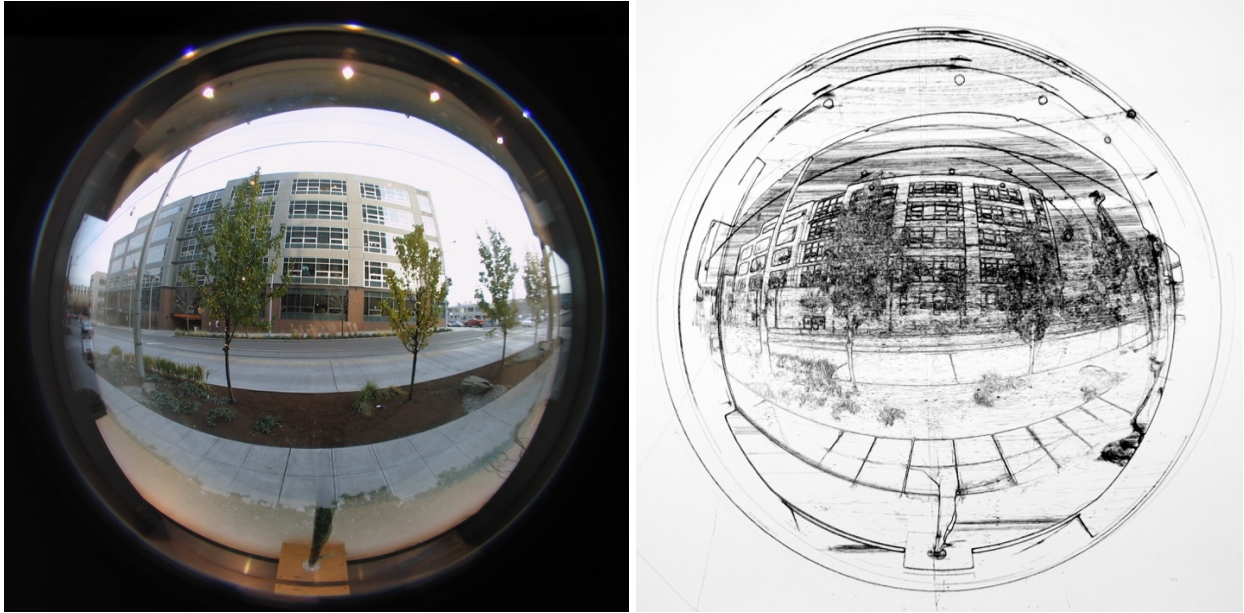


Figure 3.5. *Convex Mirror* (2013)

DXARTS Professor Juan Pampin and James Coupe's *Sanctum*<sup>84</sup> operates as a multi-modal machine observer: using algorithmically extracted quantifications of viewer identity, gender, age, etc., as a basis to produce visual, textual, and sonic narration of the public space surrounding the Henry Art Gallery at the University of Washington. Embedded across the façade of the gallery building, the system monitors passers-by and produces a continuous social narration of place. *Sanctum* shares qualities with the opportunistic systems described above: it uses participants' faces as the occasions to retrieve and synthesize textual, auditory, and sonic narrative derived from contributed social media material, collapsing remote and local information in the vein of a Smithsonian nonsite.

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<sup>84</sup> James Coupe and Juan Pampin, *Sanctum*, 2013-15; available from <https://dxarts.washington.edu/research/creative-work/sanctum>.



Figure 3.6. James Coupe and Juan Pampin, *Sanctum* (2013-15)

BIT's Suicide Box functions as a witness or machine observer to a most psychically charged phenomena: suicide victims jumping from the Golden Gate Bridge in San Francisco. Here the muteness of the system accentuates the artistic strategy: highlighting the lack of any official monitoring, safe-guarding, or reporting of this vital safety issue where automated observation is demonstrably feasible.

*Rover* (a collaboration with Michael McCrea) postulates a machine explorer (like the Martian Rover, our project's namesake) with its own perception and intelligence. It filters audio-visual experience through novel processes of machine listening and computational photography.<sup>85</sup> After initially sampling a site through a mechatronic imaging system and digital audio recording, *Rover*

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<sup>85</sup> Twomey and McCrea.

algorithmically processes and re-explores the place in a machinic search and audio-visual reminiscence. The result is a dreamlike exploration of place, existing somewhere between cinema and photography. *Rover* develops and explores the particular aesthetic character of machine perception of visual and sonic experience, playing those modes of expression off of our own inherent human understandings of these same quotidian spaces.



Figure 3.7. *Rover* (2015)

What is gained in substituting machine perception for human perception? Applying engineered models of mechanized perception, machine observers implicitly contrast their perceptual capabilities with those of their human analogs. The human interest in machine perception is in experiencing this central comparison of natural and engineered modes of perception, as these differences illuminate the function and meaning of our own. Biologist Jakob von Uexküll calls this organism-specific worldview the *umwelt*, the subjective perceptual understanding of the world defined by its sensory apparatus and cognitive capabilities.<sup>86</sup> As we develop increasingly sophisticated human-like modes of computational perception, this

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<sup>86</sup> Discussed in Giorgio Agamben, *The Open: Man and Animal* (Stanford, Calif.: Stanford University Press, 2004), 39.

comparative study of human and machine offers potentially revelatory insight about the nature of each.

### 3.3.5 *Machine as Metaphor*

Machines as simple as thermostats can be said to have beliefs.<sup>87</sup>

- John McCarthy

The ultimate formulation of my approach to human computer interaction is the idea of the machine as metaphor. As John McCarthy concisely describes in his essay “Ascribing Mental Qualities to Machines”: machines, particularly computers, have become the preeminent vessels by which to examine our human cognitive nature. Even “machines as simple as thermostats can be said to have beliefs.”<sup>88</sup> What McCarthy has written amounts to a literary description: using the device of metaphor to lever a host of human traits and qualities onto unthinking, unfeeling “intelligent machines.” This is projective identification writ large, an anthropomorphism of the dominant technology of our time.

McCarthy’s article speaks in very narrow terms about ideas later termed Strong Artificial Intelligence (AI), at a point in the 1970s where the field looked very different than it does today. But our contemporary impulse remains the same. Machine Learning (ML) is the dominant technique of our time, and facile comparisons with human perception, cognition, and learning deserve scrutiny: to elucidate the complex relationships between computational techniques and the domains they model. Art is an ideal discipline to pursue this work, comprehensively addressing

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<sup>87</sup> John McCarthy, *Ascribing Mental Qualities to Machines* (accessed March 14, 2018); available from <http://jmc.stanford.edu/articles/ascribing.html>.

<sup>88</sup> *Ibid.*, 3.

the social, cultural, and experiential dimensions of ML techniques through functional aesthetic products.



Figure 3.8. Francis Picabia, *Fille Née sans Mère* (1916-18)<sup>89</sup>

This anthropomorphism of the machine is a rich artistic tradition: Picabia attempted similar ends through purely visual metaphor in paintings such as *Fille Née sans Mère* (Daughter Born Without a Mother), seen in Figure 3.8. My imaginary daughter is spiritual kin to Picabia's daughter, similarly born without a mother, birthed of a generative conceptual machine. The opportunity, now, is to create functional machines emulating human-like cognition and perception—critically assessing the capabilities of these new technologies while untangling this complex human-machine metaphor.

A number of my works operate in this manner: addressing pressing questions about human nature through computational analogs. Rather than merely assuming the validity of this central

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<sup>89</sup> Francis Picabia, *Fille Née sans Mère* (*Girl Born without a Mother*), 1917, Gouache on railway-machine diagram.

comparison of human to machine, I always seek to question both the function and the failure of the metaphor.

My project *Searle's Room*<sup>90</sup> grows out of an engagement with these computational theories of mind, a response to John Searle's 1980 essay "Minds, Brains, and Programs." In it, Searle challenges the claims of strong AI: that "the appropriately programmed computer literally has cognitive states," and that "programs thereby explain human cognition."<sup>91</sup> To challenge this perspective, he describes what is known as the "Chinese room" thought experiment: where a human operator isolated in a room, by means of lookup tables and rules, responds "intelligently" to queries written in a foreign script they have no comprehension of. To observers on the outside, this black box appears to demonstrate comprehension and intelligent response. In this, Searle is describing the formal structure of a then state-of-the-art reasoning system—with algorithmic hierarchies of query and response—but gives lie to the idea that such mechanisms in any way demonstrates intelligence. The human in the loop, capable of self-analysis and critical reflection, clearly has no understanding of what they do. Everything else is mere process, any "intelligence" is baked into the system *a priori* by the author of the rules and data. The project is an act of technological ventriloquism.

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<sup>90</sup> Twomey, *Searle's Room*. A later variation of the project with a participatory role for the viewer was shown as Robert Twomey, *The Serious Business of Children*, 2015; available from <http://roberttwomey.com/serious-business>.

<sup>91</sup> John Searle, "Minds, Brains, and Programs," *The Behavioral and Brain Sciences* 3, no. 3 (September 1980), <https://doi.org/10.1017/S0140525X00005756>.



Figure 3.9. *Searle's Room* (2013)

My project *Searle's Room* is a parallel construction using children's babble and scribbles as protolanguage, unintelligible in any conventional linguistic sense but communicative in other registers. My piece casts the viewer as an observer on the outside of a linguistic query and response conducted in half formed baby words and scribbles. Where the observer in Searle's experiment is fluent in the language of conversation and thus attributes intelligence to the room, the viewer in my piece is linguistically in the dark. In fact, there is no language there. Rather, viewers rely on more deeply human and embodied responses to pitch, tone, and the biosocial evocations of children's utterances.

Ultimately *Searle's Room* becomes about the difference between expression and comprehension, and creates a surreal estrangement from the intimate appeal of children's speech through the distancing mechanism of the robots. Technically, the apparatus is set to fail: a speech transcription device attempting to find language (English text) where there is none. The viewer sees this, creating a critical vantage point from which to evaluate the weight and authority given to the processes of machine translation and expression.

My piece, like Searle's essay, is a reflection on the impossibility of autonomy in any technological artifact. It advances the idea that "intelligent" behavior has always been programmed in. (Today, trained in, through epochs of machine learning) This returns to Kelly Dobson's question of "what we interact with when we interact with machines."<sup>92</sup> I would argue that in most of our supposedly intelligent or autonomous creations, we are interacting with the consciousness, subjectivity, and intent of whomever constructed it. This is a kind of high-tech ventriloquism: the time-delayed manifestation of behavioral rules or data biases built by the human engineer behind the screen. The device becomes just a longer stick to paint with.

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<sup>92</sup> Dobson, 3.

## Chapter 4. A MACHINE FOR LIVING IN

### 4.1 ARRIVING AT HOME

There is ground for taking the house as a tool for analysis of the human soul.<sup>93</sup>

- Gaston Bachelard

Just what is it that makes today's homes so different, so appealing?<sup>94</sup>

- Richard Hamilton

My search for a dissertation topic was driven, like much of my creative work, by the twin forces of dissatisfaction and desire. My previous projects seemed too narrow: whether in their singular focus on individual technologies, or in their bracketing off of narrow ranges of human experience (children's language, drawing, etc.) as conceptual scenario. For my dissertation I sought a subject that would provide a more expansive field for engagement, encompassing a broad range of technical inquiry and human experience. Rather than picking bit by bit at individual threads of technical and humanistic inquiry, I wanted an encompassing site where the project could be as much about weaving a tapestry as developing the individual threads. This is a compositional challenge.

Home is a generous subject. It is a complex and layered space of multiple modes of being and experience. We are our most bodily at home, where we sleep, eat, bathe, and eliminate. Home is a space of shared language: the site of ongoing dialog and exchange between inhabitants, guests,

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<sup>93</sup> Bachelard, xxxvii.

<sup>94</sup> Richard Hamilton, *Just what is it that makes today's homes so different, so appealing?*, 1956, Collage. Hamilton's title text is taken from an advertisement for Armstrong Floors from the June 1955 issue of *Ladies Home Journal*, showing "Armstrong Royelle Linoleum" flooring. See John-Paul Stonard, "Pop in the Age of Boom: Richard Hamilton's "Just What Is It That Makes Today's Homes so Different, so Appealing?," *The Burlington Magazine* 149, no. 1254 (2007).

and tele-present others; people and animals; people and objects (including voice-responsive smart assistants). Reductively, home can be viewed as a series of discrete physical interactions between inhabitants and the doors, cabinets, objects and appliances within.<sup>95</sup> Geometrically, home is a fixed spatial envelope, a space of encapsulated living defined by its separation from the world around it, recalling Bachelard's concept of the cave as the mother of all homes, and the minimal inhabited space. Most importantly, home is an intimate space, replete with history, memory, fantasy, and quotidian narrative.

The home as a subject is too broad for a single comprehensive art historical survey. As Bachelard says: "our house is our corner of the world... it is our first universe, a real cosmos in every sense of the word." It is our first site of common human experience. Artists have variously wrapped the home,<sup>96</sup> split it,<sup>97</sup> shelled it,<sup>98</sup> burnt it,<sup>99</sup> and rebuilt it.<sup>100</sup> While thoroughly explored as an artistic subject, I believe that conversely, the home is impossible to exhaust.

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<sup>95</sup> Georges Perec created this kind of endless inventory of a Parisian street corner in Georges Perec, *An Attempt at Exhausting a Place in Paris*, trans. Marc Lowenthal (Cambridge, Mass.: Wakefield Press, 2010).

<sup>96</sup> Christo and Jeanne-Claude, *America House Wrapped*, 1970.

<sup>97</sup> Gordon Matta-Clark, *Splitting*, 1977.

<sup>98</sup> Rachel Whiteread, *House*, 1993.

<sup>99</sup> Filmmaker Andrei Tarkovsky used the image of the burning home in both *Mirror*, directed by Andrei Tarkovsky (Kino Video, 1975). And *Sacrifice*, directed by Andrei Tarkovsky (Kino Video, 1986).

<sup>100</sup> Do Ho Suh, *Apartment A, Unit 2, Corridor and Staircase, 348 West 22nd Street, New York, NY, 10011, USA*, 2011-14.



Figure 4.1. Four house transformations<sup>101</sup>

What is unique about today's homes? The major transformation of domestic space in the past twenty-plus years is the penetration of technology into the inner sanctum of the home. Commercially, this is sold as the smart home.

The term smart home first surfaced in 1995, when the American Home Builders Associate established a special interest group on "Smart Homes."<sup>102</sup> While early smart home development focused on integrating the multiple control systems and technical layers of the home, it is only in

<sup>101</sup> Clockwise from top left: Christo *America House Wrapped*, Gordon Matta-Clark *Splitting*, Rachel Whiteread *House*, and still from Andrei Tarkovsky's *Sacrifice*.

<sup>102</sup> Frances Aldrich, "Smart Homes: Past, Present, and Future," in *Inside the smart home*, ed. Richard Harper (New York: Springer, 2003).

the early 2000s that the computational smart home as we understand it arose. This is the period in which the science fictional became the nearly possible. Commercial markets are now saturated with competing smart hubs (Google Home, Amazon Alexa, Apple HomePod), communication protocols (ZigBee, Thread, Z-Wave and more), and novel technological solutions in search of a problem (smart kitchen stove knobs, smart button pushing robots, smart door cameras). Financial forecasters estimate the smart home sector will grow from a \$24.1 billion market in 2016 to \$54.3 billion by 2022.<sup>103</sup>

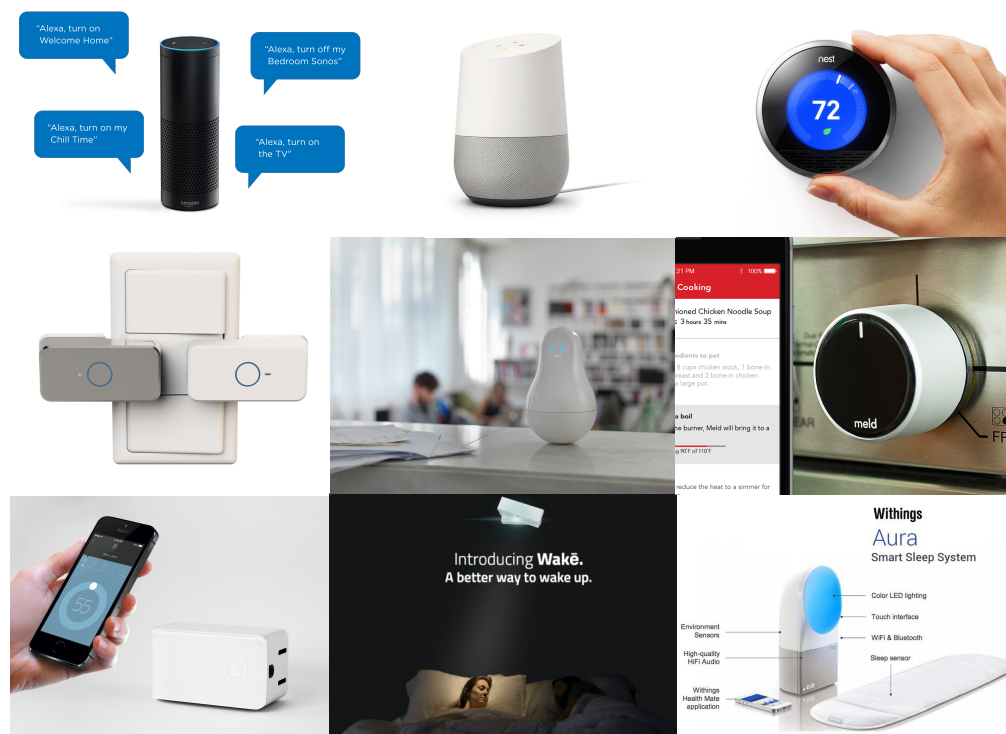


Figure 4.2. A survey of smart home devices circa 2018.<sup>104</sup>

<sup>103</sup> Zion Market Research, *Global Smart Home Market to Exceed \$53.45 Billion by 2022* (accessed March 14, 2018); available from <https://globenewswire.com/news-release/2018/01/03/1281338/0/en/Global-Smart-Home-Market-to-Exceed-53-45-Billion-by-2022-Zion-Market-Research.html>.

<sup>104</sup> Clockwise from top left: Amazon Alexa, Google Home, Nest Thermostat, Meld smart knob, Aura Smart Sleep system, Wakē smart alarm clock, Zuli smart outlet, Microbot Push smart button pusher, and Sense Mother smart sensor hub.

For my purposes, the smart home is a target of opportunity: it marries my complex interest in the home as a site and subject with the kinds of technologies I seek to examine through my work. Previously I have used speech recognition to explore language as a closed system, computer vision to create machinic attribution of identity, and physical sensors to capture and re-animate biological motion. The notional smart home gathers all of these machine perception and computational sensing technologies into a single space of ubiquitous, multi-modal machine observation: smart assistants always listening, smart cameras interpreting domestic activity, and wireless sensors monitoring all aspects of inhabited space.

My arrival at the home as a subject for the dissertation is a blend of artistic fascination with the home, a personal desire to interpret intimate life, and a critical opportunity to examine an emergent space of technological invention, the smart home.

## 4.2 LE CORBUSIER AND MACHINE LIVING

The problem of the house has not yet been stated.  
 Nevertheless, there do exist standards for the dwelling house.  
 Machinery contains in itself the factor of economy, which makes for selection.  
 The house is a machine for living in.<sup>105</sup>

—Le Corbusier

Having settled on the home as a site and subject, I needed a frame through which to develop the project. I found it in the work of Modernist French-Swiss architect Charles-Èdouard Jeanneret, known as Le Corbusier. In his 1923 book *Vers une Architecture* (Towards a New Architecture), from which the above passage is sourced, he embraces the machine as a model and engineering as the muse for the design and construction of buildings. For Le Corbusier, the epochal “problem of

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<sup>105</sup> Le Corbusier, *Towards a New Architecture* (New York: Dover Publications, 1986), 4.

the house” (circa 1923) could be addressed through a design approach focused on factors of economy and utility, akin to the engineering of functional machines.<sup>106</sup> Through discussion of a number of paradigmatic examples—the airplane, automobile, and cruise liner—Le Corbusier advocates for the streamlined, functional aesthetic that an ends-driven methodology could bring to the design of the home. He believes that these machines achieve a kind of felicitous harmony with the outside world that classical works of art and architecture achieved, and which contemporary architecture and design was sorely in need of. Rather than a literal engineering of space, his is an idealization and valorization of the engineered machine. This championing of the machine was shared by a number of contemporary artistic movements, notably the Italian Futurists and Russian Constructivists.<sup>107</sup>

Ninety years later, the computer is our ubiquitous machine and the dominant metaphor in our cultural imagination. The contemporary notion of robust, utilitarian functionality is located in technologies of ubiquitous sensing, embedded computing, cloud storage and analysis, and machine perception—accessed through smart phones, personal computers, and increasingly, through smart home appliances. Physical, mechanical aspects of technologies have receded into the background (though Dobson’s *Machine Therapy* might try to resurface them)—replaced with an evanescent digital immateriality.

Le Corbusier had a great faith in machines, that they “will lead to a new order both of work and of leisure.”<sup>108</sup> What more than the computer has led to this great reorganization in our time?

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<sup>106</sup> In a Bachelardian frame the "problem of the house" would be: what do we imagine and expect of the house as an intimate psychological site, and how can the architecture/construction of the space produce those desired results?

<sup>107</sup> The history of the machine in art is well summarized in Pontus Hultén, *The Machine: As Seen at the End of the Mechanical Age* (New York: Museum of Modern Art, 1968).

<sup>108</sup> Corbusier, 101.

As the site where computation is physically embedded in the home, the smart home telescopes the capabilities of planetary scale computing into intimate, inhabited space: it is our contemporary machine for living in.

### 4.3 HOUSE-MACHINES

If we eliminate from our hearts and minds all dead concepts in regard to the house, and look at the question from a critical and objective point of view, we shall arrive at the "House-Machine", the mass-production house, healthy (and morally so too) and beautiful in the same way that the working tools and instruments which accompany our existence are beautiful.<sup>109</sup>

- Le Corbusier

What is Home Without A Mother?<sup>110</sup>

-Buster Keaton

The two passages above juxtapose clinically utilitarian and deeply human perspectives on the home. Le Corbusier speaks of the desire to eliminate “all dead concepts” regarding the house to achieve a critical and objective point of view. For him, this approach arrives at the “house-machine”: a mass-production house that is healthy, moral, and beautiful like a tool or instrument. In Buster Keaton’s 1920 movie *The Scarecrow* the phrase “What is Home Without a Mother?” is revealed on the underside of the kitchen table as it is hoisted high onto the wall by a pair of bachelor-inhabitants, concluding their meal and departing the house. Amidst a thicket of string-operated contraptions and parodic home automation devices, this plaintive non-sequitur reframes all of this mechanized utility in terms of simple familial desire.

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<sup>109</sup> Ibid., 7.

<sup>110</sup> *The Scarecrow*, directed by Edward F. Cline and Buster Keaton (Metro Pictures, 1920), <https://archive.org/details/TheScarecrow1920>.

The “house-machine” projects discussed in this section demonstrate a similarly complex mix of engineered utility and deep human desire manifest in constructed space. Though created in different eras and fields of production, each project captures something of Le Corbusier’s total mechanizing aesthetic applied to the domain of the house, and stake out the parameters for my own research in this space.

Le Corbusier’s *Villa Savoye* (1931) is a seminal work of high modernist architecture in the International Style, and the building most readily associated with his pronouncement of the house as “a machine for living in.” It demonstrates his five points of architecture: pilotis lifting the box of the house off of the ground,<sup>111</sup> an open plan “free” interior, a free façade (non-structural and independent from the walls), horizontal ribbon windows, and rooftop gardens. The dominant character of the building is its spatial plasticity: its geometric white exterior an elevated form floating like a sculpture in the landscape, its interior plan is open to optimal use and free travel, walls and windows functioning as viewing devices to frame a series of perspectives onto interior courtyards and the surrounding environment. In stripping the building of inessential ornament, embracing new structural possibilities through technologies such as reinforced concrete, Le Corbusier’s building expresses the machine aesthetic he so admires.

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<sup>111</sup> Pilotis are reinforced concrete columns, replacing structural walls in supporting the house.

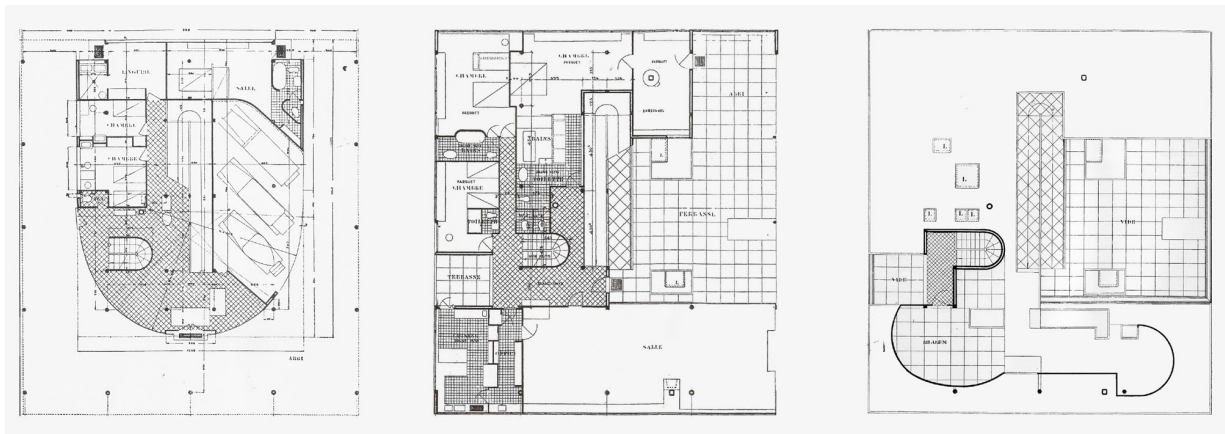


Figure 4.3. Le Corbusier, *Villa Savoye* (1931)

Buster Keaton's 1920 film *The Scarecrow* opens with two men in a small domestic interior. Over the first third of the film, they are seen operating the architecture in various ways in a series of mechanistic gags: slamming a door to pull a tooth, swinging condiments and eating utensils through the air, hoisting the kitchen table to reveal the "home without a mother" question posed above (See Figure 4.4 below). Every domestic appliance in this home has a double purpose, such

as the shaving mirror which flips to reveal a portrait of a love interest. Keaton's building is the "house as tool" in Le Corbusier's conception.

Additionally, the film manifests a systems description of the home in exchange with its environment: food waste drops through the wall into a pig pen on the outside, bath water flows to replenish a duck pond. Though the film's action moves on beyond the limits of the house, this machinic apartment—home as a site and system—establishes a mechanical context for the rest of the film. The plot unfolds through a series of mechanistic pratfalls (recalling Bergson's theory of humor as the unexpected interruption of mechanical human motion<sup>112</sup>) as the two main characters pursue the affections of a woman, ending with Keaton's character marrying her in a wedding officiated mid-stream while mounted on a motorcycle. The story continues, perhaps, into the film *One Week* (also from 1920, and co-starring the same female lead), where the protagonist and his newly wedded bride construct and inhabit a first home.

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<sup>112</sup> Henri Bergson, *Laughter: An Essay on the Meaning of the Comic* (New York: Macmillan, 1911).

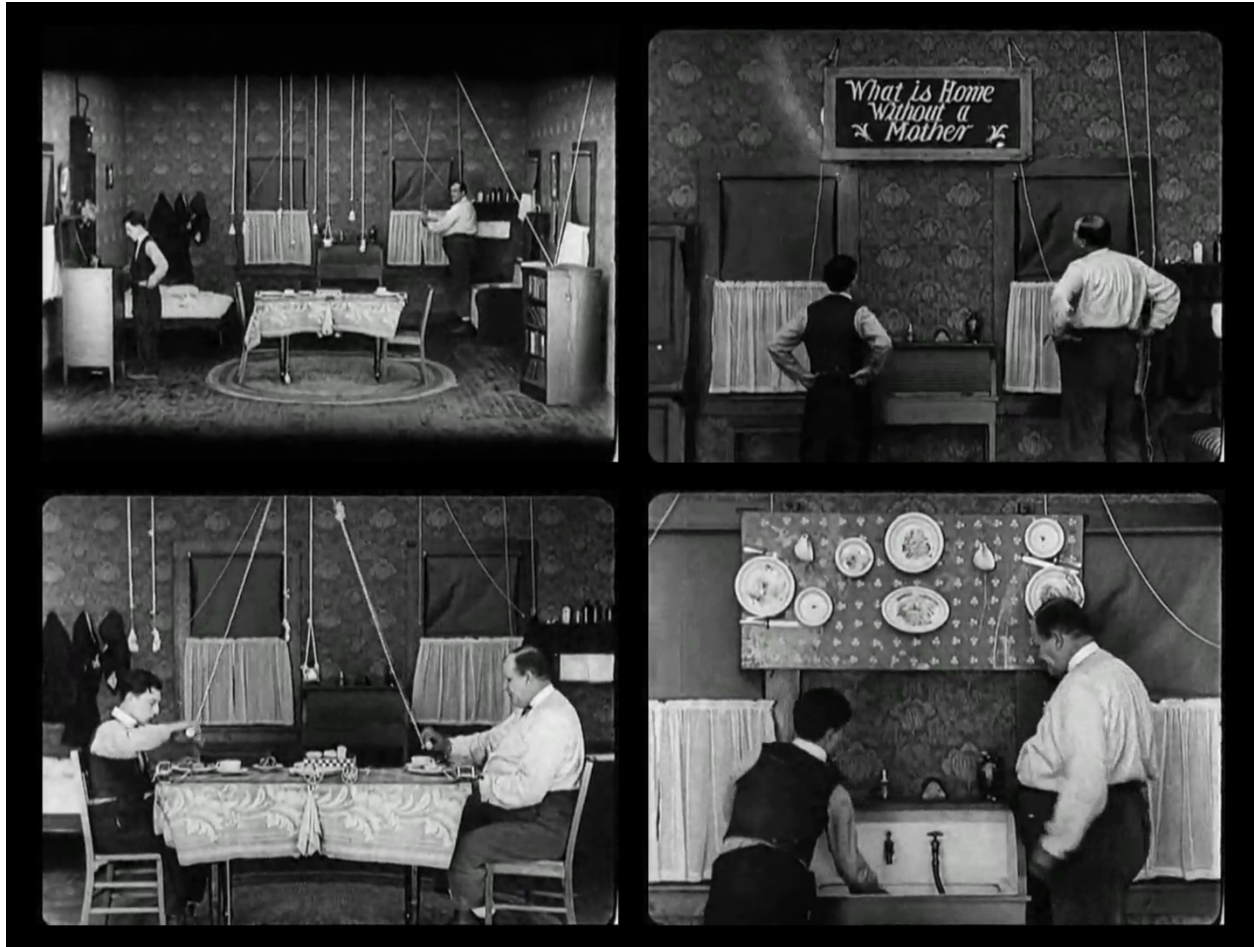


Figure 4.4. Buster Keaton, *The Scarecrow* (1920), film stills

Until recently, the smart home was a fictional construction, discussed in the writings of Ray Bradbury, Adolfo Bioy Casares, J.G. Ballard, and others.

Bradbury's short story, "There Will Come Soft Rains"<sup>113</sup> centers on one such fictional smart home. Bradbury's house contains a variety of "smart home" technologies: voice interfaces, robotic appliances for cooking and cleaning, in-wall displays, home monitoring systems, and smart smoke and fire protection systems. The story opens with a synthetic voice reciting the date, time, and

<sup>113</sup> "There Will Come Soft Rains" in Ray Bradbury, *The Martian Chronicles*, Trade ed. (New York: Bantam Books, 1979).

reminders for the inhabitants beginning with a summary of the day's events. As the textual narration moves from room to room describing this fictional smart home, it gradually reveals the absence of human inhabitants. Mid-morning ("ten-fifteen" in the story), while describing the garden and sprinklers surrounding the house, we learn that the home's inhabitants have perished in what is apparently a nuclear explosion, "their images burned on wood in one titanic instant."<sup>114</sup>

This story dwells on the quotidian rhythms of domestic space, manifest through the routinized actions of a number of robotic agents. Human tragedy and loss is expressed through the absence of inhabitants, with unsupervised automation run amok in the aftermath of a nuclear apocalypse. One full day after the story begins, after a midnight crescendo of mechanical breakdown and self-immolation, the story concludes with the home as a skeleton of burnt walls and a molten electronic nervous system announcing the arrival of the new day to an empty field, using what remains of its machinic voice.

Adolfo Bioy Casares' 1964 novel *The Invention of Morel* functions poetically in this zone of inhabited space, ubiquitous machine observation, absent others, and the psychology of loss and desire.<sup>115</sup> In the book a protagonist is stranded on a remote island, and over the course of the narrative he pieces together the parameters of a total reality-recording device (Morel's eponymous invention), the life-like "physical illusions" it projects, and the past events of a looping drama that the system sustains. In parallel with the protagonist, we learn of the illusory nature of the "inhabitants" of the island (first taken as real), and follow him as he attempts to integrate himself into this endless, repeating cycle of their projected images. The central conceit of this story—a

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<sup>114</sup> Ibid., 167.

<sup>115</sup> Adolfo Bioy Casares, *The Invention of Morel* (New York: New York Review Books, 2003).

human falling in love with the immaterial illusion of an image—echoes the myth of Pygmalion falling for his statue of Galatea.

Multiple aspects of Casares' story are relevant to the idea of the smart home and provide compositional references for my own project on the subject: the island (an encapsulated site), is monitored by a totalizing observational system that captures the texture of activity in that space. This system produces a distilled representation of those events, and the resultant experience loops in perpetuity, suspended in illusionistic stasis.

Numerous projects out of academic labs, tech startups, and corporate research parks imagine concrete future possibilities in the smart home space. The most compelling for me is Deb Roy's Human Speechome project (2006-present) from the MIT Media Lab's Cognitive Machines Group, with its intense mix of the personal and the scientific.<sup>116</sup> For this project, Roy installed an "ultra-dense" sensing apparatus in his home: 11 cameras and 14 microphones comprehensively monitored interior space, accumulating approximately 300GB of data per day.<sup>117</sup> Over a three year period of site observation, he captured 90,000 hours of video and 140,000 hours of audio documenting the life of his son from birth to 3 years of age.<sup>118</sup> In his TED Talk, "The Birth of a Word," Roy discusses how this apparatus and subsequent analytic techniques enable novel data explorations leading to new insights about the genesis of speech and language.<sup>119</sup>

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<sup>116</sup> A key reference is his paper Deb Roy et al., "The Human Speechome Project," *Cognitive Science* (2006).

<sup>117</sup> Ibid.

<sup>118</sup> Deb Roy, "New horizons in the study of child language acquisition" (paper presented at the INTERSPEECH-2009, Brighton, United Kingdom, September 6-10, 2009).

<sup>119</sup> Deb Roy, "The Birth of a Word," recorded 2011, Technology, Entertainment, Design 2011, [https://www.ted.com/talks/deb\\_roy\\_the\\_birth\\_of\\_a\\_word](https://www.ted.com/talks/deb_roy_the_birth_of_a_word).

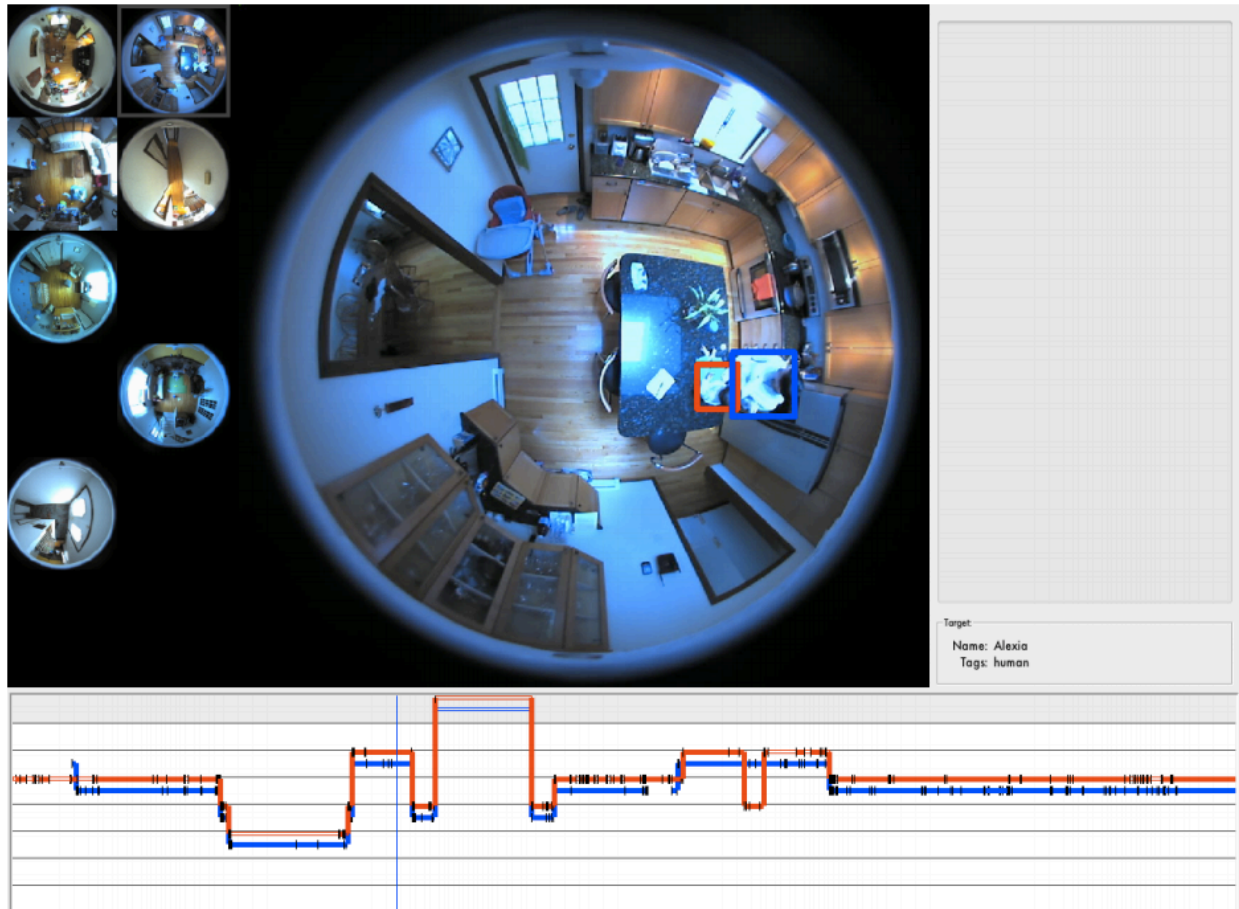


Figure 4.5. Deb Roy, *The Human Speechome Project* (2006)

In constructing a formal research apparatus to observe his family *in vivo*, Roy's project aligns with traditions of scientific self-experimentation and the personalized analyses of the Quantified Self<sup>120</sup> movement. His project becomes something complex and monumental: he has leveraged resources from a massive research institution (MIT), to build a panoptic system, documenting the intimate familial process of raising a young child. This resembles an art project (a work to be inhabited) while chasing "scientific" aims. Roy seems to recognize some of this raw poetic implication of science as portraiture: at the end of his TED talk, he recounts his son's realization

<sup>120</sup> See for instance "Quantified Self," *Wikipedia: The Free Encyclopedia* (accessed March 14, 2018); available from [https://en.wikipedia.org/wiki/Quantified\\_self](https://en.wikipedia.org/wiki/Quantified_self) or *Quantified Self* (accessed March 14, 2018); available from <http://quantifiedself.com/about/>.

that he could share this unique data portrait with his own children someday. Roy built his own *Post-Partum Document*.

To return to Le Corbusier, I will end with what I view as Le Corbusier's true "machine for living in": his Cabanon built in 1952 Roquebrune-Cap-Martin in the South of France. This was a modest vacation property that Le Corbusier designed and built to resemble a rustic wood cabin. As he describes it: "I have a castle on the Riviera, it measures 3.66 by 3.66 meters. It's for my wife, and is extremely comfortable and cosy."<sup>121</sup> The cabin is situated on the rock hillside overlooking the ocean, adjacent to the Etoile de Mere restaurant and Eileen Gray and Jean Badovici's modernist villa E-1027.<sup>122</sup>

Aside from the conspicuous lack of a kitchen (the cabin was attached to a restaurant), this space expresses an extremely reduced typology of inhabited space including: "a working area, a resting area, lavatory, wash-basin, a table, storage cupboards and a coat-rack ... concentrated into a square cell measuring 3.66m by 3.66m and 2.26m high."<sup>123</sup> The cabanon interior combines a Modernist utility stripped of ornament with the outwards appearance of a rustic hunter's cabin, itself a sort of unadorned functionalism.

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<sup>121</sup> Le Corbusier quote is uncredited, but retrieved from *Le Corbusier's Cabanon* (accessed March 14, 2018); available from <https://capmoderne.com/en/lieu/le-cabanon>.

<sup>122</sup> See *E-1027: A House by the Sea* (accessed March 14, 2018); available from <https://capmoderne.com/en/lieu/la-villa-e-1027/>. This building was also site of a scandal regarding Le Corbusier's "vandalism" through paintings he made directly on the white walls.

<sup>123</sup> "Le Corbusier's Cabanon."



Figure 4.6. Le Corbusier, *Le Cabanon* (1951).

The cabanon is an intimate space par excellence. Le Corbusier designed it for his wife, as a vacation spot. And after her death in 1957, he continued to use the space as a personal retreat until his death in 1965. Le Corbusier, an experienced swimmer, drowned off of the coast by the cabanon at the age of 1977, leading speculation as to suicide or possible intentional death.<sup>124</sup>

While Le Corbusier's other buildings may have demonstrated a machine aesthetic, inspired by the beautiful efficiency of the ends-driven engineering process of large machines, the cabanon expresses a different sort of utility. This building expresses a bare functionalism that has more in

<sup>124</sup> Izzy Ashton, *Le Corbusier's Cabanon seaside cabin is his smallest building on the World Heritage List* (accessed March 14, 2018); available from <https://www.dezeen.com/2016/07/20/le-corbusier-french-holiday-home-cabanon-17-buildings-unesco-world-heritage-list/>.

common with Henry David Thoreau's idea of reduced or essential living, expressed in *Walden* and the home that he constructed at Walden Pond: "I went to the woods because I wished to live deliberately, to front only the essential facts of life..."<sup>125</sup> Like Thoreau's cabin or Bachelard's cave or hut, the cabanon is a house stripped to its essence. Rather than the new stylistic language of International Modernism, Le Corbusier's cabanon expresses a simpler functionalism that hearkens back to an earlier time.

Le Corbusier's cabanon synthesizes a number of these in my research: it is an intimate site, it is the epitome of unadorned functionalism, transforming economy into an aesthetic, and it is overloaded with narratives and meanings. Constructing one's own home, as Thoreau did at Walden, is a quintessentially American pursuit.

By comparison, the functionality of the cabanon illustrates a core irony of the commercial smart home: its inutility, and inessential nature. Though marketed through the fantasy of utility, as stream-lining consumption, securing the home, and facilitating the free flow of information through natural interfaces, the smart home provides mere technological luxury. A most efficient, utilitarian, economical, machine-like implementation of living space would better resemble the engineered quarters of space station, submarine, or small cabin.

Together, these examples highlight the multiple dimensions of the complex engagement with the home in my dissertation work. They evoke contrasts between essential living and the technical luxury of the smart home; between the home as a place of private intimacy and of constant machine observation. They consider the implications of robotic agents and machine observers in domestic

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<sup>125</sup> Henry David Thoreau, *Walden and On the Duty of Civil Disobedience* (New York: New American Library, 1960), 66.

space. As we enmesh human-computer interactions more deeply in our lives, we shift to an era of human-computer cohabitation, and ubiquitous sensing is our new domestic condition.

#### 4.4 SITE OBSERVATION

In evaluating systems the artist is a perspectivist considering goals, boundaries, structure, input, output, and related activity inside and outside the system.<sup>126</sup>

- Jack Burnham

When I was ready, I turned on the receivers of simultaneous action. Seven days have been recorded. I performed well: a casual observer would not suspect that I am not part of the original scene... I arranged the records; the machine will project the new week eternally.<sup>127</sup>

- Bioy Casares

##### 4.4.1 *Instrumentalized Home*

*A Machine for Living In* has two phases: the construction and inhabitation of a functional smart home system, followed by an exhibition of processed data as a layered digital arts installation. This section describes the hardware and sensing setup for the site observation phase of the project. I identify the key experiential layers of domestic space to be engaged, working as a “perspectivist” in Burnham’s description above, performing an analysis of the home as site and system. I match these points of interest with effective technologies for capturing home activity. Like Morel’s invention in Casares’ novel, these are the “receivers of simultaneous action” for this project. I then discuss the parameters of site observation and the scope of collected data.

In this process of system design, my “machine for living” aims for a functional perception of space in its physical, psychological, and human dimensions. This contrasts with commercial smart

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<sup>126</sup> Burnham, 32.

<sup>127</sup> Bioy Casares, 101.

home goals of providing frictionless shopping experience, the ambient production of marketable personal information, and the refinement of corporate machine perception models.<sup>128</sup> For my purposes, the house is an observing instrument tasked with producing a durable portrait of intimate life.

As described in 4.1 above, home is an overloaded site: a space of language, bodily practice, quotidian narrative, physical actions, cultural codes, and a constructed space. The sensing apparatus created for this project records these multiple strata of experience through physical sensing, cameras, sound recording, and 3d imaging and spatial representation, as described in Table 4.1 below. The particular techniques used extend the processes of machine perception developed for my earlier projects such as *Convex Mirror*, *Solipsist*, and *Rover*, now situated and embedded within a real, lived space: the inhabited home. The topology of the situation has changed: rather than staging experimental encounters between human and machine as coequal entities in some exterior context, now the humans reside within the sensing machine. The home is instrumentalized: transformed from inert inhabited space into a documentary apparatus and impassive technological observer.

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<sup>128</sup> Amazon, Google, and Apple all gather voice data from user interactions. See Tim Moynihan, "Alexa and Google Home Record What You Say. But What Happens to That Data?," *Wired* 2016 (accessed March 14, 2018); available from <https://www.wired.com/2016/12/alexa-and-google-record-your-voice/>.

Table 4.1. Experiential Layers of Domestic Space

<i>Experience</i>	<i>Sensing Techniques</i>	<i>Concreteness</i>
Activity	ML Classifiers	Abstract
Speech	Voice Activity Detector, Google Voice Services, Kaldi	...
Motion	OpenCV, MOG FG/BG Segmentation	...
Sound	Microphone	...
Image	Camera	...
Physical Interaction	Physical Sensors	...
Architecture / Physical Space	Measurement and 3D Scanning	Concrete

The identification and selection of sensing sites for this project is itself a descriptive endeavor. Rooms in the home present a natural taxonomy of spaces: bedroom, bathroom, kitchen, living room, basement. Each is suggestive of particular functions, and particular psychology (Bachelard). The appliances, furniture, and objects in the house provide a secondary list of possible sites of engagement. A quick inventory of everyday objects provides their own suggestive meanings and histories: the bed, alarm clock, shower, toilet, sink, oven, toaster, microwave, fridge, television, and couch. Finally, the commercial smart home industry provides a variety of targets ripe for parody employing the debased “smart” descriptor: smart beds, smart sheets, smart kitchen knobs, smart door locks. My original sketch of potential sensing sites (Figure 4.7) shows this dense and overloaded perspective on home sensing.

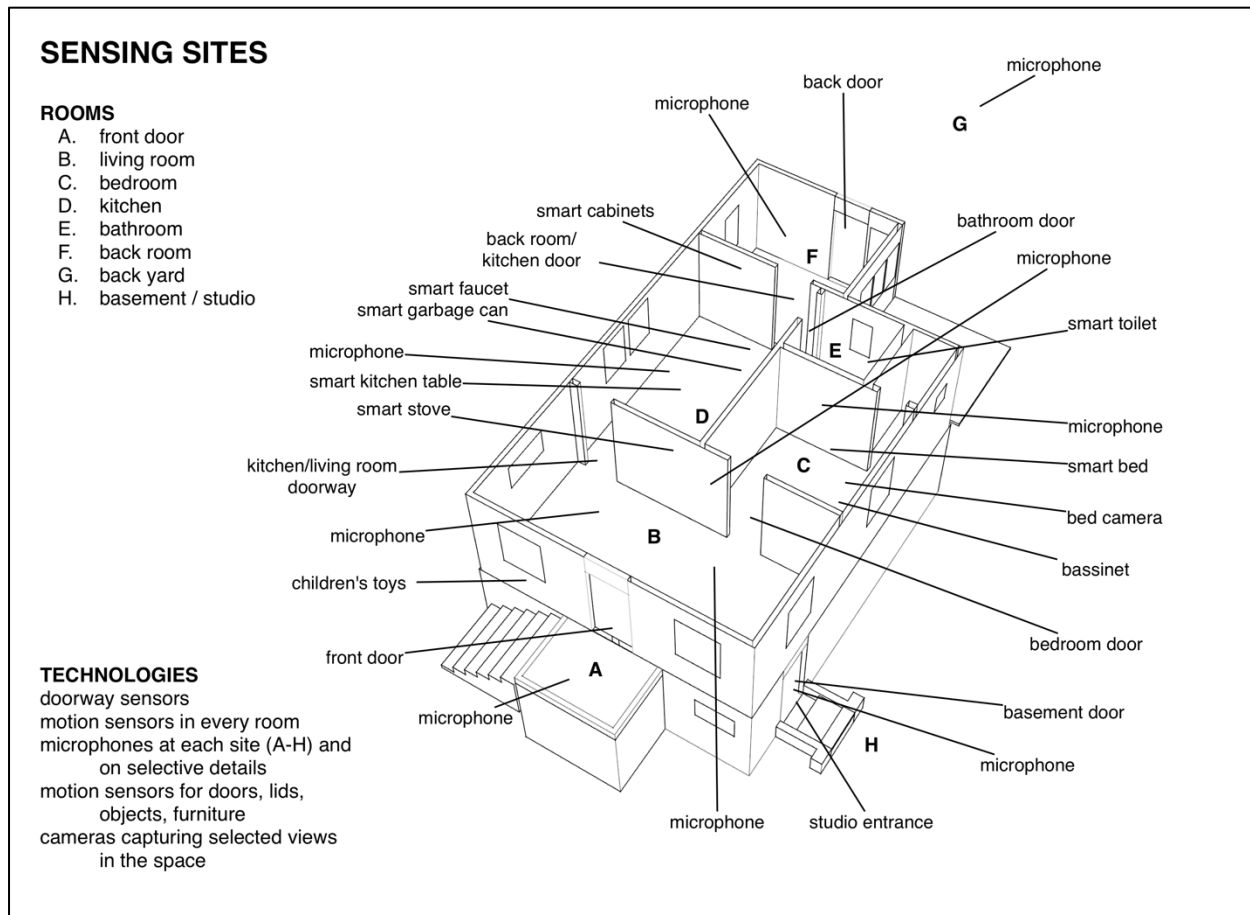


Figure 4.7. Initial home sensing sites identified in the home

What I have developed for this project is a general strategy for home sensing that can be opportunistically extended with the inclusion of new technologies. The specific sensors, platforms, and processors used are unimportant: what matters is engaging the identified sites in the home space. These are the anchors of meaning for the piece. They define the essential, functional requirements for the sensing apparatus, and are my assessment of “the problem of the house.”

The network topology of this real-time *house sensate* was a centralized hub with wireless sensing nodes as shown in Figure 4.8 below. Individual nodes were either physical sensors, digital microphones, or digital video cameras, all running on-sensor analysis and filtering. Cameras and microphones were attached to embedded Linux systems (Raspberry Pi) running basic sound and

image event detection. Physical sensors were programmed to only transmit state changes through configurable thresholds of activation and temporal criteria. Shifting these basic levels of intelligence out to the edge of the network (“edge computing”<sup>129</sup>) saved on network traffic, density of stored data, and harnessed the available computational resources of the various sensors most efficiently.

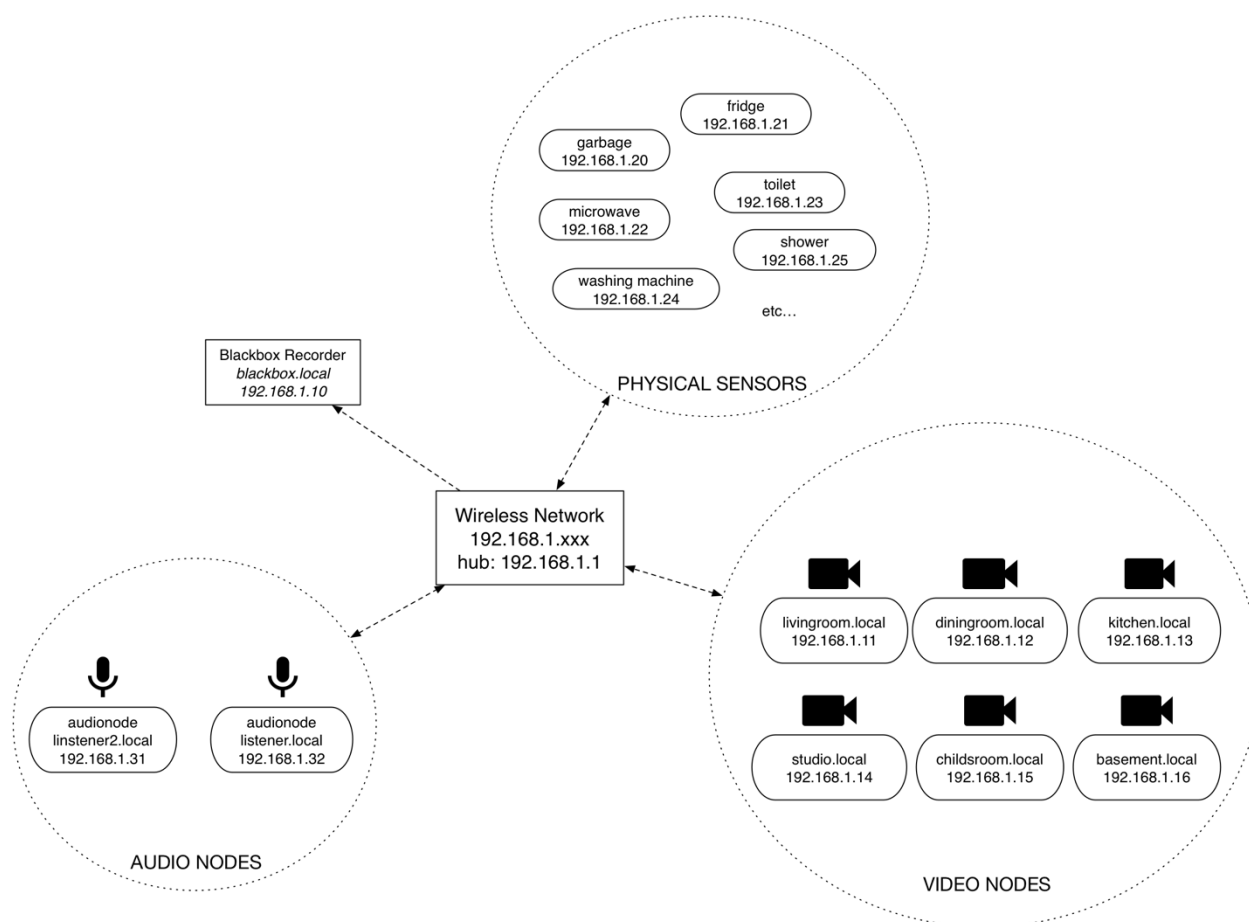


Figure 4.8. Home sensor network

Devices were attached to a Wireless Local Area Network (WLAN) communicating with sensors and receivers using Open Sound Control (OSC) and various communication and file

<sup>129</sup> See "Edge Computing," *Wikipedia: The Free Encyclopedia* (accessed March 14, 2018); available from [https://en.wikipedia.org/wiki/Edge\\_computing](https://en.wikipedia.org/wiki/Edge_computing).

transfer protocols (scp, ftp, and ssh). The following sections describe the data logger, physical sensors, audio sensors, and video sensors used for the project.

#### 4.4.2 *Geometric Space*

This project commenced with a manual survey of the built space of the home using a tape measure and pen and paper. These measurements were then consulted to produce a 3D CAD model of the home using the Rhinoceros 3D software,<sup>130</sup> as seen in Figure 4.9. In a later phase, I used a handheld 3D scanner (repurposed Microsoft Kinect<sup>131</sup>) and Real-Time Appearance-Based Mapping (RTAB-Map) software<sup>132</sup> to create 3d point cloud models of built space. These were cleaned and edited using MeshLab<sup>133</sup> and Rhinoceros 3D to produce point cloud models on the order of 10 million 3D vertices per room.

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<sup>130</sup> Robert McNeel and Associates, *Rhinoceros 3D* (accessed available from <https://www.rhino3d.com/>).

<sup>131</sup> "Kinect for Xbox 360 (2010)," *Wikipedia: The Free Encyclopedia* (accessed March 14, 2018); available from [https://en.wikipedia.org/wiki/Kinect#Kinect\\_for\\_Xbox\\_360\\_\(2010\)](https://en.wikipedia.org/wiki/Kinect#Kinect_for_Xbox_360_(2010)).

<sup>132</sup> *RTAB-Map* (accessed March 14, 2018); available from <http://introlab.github.io/rtabmap/>.

<sup>133</sup> *Meshlab* (accessed March 14, 2018); available from <http://www.meshlab.net/>.

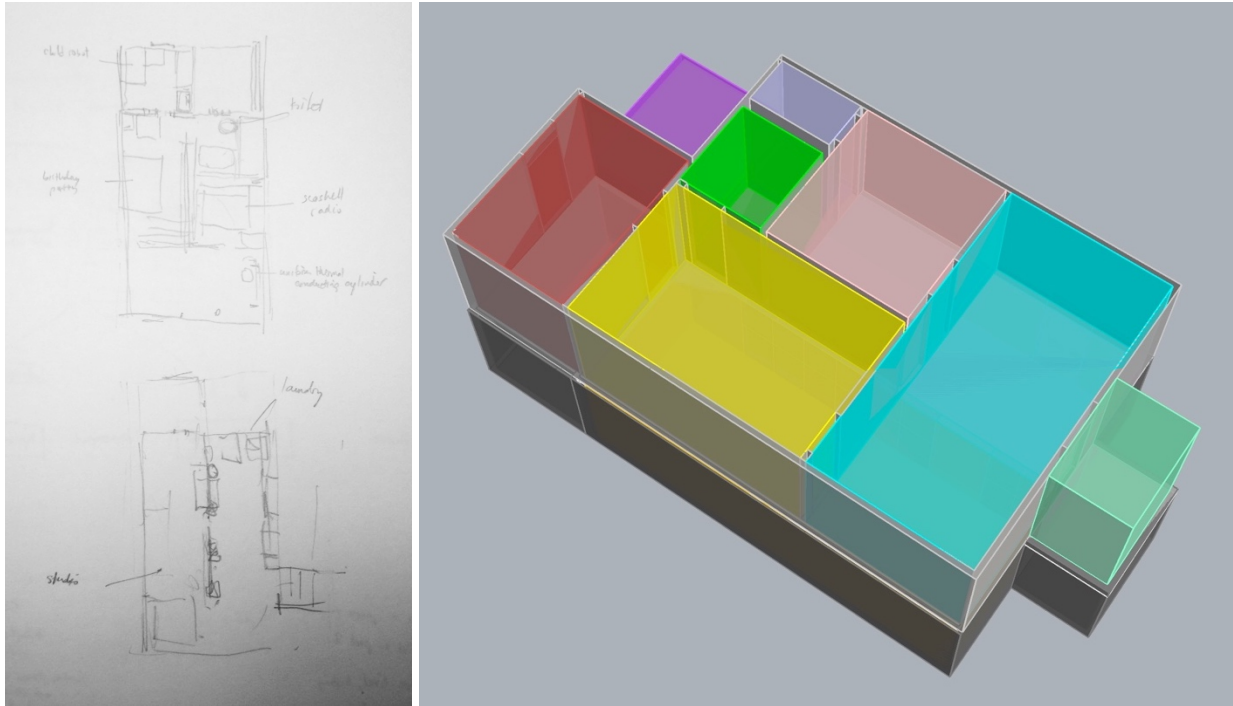


Figure 4.9. Measured floor plan and CAD model

#### 4.4.3 *Physical Sensors*

The first layer of sensing in this project are the physical sensors. These are embedded, situated devices attached to particular locations in the house, each using different sensing technologies to capture tangible physical interactions in the home space. Table 4.2 shows the various sensing modalities, sensing sites, and technologies deployed for this project.

Table 4.2. Sensor technologies and sensing locations

<i>Sensing Modality</i>	<i>Sensing Location</i>	<i>Sensor Technology</i>
temperature and humidity	shower, stove	DHT11
open/closed	closets, doors, garbage can, fridge, etc.	magnetic reed switch
presence	interior passageways	IR send/receive pair
vibration	microwave, washing machine, chairs, tables	piezo
motion	room occupancy	Passive Infrared (PIR)
proximity	toilet, sink	IR range finder

All physical sensors in the house were connected to Particle Photon wireless controllers.<sup>134</sup> Photons combine a STM32 ARM Cortex M3 microcontroller and a Cypress Wi-Fi chip with a number of standard digital interfaces (I2C, I2S, Serial) and analog and digital pinouts. Individual code was adapted for each sensor from a common housenode codebase I developed specifying naming conventions, communication protocols (OSC), and over-the-air programmable configuration options (not requiring a USB connection). Nodes were given descriptive names and could be reconfigured live with OSC messages. Node names, server addresses, and sensory and temporal thresholds were stored in onboard Flash memory where they would remain after power was turned off. Once the nodes were attached to physical sites and configured, these settings remained largely unchanged for data collection periods. Figure 4.10 shows sensors installed on various sensing sites in the home.

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<sup>134</sup> *Particle Photon Wi-Fi Hardware* (accessed March 14, 2018); available from <https://www.particle.io/products/hardware/photon-wifi-dev-kit>.



Figure 4.10. Photon with sensors on the washing machine, fridge, garbage can, and toilet

#### 4.4.4 Video Nodes

Video data was captured from a number of overhead vantage points using embedded Linux systems (Raspberry Pi 3<sup>135</sup> and Raspberry Pi Zero W<sup>136</sup>) with circular fisheye lenses<sup>137</sup> and the PiKrellCam motion triggered recording software.<sup>138</sup> Video was recorded at 15fps and 1560x1080, the maximum resolution and framerate possible for a full fisheye view given this image sensor and the inbuilt constraints on the video processing capabilities of the Raspberry Pi.

<sup>135</sup> *Raspberry Pi 3 Model B* (accessed March 14, 2018); available from <https://www.raspberrypi.org/products/raspberry-pi-3-model-b/>.

<sup>136</sup> *Raspberry Pi Zero W* (accessed March 14, 2018); available from <https://www.raspberrypi.org/products/raspberry-pi-zero-w/>.

<sup>137</sup> *Arducam OV5647 Camera Board with LS-40180 Fisheye Lens M12x0.5 Mount for Raspberry Pi 3* (accessed March 14, 2018); available from <https://www.amazon.com/Arducam-LS-40180-Fisheye-M12x0-5-Raspberry/dp/B013JWEGJQ>.

<sup>138</sup> Bill Wilson, *PiKrellCam - OSD Motion Detect Program* (accessed March 14, 2018); available from <http://billw2.github.io/pikrellcam/pikrellcam.html>.

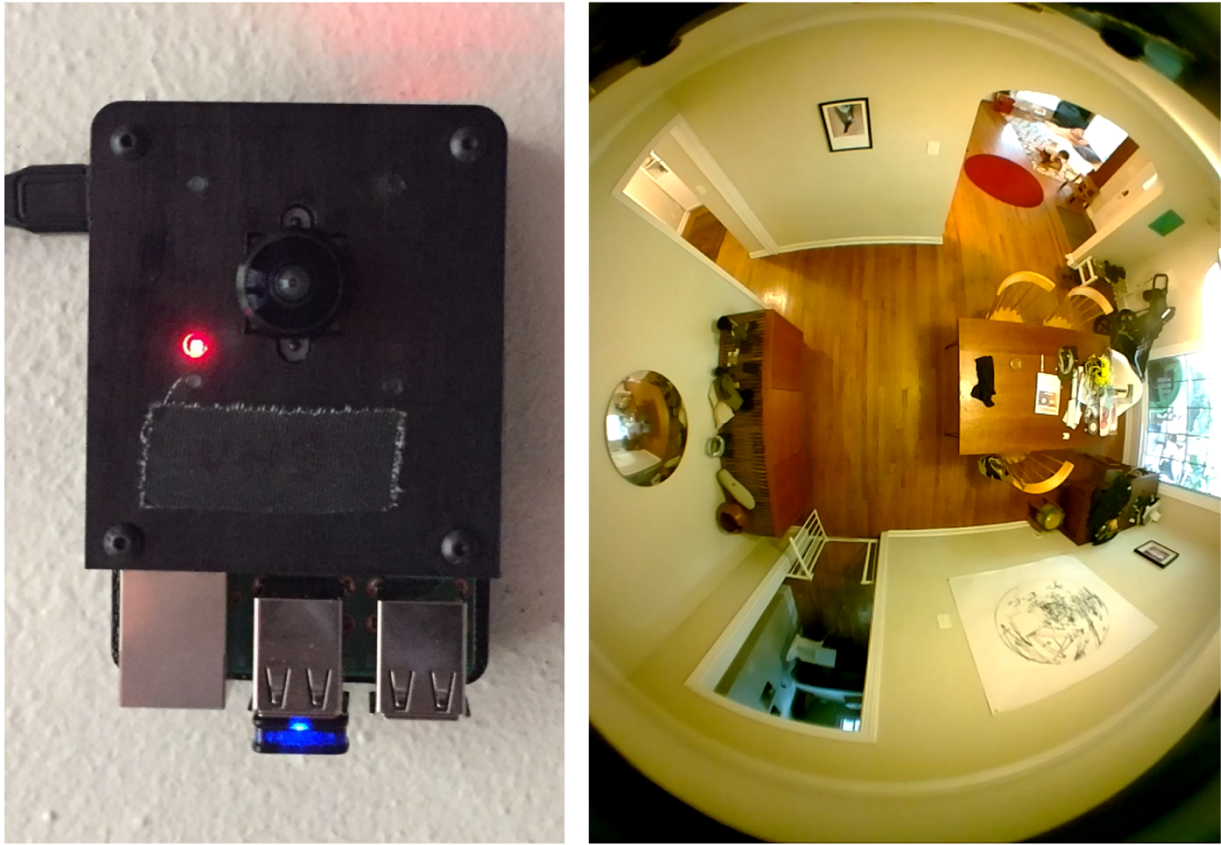


Figure 4.11. Video node and ceiling view

Software parameters were tuned to capture the movements of all inhabitants of the house (animal, human, and baby human) across various bodily scales and viewing distances, and to ignore changes in environmental lighting where possible.<sup>139</sup> This amounted to a first level of intelligence implemented in the sensing approach. Video was further filtered as described in the following section. Inhabitant tracking was accomplished with custom code written in Python using OpenCV<sup>140</sup>, also describe below.

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<sup>139</sup> Parameters included size of motion activation regions, magnitude thresholds for calculated visual motion, duration of motion trigger, and duration of pre- and post-event recording. All were set through pikrellcam software configuration files.

<sup>140</sup> *OpenCV* (accessed March 14, 2018); available from <https://opencv.org/>.

Additional video data was recorded through thermal imaging cameras (FLIR Lepton<sup>141</sup>) running on a Raspberry Pi. This produced very low resolution (80x60 pixels, 16 bits per pixel) video at low frame rates (1 fps), but was a novel mode to record traces of human presence and inhabitation through lingering heat signatures. Figure 4.12 below shows successive infrared frames from an overnight recording session of the bed.



Figure 4.12. Still frames from infrared (IR) imaging of the bed

#### 4.4.5 *Audio Nodes*

Audio data was gathered through a number of audio nodes consisting of omni MEMS microphones, the InvenSense ICS-43432<sup>142</sup> attached to embedded Linux systems (Raspberry Pi) running open-source voice activity detection software *webrtcvad*.<sup>143</sup> Figure 4.13 shows an audio node. The circuit for the microphone was designed and fabricate by the artist, and is documented online.<sup>144</sup> The sound listening service was written in Python, and only audio classified as “voice

<sup>141</sup> *FLIR Lepton* (accessed March 14, 2018); available from <https://www.flir.com/products/lepton/>.

<sup>142</sup> InvenSense, *ICS-43432 Datasheet* (accessed March 14, 2018); available from <https://www.invensense.com/products/digital/ics-43432/>.

<sup>143</sup> John Wiseman, *py-webrtcvad* (accessed March 14, 2018); available from <https://pypi.python.org/pypi/webrtcvad>.

<sup>144</sup> Flexible circuit design for ICS-43421: <https://github.com/roberttwomey/ics43432-pi>.

activity” was recorded to disk. Audio was recorded at 48kHz sample rate and 24-bit sample depth, to give the greatest degree of fidelity for later analysis and synthesis. In the analysis phase, audio features were extracted, clustered, and resynthesized as discussed in the following section.

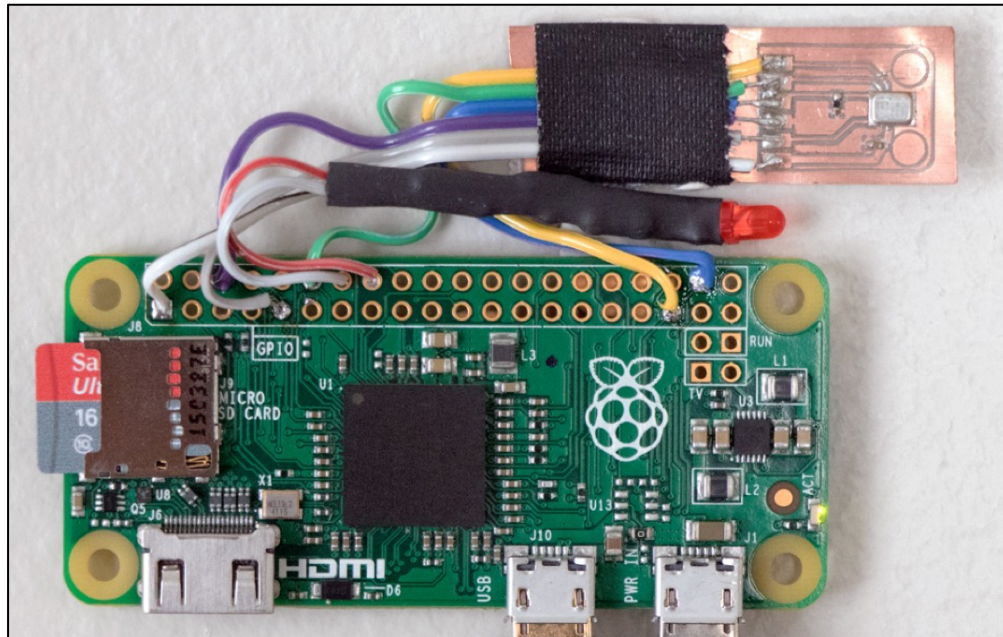


Figure 4.13. Audio node with MEMS mic and Raspberry Pi Zero

#### 4.4.6 *Black Box Recorder*

Centralized event logging and data storage was accomplished through a single embedded Linux system with attached disk storage. This device, *blackbox.local*, had an attached Real Time Clock (RTC) with battery backup to create a master clock for the home system, and stored incoming sensor messages as well as aggregating sound and video files.

In commercial aviation the flight data recorder (FDR) and cockpit voice recorder (CVR) are the two pieces of technology colloquially known as the black box recorder. They create a comprehensive running record of the physical state of the aircraft, pilot actions, and cockpit conversations for some prior period of time. I strove for a similar functionality through the site-

observation system I developed for this piece, likening the data logger and file storage to a black box recorder installed in the home (itself an encapsulated site like an aircraft).

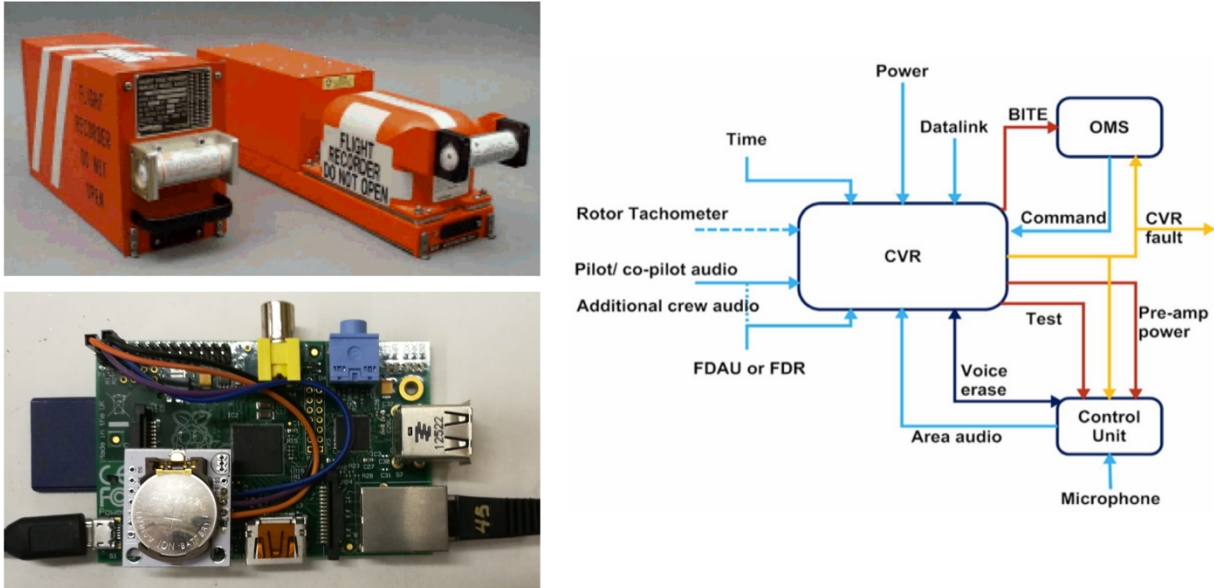


Figure 4.14. Black box recorders

#### 4.4.7 *What the Machine Saw*

The combined approaches above formed a comprehensive engagement with the home as an intimate site and produced large corpora of audio, visual, spatial, and physical sensing data. Taken together, these materials provide a composite image of inhabitation. The scale and heterogeneous character of this data provided complex challenges both computationally and compositionally, in cleaning the data and in processing it to produce meaningful distillations. Over the course of this site observation, the project recorded 40GB of compressed video data, 60 GB of uncompressed audio data, and approximately 200,000 sensor activations.

*A Machine for Living In* differs from my earlier work in its integrative intent: my aim with the project is to place these diverse experiential aspects of place within a unified frame, where

each type of information can communicate with the others. Secondly, the scale of data collected for this project presents new challenges: the sensing apparatus produced hundreds of hours of audio and video, tens of thousands of sensor readings, and millions of point cloud points. Data storage and analysis were problems to be solved. Finally, the compositional challenge with this project is to produce meaningful distillations of domestic activity, and to manifest these experiences in an exhibition scenario. My compositional approach and methodological models are discussed in the following section.

The goal of the sensing approach was to create a transcript of activities, a record of speech, images of inhabitation. Following Perce, to document the infra-ordinary:

What speaks to us, seemingly, is always the big event, the untoward, the extra-ordinary: the front-page splash, the banner headlines. Railway trains only begin to exist when they are derailed, and the more passengers that are killed, the more the trains exist. Aeroplanes achieve existence only when they are hijacked. The one and only destiny of motor-cars is to drive into plane trees.... How should we take account of, question, describe what happens every day and recurs everyday: the banal, the quotidian, the obvious, the common, the ordinary, the infra-ordinary, the background noise, the habitual?<sup>145</sup>

#### 4.5 CONSTRUCTED HOME

A house that has been experienced is not an inert box. Inhabited space transcends geometric space.<sup>146</sup>

- Gaston Bachelard

The second phase of *A Machine for Living In* is an exhibition of processed domestic data as a multilayered digital arts installation. In this section I discuss the technical and compositional problems of working with the complex, multi-modal data produced in phase one of the project:

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<sup>145</sup> “Approaches to What?” in Perce, *Species of Spaces and Other Pieces*.

<sup>146</sup> Bachelard, 140.

how to synthesize diverse machine observations into a singular, cohesive viewer experience. I describe my approach to data analysis, visual and temporal composition, and exhibition design for the project.

*A Machine for Living In*, the exhibition, is a signifying system and sculptural non-site. The piece necessarily accomplishes dimensional reduction of data, sculptural distillation of form, and the computational analysis and classification of domestic activity. Recorded site data is filtered through machine perception processes, then composed by the artist in a process of joint human-machine authorship.

#### 4.5.1 *Exhibition Space*

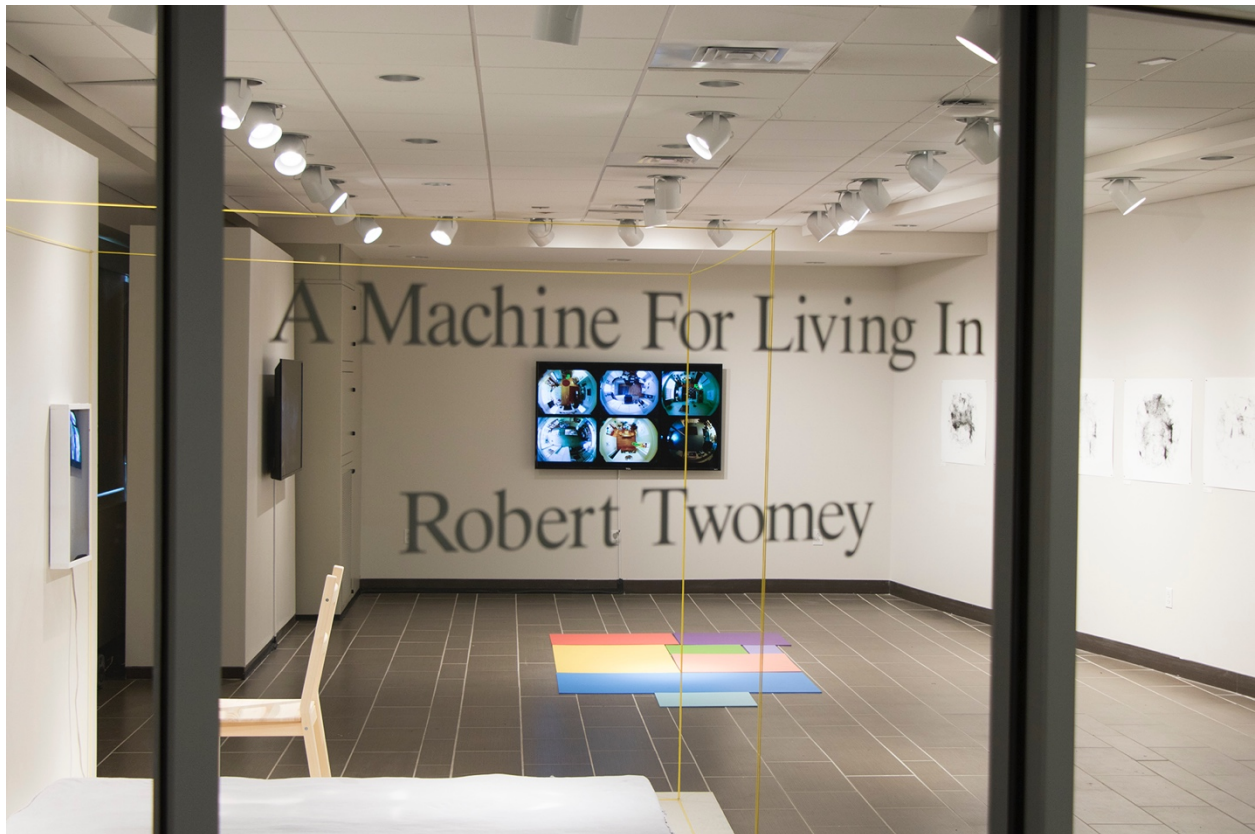


Figure 4.15. *A Machine for Living In*, exhibition view

The inaugural exhibition of *A Machine for Living In* was at the Foster Art Gallery at Westminster College in New Wilmington, PA, from August through October 2017. Compositionally, the installation created a spatialized representation of the data gathered in phase one of the project. This entire show is to be viewed as a sculptural non-site (Smithson) representing material gathered at the primary site, the home. A multi-layered exhibition, the project combines audio, video, text, digital drawings, and a small constructed room within the room. Figure 4.16 below shows the key elements of the exhibition labelled on a floor plan for the installation.

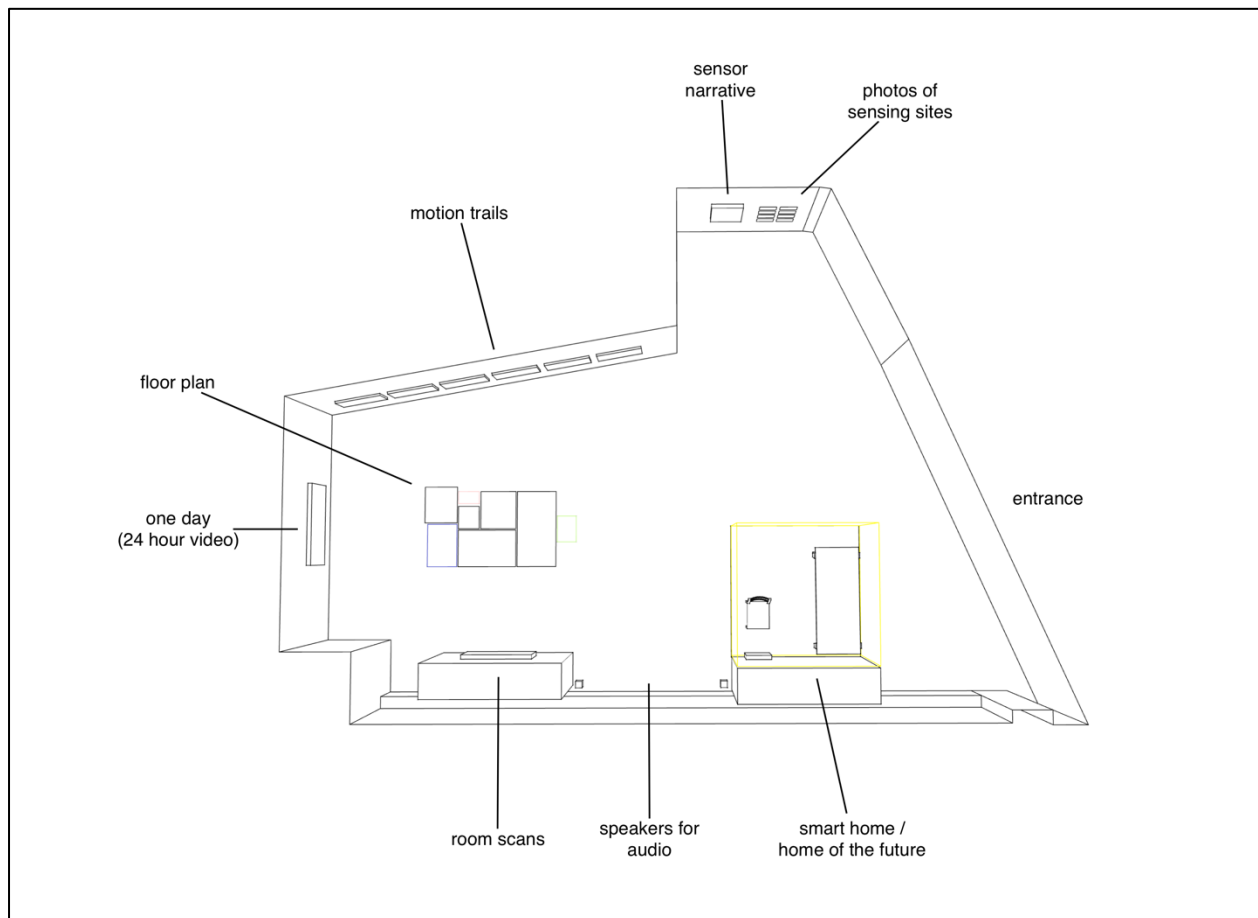


Figure 4.16. *A Machine for Living In*, exhibition floor plan

The project announces itself before viewers enter the space of the gallery. A looping 24-minute audio piece fills the room and spills out into the hallway and surrounding space of the

building. Dogs' barks, babies' cries, and other domestic noises punctuate the local sonic environment and invite viewers into the show.

Encountering the piece through the front entrance as shown in Figure 4.17, viewers experience multiple competing forms and modes of representation operating in a shared space of signification. To the left is a small room encapsulated in bright yellow contour lines. In the back third of the piece (the left-hand side of the above floor plan) various representations of domestic space vie for representational authority: 3d architectural scans floating in a digital null space on a monitor to the left, brightly colored panels on the floor illustrate a geometric house layout, densely rendered drawings on the right wall show patterns of motion in the space, and directly ahead a large flat screen television shows overhead views of each room in the house in a twenty-four minute video matched to the audio composition playing in the room. In relation to my past work and research trajectory, this exhibition most directly resembles the *Father-Daughter Art Show*: individual pieces employing diverse modes of representation communicate with one another to create a complicated, layered experience for the viewer.



Figure 4.17. *A Machine for Living In*, front view looking in

Looking to the right (Figure 4.18), in a small nook past the row of motion trail drawings, a vertical monitor plays a textual sensor narrative, accompanied by photos of sensors and sensing sites documented *in situ*.



Figure 4.18. *A Machine for Living In*, right hand side of exhibition

Different perspectives through the space create new meanings combining elements along lines of site. Looking forward from the rear of the piece, as in Figure 4.19 below, the brightly colored floor plan tiles contrast with the floating point cloud representation of the house on the screen to the right, while at the same anchoring the yellow wireframe box of the white space / smart home seen at the front of the exhibition. These different representations resonate off of one another in the exhibition space.



Figure 4.19. *A Machine for Living In*, showing three perspectives on built space

#### 4.5.2 *Visual Elements*

The primary visual element of the exhibition is the overhead video playing on the large monitor at the back of the room, shown in Figure 4.20 below. This top-down fisheye panopticon offers a comprehensive and omniscient perspective on the home and its inhabitants as they unwittingly carry out the activities of the day.



Figure 4.20. *A Machine for Living In*, one day, still from 24-minute video

This visual perspective emphasizes both a flattening seriality to the rooms of the house (as just a finite set of room boxes), and the essential encapsulation of interior space. The distortions induced by the geometry of the fisheye lenses make the periphery nearly unreachable: as people or objects approach the edge of the frame they shrink to minuscule proportions. Windows and doors are similarly rendered opaque, thus the only signs of the exterior environment surrounding the home are evident in the varying lighting conditions in the rooms. Room light is momentarily transformed as clouds pass by the sun, and brightness gradually cycles over the course of the day. Due to the fisheye lens, each room is focused around a spherical microcosm anchored on the center of the frame, a zone of pictorial enlargement where people and animals dominate their surroundings.

The room scans seen in Figure 4.21 afford a more immediate perspective on interior space. The video shows a series of rotating views of the rooms of the house floating in a black digital

non-space. Here light emanates from the thousands of three-dimensional points captured by the 3d scanning technology. These rooms are purposefully devoid of human presence but show traces of inhabitation in the casual detritus of everyday life: books on counters, papers strewn about, lights left on. Models were captured from within the rooms but are viewed from the outside: producing exterior views of the interior of the house. These scans demonstrate a painterly aesthetic in their loose digital materiality, and situate the viewer immersively in the inhabited space of the home. They combine individual rooms (basement, kitchen, living room) in a digital non-space, creating more of a virtual sculptural object than a video piece.



Figure 4.21. Room Scan, still from animation

Juxtaposed with the room scans and overhead video, on the floor we have a brightly colored geometric representation of the floor plan of the house. This element was added to anchor the ground plane of the exhibition in the ground plane of the house, to manifest something of the

architectural CAD modelling done for the project (see Figure 4.22 below), and lends color to the exhibition as a meta-compositional decision, balancing the other visual elements in the room.

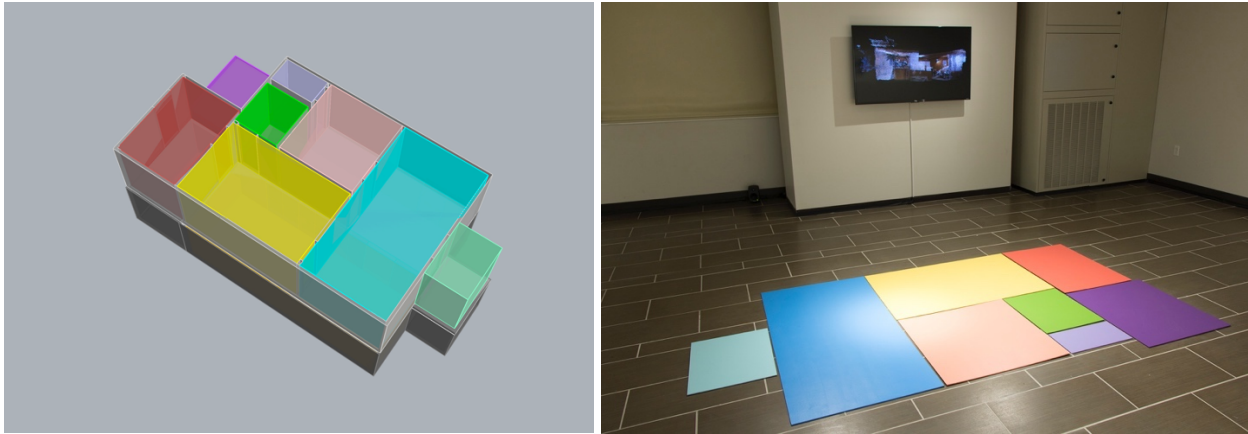


Figure 4.22. Floor plan in CAD, floor plan and 3D scans in the exhibition.

Along the long wall to the right we have a series of motion trail drawings derived from video observation of the house, shown in Figure 4.23. These digital prints recall the line drawings from *Convex Mirror*. No longer mechanically concentrated in the body of a drawing machine, here the “machine observer” is dispersed in the house (one camera in each room), and the drawings are produced at a remove from the observed space. But the descriptive intent is similar, to produce a temporally layered image of place. Bachelard:

Thus we cover the universe with drawings we have lived. These drawings need not be exact. They need only to be tonalized on the mode of our internal space.<sup>147</sup>

Figure 4.24 below shows an example frame of overhead video from the living room demonstrating people detection and extracted motion trails. On the right we see the accumulated

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<sup>147</sup> Ibid., 12.

mass of lines showing cumulative motion over time in the living room, with concentrated masses on the couch, television, and flowing into the next room.



Figure 4.23. *A Machine for Living In*, motion trail drawings installed.

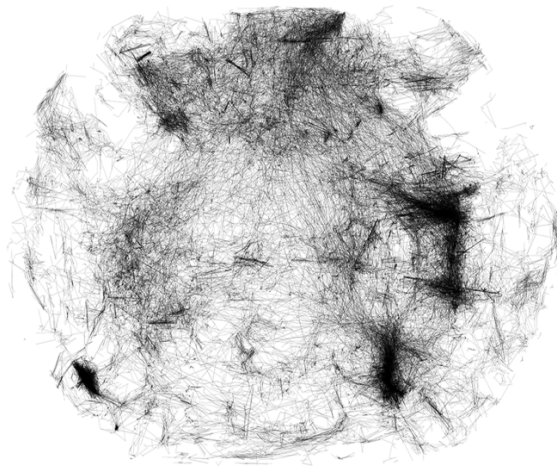


Figure 4.24. Motion trail extraction from video and a resulting drawing



#### 4.5.3 *Model Smart Home / Home of the Future*



Figure 4.26. *A Machine for Living In*, model smart home

The final visual element of the project is a model smart home / home of the future, seen in Figure 4.26 above. This is a room within a room, a blank white space outlined with a bright yellow geometric wireframe, constructed within the space of the gallery. The room is arranged to resemble Le Corbusier's cabanon, with its reduced typography of inhabited space as an interior living cell. Within the room there is a bed, a chair, and a mirror, simple accompaniments to domestic life. The room asserts its purity with a very modernist or science fictional aesthetic: all white space, light wood, reflective mirror, and fluorescent yellow geometry.<sup>148</sup>

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<sup>148</sup> For modernist white spaces in general, see *THX 1138*, directed by George Lucas (Warner Bros., 1971), or Ernest Hemingway's "A Clean, Well-Lighted Place" in Ernest Hemingway, *Winner Take Nothing* (New York: Collier Books, 1987).

This room expresses a simple encapsulation of domestic activity. Much like a submarine, spaceship, or studio apartment, it contains the necessary elements of reduced or essential living in a closed space. The compositional references for this open frame construction are both the glowing lines of CAD geometry (wireframe models), and the encapsulated space of Francis Bacon's round areas, arenas, and cubes — “the operative field.”<sup>149</sup> This painted structure is particularly evident in the two exterior images from his triptych *Sweeney Agonistes* (1967, Figure 4.27 below). On the left and the right sides, we see these boxlike structures: open to the air, with a solid ground plane, a stage, and some mirrored or televisual curved imaging plane on the right-hand side.



Figure 4.27. Francis Bacon, *Sweeney Agonistes* (1967) triptych

Bacon aims to achieve an isolation and encapsulation of the body: avoiding the “figurative, illustrative, and narrative character the Figure would necessarily have if it were not isolated.”<sup>150</sup>

The spaces he constructs have been called variously a cage, arena, vitrine, or boxing ring. What I

<sup>149</sup> Gilles Deleuze, *Francis Bacon: The Logic of Sensation* (Minneapolis: University of Minnesota Press, 2004), 6.

<sup>150</sup> Ibid.

find most compelling about these paintings is the contrast between the smooth pastel panels and clean curved surfaces of the containing environments and the comingled fleshy masses within. This compositional dynamic plays out between the visceral explosion of bodily matter on the chair in the central image, and the spatial and organic constraint in the two bracketing images. These paintings map out a triangulation of viewership between the massed bodies on the platforms, the mirrors or screens on the right (including the staring figure on the phone), and the embodied spectator (us) looking at the paintings and seeing both subject and mediating observer / device.



Figure 4.28. Detail of bed, mirror, and chair in model smart home

Figure 4.28 above shows a detail view the model smart room I have constructed. The objects within embody traces of inhabitation. The mirror displays video originally recorded through the bathroom mirror, playing back what it saw here in the exhibition. The bed similarly plays traces

of body heat captured in the house. Covered with an array of heating elements and a thermochromic blanket,<sup>151</sup> the fluctuations in temperature of the bed outline visually reveal the outline of a body in white against the gray ground. If the viewer touches the blanket, they can feel real heat emanating from this image. The plain wooden chair has an attached piezo sensor that visually registers when a viewer sits in it.

I call this constructed space the model smart home because it serves as a nexus of imaginations and concrete manifestations of smart home technologies. Replaying recorded traces of absent individuals, the objects within recall the automated remnants of the smart house in Bradbury's "There Will Come Soft Rains."

#### 4.5.4 *Temporal Composition and Joint Authorship*

What machines do is to telescope and edit experiences in a way that printed materials cannot.<sup>152</sup>

- Jack Burnham

Now that I am accustomed to seeing a life that is repeated, I find my own irreparably haphazard.<sup>153</sup>

- Bioy Casares

The overhead video, audio, and sensor narrative screens function together as the temporal core of the project. They all participate in the same kind of time compressed edit: structured as one complete day in a twenty-four-minute loop, where one minute represents one hour. The larger corpus of recorded house data is telescoped and edited by software, capitalizing on the machinic

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<sup>151</sup> Body Faders, *Grey to White Heat Color Changing Fabric* (accessed March 3, 2017); available from <http://www.bodyfaders.com/shopping/pc/viewCategories.asp?idCategory=29>.

<sup>152</sup> Jack Burnham, "Notes on art and information processing," in Jewish Museum, American Motors Corporation, and Smithsonian Institution, *Software; An Exhibition* (New York: Jewish Museum, 1970), 14.

<sup>153</sup> Bioy Casares, 85.

potential Burnham describes above. The final pieces in the show are products of joint human-machine authorship consisting of data analysis, classification, structured query, and algorithmically assisted edits. These efforts align with technical fields of computational creativity,<sup>154</sup> algorithmic composition, and computer supported cooperative work (CSCW).<sup>155</sup>

This looping structure was largely inspired by Bioy Casares' story *The Invention of Morel*. Existential loop. Endless recurrence (eternal return). Temporal durability. Giving oneself over to the representation.

The video piece was visually described in the previous section with its six overhead views of interior space. The source material is doubly filtered. On site, the recording system only captured when motion was detected: thus, all events on screen in the resulting piece are moments where motion was detected in the original house context. To detect motion, the video software used relatively simplistic camera motion vector fields that are produced as part of the hardware video compression process. Thus, detected motion means that some object, person, or animal moved in the space, or that some spurious change in lighting registered as "motion." Thus, there is a need for a second level of filtering.

Video was additionally processed using computer vision techniques implemented with OpenCV<sup>156</sup> in python. Foreground/background segmentation was accomplished using the K-nearest neighbor background subtractor implemented in OpenCV.<sup>157</sup> Background pixels were masked out, the foreground image was thresholded, and contours were detected. Contours size was

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<sup>154</sup> *Association for Computational Creativity* (accessed March 14, 2018); available from <http://computationalcreativity.net/home/>.

<sup>155</sup> *ACM Conference on Computer-Supported Cooperative Work and Social Computing* (accessed March 14, 2018); available from <https://cscw.acm.org/2018/>.

<sup>156</sup> OpenCV 3.2, "OpenCV."

<sup>157</sup> *OpenCV BackgroundSubtractorKNN* (accessed March 14, 2018); available from [https://docs.opencv.org/3.3.1/db/d88/classcv\\_1\\_1BackgroundSubtractorKNN.html#details](https://docs.opencv.org/3.3.1/db/d88/classcv_1_1BackgroundSubtractorKNN.html#details).

tuned to capture animals, human adults, and children in the home imaging space. Processed clips containing tracked motion were selected for inclusion in the final video composition to provide a continuous image of inhabitation throughout the course of the day.

This kind of structured query is an approach to algorithmic video editing employed by James Coupe in his project *General Intellect* (2014-15). His piece engages the pool of internet-mediated labor available through the Amazon Mechanical Turk (MTurk) marketplace<sup>158</sup> to produce a collective portrait through the platform. Coupe's piece relies on the anonymous production of MTurk workers, paying them to record one minute of video per hour between 9am and 5pm. Workers additionally were required to write captions for their videos and provided detailed metadata about themselves.<sup>159</sup> These rules structure participation for the MTurk workers, and provide a framework for algorithmic composition of the resultant media.

At the Morningside Academy in Seattle, Coupe's piece was exhibited as a series of thirteen queries on the dataset: demographically, temporally, or by any other metadata the workers provided or that could be extracted.<sup>160</sup> The resultant videos—manually labelled, then computationally queried according to manually selected criteria—are then layered into a formerly inhabited site, the abandoned middle school as shown in Figure 4.29 below. Viewers experience these intimate video snapshots in the context of a site that is itself marked by absence, the abandoned school. The locus of creative agency in this piece is difficult to attribute. The videos are multiply authored: by the original MTurk workers, by the artist in selecting search criteria, by

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<sup>158</sup> Amazon Mechanical Turk (MTurk) marketplace, *Amazon Mechanical Turk* (accessed March 14, 2018); available from <https://www.mturk.com/>.

<sup>159</sup> His methods are described on the project website for the original version of the project at Bath Spa University, James Coupe, *General Intellect*, 2015; available from <http://jamescoupe.com/?p=2093>.

<sup>160</sup> As installed at Morningside Academy in Seattle, James Coupe, *General Intellect Exhibition in Seattle*, 2015; available from <http://jamescoupe.com/?p=2157>.

the system in executing those edits, and by the artist in selecting and realizing the exhibition context.

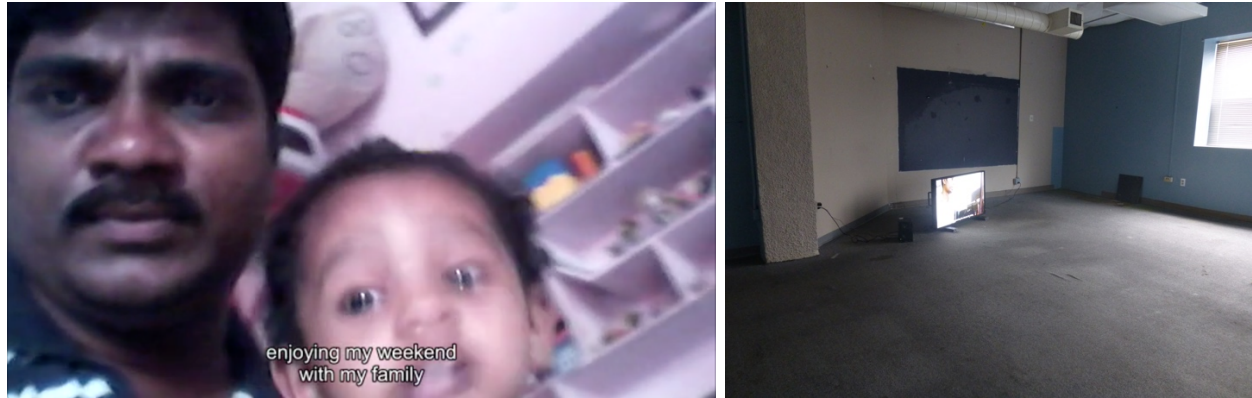


Figure 4.29. James Coupe, *General Intellect* (2014-15)

My project aims for a similar sort of structured query. My materials (the model or data set) are structured semantically (the names of sensors), spatially (room locations), and temporally (when data was captured / activity occurred). Additionally, I use software tools to produce a number of additional layers of metadata: for instance, using machine learning classifiers to identify activities and objects in the scene, classifying sonic events, and recognizing speech data in the audio recordings.

The second temporal loop in *A Machine for Living In* is the audio playing in the room. Like the video, the audio is structured on a twenty-four-minute day, where one minute in viewer experience represents one hour in the day. Initially intended just to record speech in the house through the use of the voice activity detection software, the machine listening system gathered a much broader set of matching sonic events. As with the video, a second level of classification was necessary.

The techniques employed for audio analysis extend work done with Michael McCrea for *Rover*, discussed in our SIGGRAPH paper from 2017.<sup>161</sup> In this instance, detected sounds were analyzed using the SuperCollider Music Information Retrieval (SCMIR) library<sup>162</sup> implemented in the SuperCollider digital audio language. Audio samples were split using beat detection, and analyzed with SCMIR to produce twelve dimensional descriptive vectors for each segment. Descriptors consisted of: 4 Mel-Frequency Cepstral Coefficients, the Spectral Centroid, a 6-point Chromagram, and the Fast Fourier Transform crest. These audio descriptors were clustered using *k*-Means<sup>163</sup> and HDBSCAN,<sup>164</sup> as shown in Figure 4.30 below. T-SNE handles the dimensional reduction necessary to display the detected twelve-dimensional clusters in a 2-dimensional image.<sup>165</sup>

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<sup>161</sup> Twomey and McCrea.

<sup>162</sup> Nick Collins, *SCMIR: A SuperCollider Music Information Retrieval Library*, ICMC (2011).

<sup>163</sup> "k-means Clustering" *Wikipedia: The Free Encyclopedia* (accessed March 14, 2018); available from [https://en.wikipedia.org/wiki/K-means\\_clustering](https://en.wikipedia.org/wiki/K-means_clustering).

<sup>164</sup> *Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN)* (accessed March 14, 2018); available from <http://hdbscan.readthedocs.io/en/latest/index.html>.

<sup>165</sup> "T-distributed Stochastic Network Embedding (t-SNE)," *Wikipedia: The Free Encyclopedia* (accessed March 14, 2018); available from [https://en.wikipedia.org/wiki/T-distributed\\_stochastic\\_neighbor\\_embedding](https://en.wikipedia.org/wiki/T-distributed_stochastic_neighbor_embedding).

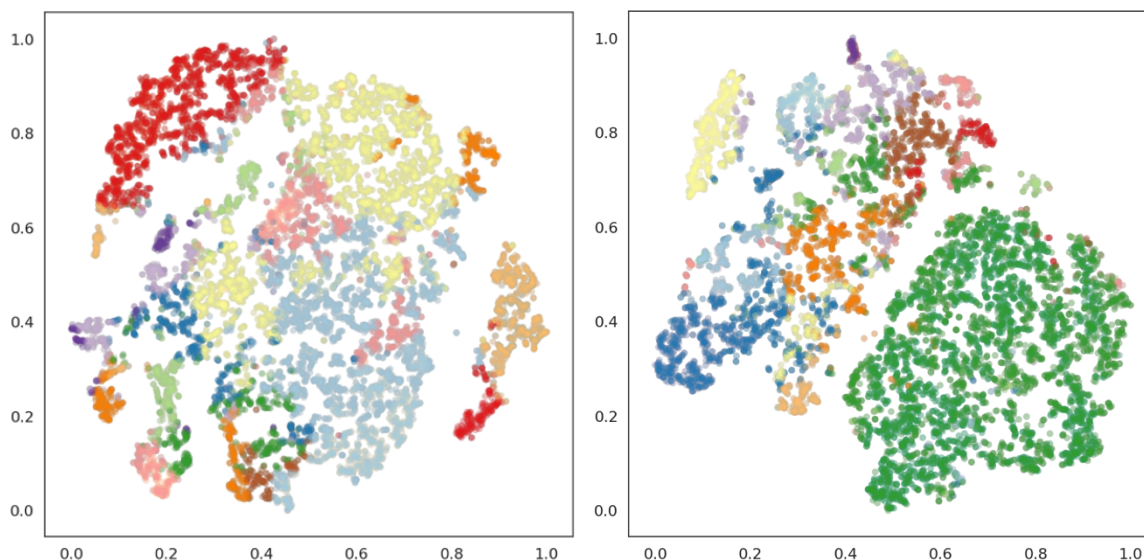


Figure 4.30. Classified audio data, clustered, and visualized with t-SNE

To produce the final audio composition, clustered audio data was explored using an interactive cluster browser GUI written in SuperCollider. Particular clusters for each hour of audio were noted for later use. These files and clusters were then fed into a modified GrainScanner instrument,<sup>166</sup> altered to work with HDBSCAN cluster labels. The GrainScanner uses granular synthesis on samples grouped around the previously identified clusters of interest to synthesize representative audio for each hour in the house.

I liken the aesthetic effect of the audio process to Juan Pampin's ambisonic audio piece *A Line*.<sup>167</sup> His piece collapses sonic experience across the various sites and durations of a trip on the historic Linea A in Buenos Aires. My piece collapses sonic material spatially and temporally in the home.

<sup>166</sup> Michael McCrea, *GrainScanner* (accessed March 14, 2018); available from <https://github.com/mtmccrea/mtm-sc-extensions/tree/master/GrainScanner/classes>.

<sup>167</sup> Juan Pampin, "A Line," recorded 2015, Ambisonic audio, accessed March 14, 2018, <https://dxarts.washington.edu/research/creative-work/line#>.

Pampin's piece starts at the beginning of the train route with binaural audio recording of the composer and his son, traversing through a series of sites on the train and the streets above. The initial sounds of the train transitions to the drumbeat of a parade on the avenue above. Quickly we move to the next aural scene: a bell ringing and dog barking. Back to the train, then traffic sounds. The sonic material of the train's journey serves as the connective tissue throughout the piece.

This aural space is plastic and malleable: a door slamming transforms into a truck idling. There is acute perceptual ambiguity about what is real and what is constructed. Pampin's piece is bracketed at the start and finish with sounds of the train beginning and ending its run, layered with short conversational exchanges with his son. He documents a place and experience that are no longer available (the historic train route), with sonic material recorded in the last period before the train cars were removed and replaced. Intimate and doubly documentary, the piece is biographical, framed as a shared experience between father and son.

My own work, while rendered in stereo, produces a similar collapsing of space and time in the representation of place. In my project, the space is all internal, encapsulated within the confines of the home. Audio was recorded using audio nodes, and processed and classified using machine listening techniques. In choosing particular clusters and synthesis parameters to represent each hour of the day, I am making editorial and creative decisions about the representation of place.

The third temporal loop in the project is the textual sensor narrative playing on the vertical monitor. Over the course of a twenty-four-minute cycle, each minute of viewer experience represents one hour of the day. Individual sensor activations are shown through their semantic labels, producing texts like "washingmachine toilet toilet frontdoor fridge fridge microwave" that create a running record on the vertical monitor. The data is sourced from the time-stamped sensor readings transmitted to the black box recorder over the course of the site observation.

These recorded activations were aggregated in time to produce a statistical distribution of likely sensor activations for each hour. Additionally, total numbers of activations per hour were normalized to produce a representative distribution of activation frequency across the hours of the day. These simple statistical distributions (seen in Figure 4.31) were used to generate new textual narratives using Python code.

hours	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
sensors																								
/announce	0	0	0	0	0	0	0	0	4	10	22	3	14	12	23	16	6	9	10	1	1	16	8	1
/basement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
/bathroomdoor	28	0	0	0	0	0	0	0	0	0	6	22	16	4	14	36	80	22	70	16	48	14	48	0
/bed	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	15	0	0	0	0	0	0	0	0
/bedroomdoor	36	0	0	0	0	0	0	0	0	0	62	11	147	117	14	34	142	28	180	32	118	58	94	18
/chair	0	0	0	0	0	0	0	0	217	150	68	0	10	329	83	147	33	28	0	0	0	0	0	0
/chair2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
/couch	0	0	0	0	0	0	0	0	14	2	4	0	0	3	10	5	2	0	0	0	0	4	0	0
/debug	0	0	0	0	0	0	0	0	0	13	32	0	10	5	33	0	0	18	8	0	1	0	0	0
/deskLamp	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	35	0	1
/diningroom	0	0	0	0	0	0	0	0	11	24	45	5	0	5	0	0	0	36	15	18	0	0	24	1
/fridge	10	1	6	6	8	24	90	259	160	134	120	150	207	164	75	90	123	223	201	169	161	133	61	15
/frontdoor	0	0	0	0	0	0	0	0	2	18	3	0	0	3	2	0	3	5	0	0	2	0	1	2
/garbage	2	0	0	2	1	4	36	91	84	34	45	38	45	19	52	30	70	43	95	79	52	37	13	6
/kitchen	0	0	0	0	0	0	0	0	3	44	94	6	28	28	0	30	78	19	8	87	38	10	25	0
/lamp	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	10	0	1
/livingroom	0	0	0	0	0	0	21	5	46	79	156	106	69	58	92	32	56	34	89	295	201	52	30	4
/microwave	33	51	44	18	8	19	12	10	72	52	142	93	45	82	29	27	12	60	28	44	71	123	76	46
/nodeinfo	0	0	0	0	0	0	0	0	0	8	18	0	757	596	21	3	8	0	9	0	4	24	0	0
/occupancy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	14	0	0
/photon	0	0	0	0	0	0	0	0	156	0	25	0	67	0	2	0	0	0	2	0	0	3	63	0
/print	0	0	0	0	0	0	0	0	4	0	1	0	0	0	2	0	0	0	0	0	0	2	0	0
/shower	9	12	9	9	7	700	902	1360	1966	5178	3939	957	636	664	1192	2565	1967	454	1850	1179	961	734	29	16
/sink	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
/stove	0	0	0	0	0	0	0	0	1957	2311	0	0	0	1080	1570	1555	1561	1562	1559	1556	1562	1558	719	0
/studio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66	69	0	0
/studiooccupancy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	0	0	0	0	0	0
/table	0	0	0	0	0	0	0	0	427	106	66	0	0	67	543	40	4	7	0	0	0	7	0	0
/toaster	0	0	0	0	0	0	0	0	0	0	0	0	2551	86	0	0	0	0	0	0	0	0	0	0
/toilet	63	51	40	58	50	70	44	102	174	90	2157	9247	869	639	1313	108	60	82	75	88	104	87	56	60
/washingmachine	0	0	0	0	0	0	0	1	0	0	0	0	75	1794	0	0	0	0	0	8	0	103	0	0

Figure 4.31. Sensor frequencies by hour

This narrative textual display speaks with a kind of deadpan literalism. Like Georges Perec in *An Attempt at Exhausting a Place in Paris*,<sup>168</sup> the text is a simple registration of events through a descriptive process of creative notation. Where Perec manually inventories his perceptions of place (the “infra-ordinary”) through writing, in this case the machine produces a textual transcript of material interactions in the home. Though constructed by the artist and shaped through the specific assignment of language to sensor activations, the computational sensing apparatus mechanistically

<sup>168</sup> Perec, *An Attempt at Exhausting a Place in Paris*.

generates this deadpan narration. The type of notational, deadpan, literal voice in this piece is popular in conceptual art and contemporary experimental literature, particularly in the practice of “Uncreative Writing” championed by Kenneth Goldsmith and Craig Dworkin.<sup>169</sup>

All three of the temporal artifacts discussed in this section participate in a durable circularity that echoes the experience of Casares’ protagonist, quoted at the beginning of this section. The events of some ideal day (in Casares case, an ideal week) repeat in perpetuity. For computer nerds, this is the endless loop. These circular structures in time also anchor the temporal experience of the viewer in the exhibit, portraying the house as a place of cyclical repetition: diurnal cycles of day and night, and bodily rhythms of inhabitation.

These pieces are all produced through joint human-machine authorship. For the textual narration, I gave the systems the words/labels to use in a ventriloquistic effort, but the system applies them. I define the limits of the model, the parameters of the space, but the algorithm and hardware implement them in a rote and uncreative process. For the video and audio, what the viewer sees is a mix of machine classified material and subjective human compositional decisions, thus computer supported collaborative work. Each type of judgment, human and machine, is in its own way aesthetic: even the audio-visual analysis systems operate on evident phenomenological traits of their analyzed materials. Telescoping outwards (to invert Burnham’s perspective), the choice of data and training parameters for these machine perception models determine the space of comprehension they can achieve. Choices about the representativeness of the resultant media, and their communicative effects, are entirely in the subjective judgment of the artist.

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<sup>169</sup> See Kenneth Goldsmith, *Uncreative Writing: Managing Language in the Digital Age* (New York: Columbia University Press, 2011)., and Craig Douglas Dworkin and Kenneth Goldsmith, *Against Expression: An Anthology of Conceptual Writing* (Evanston Illinois: Northwestern University Press, 2011).

## Chapter 5. CONCLUSIONS AND FUTURE DIRECTIONS

### 5.1 CONCLUSIONS ON A MACHINE FOR LIVING IN

Ultimately . . . systems theory may be another attempt by science to resist the emotional pain and ambiguity that remain an unavoidable aspect of life.<sup>170</sup>

-Jack Burnham

This project serves dual purposes: to study the home as a site of intimate life, and to evaluate the meanings and uses of new smart technologies in that domestic space. To create this project, I constructed a home sensing apparatus that recorded what I deemed to be the substantive sites of meaning in the home. Installed for a period of months in a real home, this machine observation produced rich, multi-modal data, which I have analyzed and processed to create the exhibit described above. At the conclusion of the project, I recognize three main areas for future development: improvements in instrumentation, new modes of data analysis, and new exhibition forms and venues.

#### 5.1.1 *Sensing and Home Instrumentation*

While I am satisfied with the receptive scope of the home sensing apparatus, in the area of instrumentation there is room for improvement in:

- Streamlining the deployment of sensors using zero-configuration networks and mesh networking.

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<sup>170</sup> Jack Burnham, *Great Western Salt Works; Essays on the Meaning of Post-Formalist Art* (New York: G. Braziller, 1974), 11.

- Improving the robustness of network connectivity, for instance automatically reconnecting to the network on dropped wireless signal, and improving data transmission to re-transmit lost packets.
- Addition of Bluetooth Low Energy (BLE) sensors for monitoring small, mobile objects such as forks, spoons, cups, where larger batteries and power supplies are not feasible.<sup>171</sup>
- Incorporate far-field microphones: using beam-forming and far-field microphone arrays to filter spatially, reject noise, and provide directional information about audio.
- Develop single smart home elements (for instance a heat sensing blanket that both records and plays back body heat data) as individual projects.

My ultimate goal for the instrumentation portion of this project would be to develop these sensing technologies into a more unified kit for reading and writing inhabited space. I gave a recent workshop on this subject at Carnegie Mellon University,<sup>172</sup> using the sensing and networking setup I developed for the project to interface with the building we were in. Further work is needed to streamline this process and toolset.

### 5.1.2 *Data Analysis and Machine Perception*

The second area for future improvement is in the analysis of recorded data. Even with the current sensing approach, this project produces a dense set of observed house data that can be sliced and processed in a variety of ways. *A Machine for Living In* proposes the house, and smart

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<sup>171</sup> At the time of the dissertation, I have done initial experiments with the LightBlue Bean. Punch Through Design LLC., *LightBlue Bean* (accessed March 14, 2018); available from <https://store.punchthrough.com/collections/bean-family/products/bean>.

<sup>172</sup> Robert Twomey, *Workshop: Reading and Writing Inhabited Space* (accessed March 14, 2018); available from <https://github.com/roberttwomey/housemachine-workshop>.

home sensing, as a meeting point between personal analytics and big data science. I am particularly interested in extracting higher orders of description in the data processing workflow. Additional computer vision, audio analysis, and physical sensing methods can provide more nuanced interpretations of domestic activity. Future directions in this area include:

- Speech and language transcription of all processed data.<sup>173</sup>
- Contextual video description including identification of objects, inhabitants, etc.
- Improved audio feature descriptors and clustering algorithms.
- Activity classification for audio, video, and physical sensors.
- Bespoke recognition / classification models trained on house data.
- Generative models for audio, video, and sensor activations trained on house data.

I expect that these technical developments for the project will track with the growth and availability of new tools in machine learning and data analysis fields. With increased intelligence built into these processing tools, the “machine” element of *A Machine for Living In* will take greater authorial responsibility or the resulting works.

### 5.1.3 *New Exhibition Forms and Venues*

Beyond the gallery exhibition presented above, *A Machine for Living In* can be developed for a number of new formats, contexts, and presentation scenarios. These include:

- Using the sensor activations, speech transcription, and other textual descriptions of recognized activities to produce an experimental form digital literature. I believe this

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<sup>173</sup> I’ve already done this using *Kaldi* (accessed March 14, 2018); available from <http://kaldi-asr.org/>, and the *Google Speech API* (accessed March 14, 2018); available from <https://cloud.google.com/speech/>, but did not incorporate those results into the initial exhibition.

is a novel, sensor-driven approach to authoring digital texts, and could be of interest to e-literature communities, among others.<sup>174</sup>

- Algorithmically assembled video and audio from the project as stand-alone experimental video work. This could result from further queries on the existing data, or extracting new “details” studying particular elements of the home (for instance a cut focused on domestic labor in the kitchen, centered on the stove, fried, and sink).
- A site-specific installation of the project in the space of an abandoned house. This site would be doubly marked with absence: the recorded digital traces of inhabitation layered onto a place that is rich with physical signs of absent others.

Much of the effort in creating this project was invested in developing and testing the functional version of the sensing apparatus. Taking the lessons learned from this process, it would be valuable to install the system in a significant new space and produce a new dataset. A number of future sites of interest that could be profitably engaged as “Machines for Living” include:

- the workplace<sup>175</sup>
- the school<sup>176</sup>
- the automobile<sup>177</sup>

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<sup>174</sup> See *Electronic Literature Organization* (accessed March 14, 2018); available from <https://eliterature.org/what-is-e-lit/>.

<sup>175</sup> Automation in the workplace is a hot topic both in terms of advanced manufacturing, co-robotics, and even the recent automation of the commercial storefront with the Amazon Go store in Seattle: *Amazon Go* (accessed March 14, 2018); available from <https://www.amazon.com/b?node=16008589011>.

<sup>176</sup> Contrasting human and machine learning (like *Searle’s Room*), and also thinking about schools as a physical site at a time of rising interest in massively distributed online courses.

<sup>177</sup> The idea of the automobile as a “machine for living” conjures wildly divergent associations, from low-tech RV homes and trailers to high-tech Tesla self-driving vehicles.

The strategy for each of these contexts is to explore the descriptive potential and conceptual ramifications of interpreting the site as a system, and playing out the machine analogy.

## 5.2 MACHINES FOR LIVING: DESIGNING INTROSPECTIVE TECHNOLOGIES

introspection: "the examination or observation of one's own mental and emotional processes."

introspection: "the ability to examine the type or properties of an object at runtime."

To codify my research practice: this work generalizes to a broader investigation of machine living, our contemporary condition of life lived with ubiquitous computing and machine perception. Constructing technological experiments and art systems to operate in this space of intimate human-machine cohabitation, I aim for a targeted introspection into the nature of human and machine. We, as people, need to look inward and ask questions of ourselves and our natures. Our technologies, as autonomous machines, should aim for a similar self-examination and critical introspection.

I seek to foster a reciprocal diagnosis, creating mutually revelatory encounters between humans and machines, where each reveals something about the other. I use the word diagnosis to invoke therapy, because I believe that each part has some essential lack that needs to be addressed.

Machines for living are technologies that are sufficiently sophisticated to operate as digital surrogates and autonomous interlocutors, seamlessly integrating into the everyday. They are cybernetic systems and psychological feedback devices, harnessing emerging technologies to bring insight about ourselves. I exercise both an optimistic embrace of new technological possibilities and a critical examination of their consequences. Future "machines for living" will chase these engagements deeper into our intimate lives, to teach us more about how we live them.

## BIBLIOGRAPHY

*ACM Conference on Computer-Supported Cooperative Work and Social Computing*. Accessed March 14, 2018. Available from <https://cscw.acm.org/2018/>.

*Amazon Go*. Accessed March 14, 2018. Available from <https://www.amazon.com/b?node=16008589011>.

*Amazon Mechanical Turk*. Accessed March 14, 2018. Available from <https://www.mturk.com/>.

*Association for Computational Creativity*. Accessed March 14, 2018. Available from <http://computationalcreativity.net/home/>.

*CMUSphinx*. Accessed March 14, 2018. Available from <https://cmusphinx.github.io/>.

*E-1027: A House by the Sea*. Accessed March 14, 2018. Available from <https://capmoderne.com/en/lieu/la-villa-e-1027/>.

"Edge Computing." *Wikipedia: The Free Encyclopedia* (Accessed March 14, 2018). [https://en.wikipedia.org/wiki/Edge\\_computing](https://en.wikipedia.org/wiki/Edge_computing).

*Electronic Literature Organization*. Accessed March 14, 2018. Available from <https://eliterature.org/what-is-e-lit/>.

*Google Speech API*. Accessed March 14, 2018. Available from <https://cloud.google.com/speech/>.

*Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN)*. Accessed March 14, 2018. Available from <http://hdbscan.readthedocs.io/en/latest/index.html>.

"k-means Clustering " *Wikipedia: The Free Encyclopedia* (Accessed March 14, 2018). [https://en.wikipedia.org/wiki/K-means\\_clustering](https://en.wikipedia.org/wiki/K-means_clustering).

*Kaldi*. Accessed March 14, 2018. Available from <http://kaldi-asr.org/>.

"Kinect for Xbox 360 (2010)." *Wikipedia: The Free Encyclopedia* (Accessed March 14, 2018). [https://en.wikipedia.org/wiki/Kinect#Kinect\\_for\\_Xbox\\_360\\_\(2010\)](https://en.wikipedia.org/wiki/Kinect#Kinect_for_Xbox_360_(2010)).

*Le Corbusier's Cabanon*. Accessed March 14, 2018. Available from <https://capmoderne.com/en/lieu/le-cabanon>.

- Machine Perception Lab (MPLab) at the University of California, San Diego.* Accessed March 14, 2018. Available from <http://mplab.ucsd.edu/wordpress/>.
- OpenCV BackgroundSubtractorKNN.* Accessed March 14, 2018. Available from [https://docs.opencv.org/3.3.1/db/d88/classcv\\_\\_1\\_1BackgroundSubtractorKNN.html#details](https://docs.opencv.org/3.3.1/db/d88/classcv__1_1BackgroundSubtractorKNN.html#details).
- Particle Photon Wi-Fi Hardware.* Accessed March 14, 2018. Available from <https://www.particle.io/products/hardware/photon-wifi-dev-kit>.
- "Quantified Self." *Wikipedia: The Free Encyclopedia* (Accessed March 14, 2018. [https://en.wikipedia.org/wiki/Quantified\\_self](https://en.wikipedia.org/wiki/Quantified_self)
- Quantified Self.* Accessed March 14, 2018. Available from <http://quantifiedself.com/about/>.
- Raspberry Pi 3 Model B.* Accessed March 14, 2018. Available from <https://www.raspberrypi.org/products/raspberry-pi-3-model-b/>.
- Raspberry Pi Zero W.* Accessed March 14, 2018. Available from <https://www.raspberrypi.org/products/raspberry-pi-zero-w/>.
- "T-distributed Stochastic Network Embedding (t-SNE)." *Wikipedia: The Free Encyclopedia* (Accessed March 14, 2018. [https://en.wikipedia.org/wiki/T-distributed\\_stochastic\\_neighbor\\_embedding](https://en.wikipedia.org/wiki/T-distributed_stochastic_neighbor_embedding).
- Meshlab.* Accessed March 14, 2018. Available from <http://www.meshlab.net/>.
- Arducam OV5647 Camera Board with LS-40180 Fisheye Lens M12x0.5 Mount for Raspberry Pi 3.* Accessed March 14, 2018. Available from <https://www.amazon.com/Arducam-LS-40180-Fisheye-M12x0-5-Raspberry/dp/B013JWEGJQ>.
- FLIR Lepton.* Accessed March 14, 2018. Available from <https://www.flir.com/products/lepton/>.
- OpenCV.* Accessed March 14, 2018. Available from <https://opencv.org/>.
- RTAB-Map.* Accessed March 14, 2018. Available from <http://introlab.github.io/rtabmap/>.
- Jibo.* Accessed March 14, 2018. Available from <https://www.jibo.com/>.
- Agamben, Giorgio. *The Open: Man and Animal*. Stanford, Calif.: Stanford University Press, 2004.
- Aldrich, Frances. "Smart Homes: Past, Present, and Future." In *Inside the smart home*, edited by Richard Harper. New York: Springer, 2003.

- Ashton, Izzy. *Le Corbusier's Cabanon seaside cabin is his smallest building on the World Heritage List*. Accessed March 14, 2018. Available from <https://www.dezeen.com/2016/07/20/le-corbusier-french-holiday-home-cabanon-17-buildings-unesco-world-heritage-list/>.
- Associates, Robert McNeel and. *Rhinoceros 3D*. Accessed from <https://www.rhino3d.com/>.
- Bachelard, Gaston. *The Poetics of Space*. Boston: Beacon Press, 1994.
- Bass, Dina and Ellen Huet. "Researchers Combat Gender and Racial Bias in Artificial Intelligence." *Bloomberg* (December 4 2017). <https://www.bloomberg.com/news/articles/2017-12-04/researchers-combat-gender-and-racial-bias-in-artificial-intelligence>.
- Benjamin, H. D. Buchloh. "Conceptual Art 1962-1969: From the Aesthetic of Administration to the Critique of Institutions." *October* 55 (Winter 1990): 105-43. <http://dx.doi.org/10.2307/778941>.
- Bergson, Henri. *Laughter: An Essay on the Meaning of the Comic*. edited by Cloudesley Brereton and Fred Rothwell. New York: Macmillan, 1911.
- Bertalanffy, Ludwig von. *General Systems Theory; Foundations, Development, Applications*. New York: G. Braziller, 1969.
- Bioy Casares, Adolfo. *The Invention of Morel*. edited by Ruth L. C. Simms. New York: New York Review Books, 2003.
- Bochner, Mel. "Serial Art, Systems, Solipsism." *Arts Magazine*, no. Summer (1967).
- Bradbury, Ray. *The Martian Chronicles*. Trade ed. New York: Bantam Books, 1979.
- Breazeal, Cynthia. *Kismet*. Accessed March 14, 2018. Available from <http://www.ai.mit.edu/projects/sociable/baby-bits.html>.
- Burnham, Jack. "Systems Esthetics." *Artforum* 7, no. 1 (September 1968): 30-35.
- Burnham, Jack. *Great Western Salt Works; Essays on the Meaning of Post-Formalist Art*. New York: G. Braziller, 1974.
- Burton, Carl. *Shelter*. Accessed March 15, 2018. Available from <http://carlburton.io/index.php?/anim/shelter/>.
- The Scarecrow*. Directed by Cline, Edward F. and Buster Keaton. Metro Pictures, 1920.
- Collins, Nick. *SCMIR: A SuperCollider Music Information Retrieval Library*. ICMC, 2011.

- Corbusier, Le. *Towards a New Architecture*. New York: Dover Publications, 1986.
- Deleuze, Gilles. *Francis Bacon: The Logic of Sensation*. Minneapolis: University of Minnesota Press, 2004.
- Dobson, Kelly. "Machine Therapy." Ph.D. diss., Massachusetts Institute of Technology, 2007.
- Dworkin, Craig Douglas and Kenneth Goldsmith. *Against Expression: An Anthology of Conceptual Writing*. Evanston Illinois: Northwestern University Press, 2011.
- Faders, Body. *Grey to White Heat Color Changing Fabric*. Accessed March 3, 2017. Available from <http://www.bodyfaders.com/shopping/pc/viewCategories.asp?idCategory=29>.
- Goldsmith, Kenneth. *Uncreative Writing: Managing Language in the Digital Age*. New York: Columbia University Press, 2011.
- Hemingway, Ernest. *Winner Take Nothing*. New York: Collier Books, 1987.
- Hultén, Pontus. *The Machine: As Seen at the End of the Mechanical Age*. edited by Art Museum of Modern, Thomas University of St, and Art San Francisco Museum of. New York: Museum of Modern Art, 1968.
- Hutchens, Jason. *MegaHAL*. Accessed March 14, 2018. Available from <https://megahal.aliioth.debian.org/>.
- InvenSense. *ICS-43432 Datasheet*. Accessed March 14, 2018. Available from <https://www.invensense.com/products/digital/ics-43432/>.
- Jermeijenko, Natalie. *Environmental Health Clinic*. Accessed March 14, 2018. Available from <http://www.nyu.edu/projects/xdesign/clinic/>.
- Kelly, Mary. *Post-Partum Document*. Berkeley, Calif.: University of California Press, 1999.
- Knight, Will. "Forget Killer Robots—Bias Is the Real AI Danger." *MIT Technology Review* (October 3 2017). <https://www.technologyreview.com/s/608986/forget-killer-robotsbias-is-the-real-ai-danger/>.
- Lab, MIT Media. *Personal Robotics Group*. Accessed March 14, 2018. Available from <http://robotic.media.mit.edu/>.
- LLC., Punch Through Design. *LightBlue Bean*. Accessed March 14, 2018. Available from <https://store.punchthrough.com/collections/bean-family/products/bean>.
- THX 1138*. Directed by Lucas, George. Warner Bros., 1971.

- Markson, David. *Wittgenstein's Mistress*. First edition ed. Elmwood Park, IL, USA: Dalkey Archive Press, 1988.
- McCarthy, John. *Ascribing Mental Qualities to Machines*. Accessed March 14, 2018. Available from <http://jmc.stanford.edu/articles/ascribing.html>.
- McCrea, Michael. *GrainScanner*. Accessed March 14, 2018. Available from <https://github.com/mtmccrea/mtm-sc-extensions/tree/master/GrainScanner/classes>.
- McDonald, Kyle. *ofxFaceTracker*. Accessed March 14, 2018. Available from <https://github.com/kylemcdonald/ofxFaceTracker>.
- Moynihan, Tim. "Alexa and Google Home Record What You Say. But What Happens to That Data?" *Wired* (2016). Accessed March 14, 2018. <https://www.wired.com/2016/12/alexa-and-google-record-your-voice/>.
- Museum, Jewish, American Motors Corporation, and Smithsonian Institution. *Software; An Exhibition*. New York: Jewish Museum, 1970.
- Oldenburg, Claes and Emmett Williams. *Store Days: Documents from The Store, 1961, and Ray Gun Theater, 1962*. New York: Something Else Press, 1967.
- Oliver, Julian, Gordan Savičić, and Danja Vasiliev. *Critical Engineering Manifesto*. Accessed March 14, 2018. Available from <https://criticalengineering.org/>.
- Pampin, Juan. "A Line." Ambisonic audio. 2015.
- Perec, Georges. *Species of Spaces and Other Pieces*. Rev. ed., edited by John Sturrock. New York, N.Y., USA: Penguin Books, 1999.
- Perec, Georges. *An Attempt at Exhausting a Place in Paris*. Translated by Marc Lowenthal. Cambridge, Mass.: Wakefield Press, 2010.
- Raby, Dunne and. *Biography*. Accessed March 15, 2018. Available from <http://www.dunneandraby.co.uk/content/biography>.
- Raby, Dunne and. *Critical Design FAQ*. Accessed March 15, 2018. Available from <http://www.dunneandraby.co.uk/content/bydandr/13/0>.
- Ramsey, Doug. *Apple Acquisition of UC San Diego Startup Paves Way for Further Robotics Research at UC San Diego*. Accessed March 14, 2018. Available from [http://ucsdnews.ucsd.edu/pressrelease/apple\\_acquisition\\_of\\_uc\\_san\\_diego\\_startup\\_paves\\_way\\_for\\_further\\_roboti](http://ucsdnews.ucsd.edu/pressrelease/apple_acquisition_of_uc_san_diego_startup_paves_way_for_further_roboti).
- Research, Zion Market. *Global Smart Home Market to Exceed \$53.45 Billion by 2022*. Accessed March 14, 2018. Available from <https://globenewswire.com/news->

[release/2018/01/03/1281338/0/en/Global-Smart-Home-Market-to-Exceed-53-45-Billion-by-2022-Zion-Market-Research.html](https://www.zionmarketresearch.com/release/2018/01/03/1281338/0/en/Global-Smart-Home-Market-to-Exceed-53-45-Billion-by-2022-Zion-Market-Research.html).

Roy, Deb, "New horizons in the study of child language acquisition." INTERSPEECH-2009, Brighton, United Kingdom, September 6-10, 2009.

Roy, Deb. "The Birth of a Word." Technology, Entertainment, Design 2011, 2011.

Roy, Deb, Rupal Patel, Philip DeCamp, Rony Kubat, Michael Fleischman, Brandon Roy, Nikolaos Mavridis, Stefanie Tellex, Alexia Salata, and Jethran Guinness. "The Human Speechome Project." *Cognitive Science* (2006).

Searle, John. "Minds, Brains, and Programs." *The Behavioral and Brain Sciences* 3, no. 3 (September 1980): 417-57. <https://doi.org/10.1017/S0140525X00005756>.

Smithson, Robert. *Robert Smithson, The Collected Writings*. Edited by Jack D. Flam. Berkeley: University of California Press, 1996.

Stark, Luke. "Come on Feel the Data (and Smell It)." *The Atlantic* (May 19 2014). Accessed March 14, 2018. <https://www.theatlantic.com/technology/archive/2014/05/data-visceralization/370899/>.

Stonard, John-Paul. "Pop in the Age of Boom: Richard Hamilton's "Just What Is It That Makes Today's Homes so Different, so Appealing?"." *The Burlington Magazine* 149, no. 1254 (2007): 607-20.

*Mirror*. Directed by Tarkovsky, Andrei. Kino Video, 1975.

*Sacrifice*. Directed by Tarkovsky, Andrei. Kino Video, 1986.

Technology, Bureau of Inverse. Accessed March 14, 2018. Available from <http://bureauit.org/bitindex.html>.

Thoreau, Henry David. *Walden and On the Duty of Civil Disobedience*. New York: New American Library, 1960.

Turkle, Sherry. "Why these friendly robots can't be good friends to our kids." *The Washington Post*. December 17, 2018.

Twomey, Robert. *Workshop: Reading and Writing Inhabited Space*. Accessed March 14, 2018. Available from <https://github.com/roberttwomey/housemachine-workshop>.

Twomey, Robert and Michael McCrea. "Transforming the Commonplace through Machine Perception: Light Field Synthesis and Audio Feature Extraction in the Rover Project." *Leonardo* 50, no. 4 (2017): 400-08. [http://dx.doi.org/10.1162/LEON\\_a\\_01458](http://dx.doi.org/10.1162/LEON_a_01458).

Wilson, Bill. *PiKrellCam - OSD Motion Detect Program*. Accessed March 14, 2018. Available from <http://billw2.github.io/pikrellcam/pikrellcam.html>.

Wiseman, John. *py-webrtcvad*. Accessed March 14, 2018. Available from <https://pypi.python.org/pypi/webrtcvad>.

## VITA

Robert Twomey (b. 1979, Washington, DC) is an artist and engineer exploring the poetic intersection of human and machine perception. He exploits the potential of new technologies while critically revealing their limits. Engaged with the messy conditions of everyday life, his works ask questions about our technologies and ourselves to reveal moments of insight.

He has created a computer simulation of a grandmother with Alzheimer's disease, a body of work exploring the fantasy of an imaginary daughter, and recreated John Searle's Chinese Room as an exchange between synthetic child voice and robotic child drawing.

Twomey has worked in a variety of research labs throughout his career, notably the Center for the Study of Learning, the Center for Research in Computing and the Arts with Sheldon Brown, the Experimental Design Lab with Natalie Jeremijenko, and the Center for Digital Arts and Experimental Media.

Twomey has presented his work at SIGGRAPH, the Museum of Contemporary Art San Diego, the Seattle Art Museum, and has been featured by Microsoft and Amazon. He received his BS from Yale with majors in Art and Biomedical Engineering, and his MFA in Visual Arts from the University of California, San Diego. He is currently an Assistant Professor of Digital Media at Youngstown State University.