The Organism as Networked Object: Cognitive Perception and Organization as Applied to Living and Non-Living Processes.

by

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ACKNOWLEDGMENT

In 1995, I read a copy of Theodore Kaczynski's "Industrial Society and Its Future" in the original print of the Washington post. The paper was abandoned in my local library on the table and I read it over, I wish now I had stolen the newspaper as it was likely placed in the recycling. The primary thesis of his writing - if you have not read it or has been some time since you last have, you should search the worldwide web for a reprint – is that the leftist politic is one of over-socialization. The process of attaining goals is detached in such a way that we are disempowered from our personal life. The role of science and technology in society has become the means of generating and fulfilling artificially created desires and has led to psychological defeatism. This has always been self evident in the years following the publishing of Kaczynski's manifesto. I feel there is truth in his writing, and he has influenced me to pursue my own academic interests in the area of machine-human behavior and social theory, in hopes of finding logical truths of my own.

ABSTRACT

The integration of living and non-living is the central focus of this thesis. The projects are studies of interaction between people and machines, and living plants and machines. Additionally, the mediation of information by a machine between people and an environment or a living plant and its environment is of topic. By implying interaction, this work also serves as a discussion of the social-political mechanisms of communication and perception. What I hope the reader will take away from this critique is the thought of why humans are the way they are, not in a psychological sense, but in the way culture or societies are influenced by technology and are organized thusly.

While language allows articulation and communication of thought, it also defines parameters for how life is structured and the relationship between the self and the other. The symbols inherent in speech can be translated into perceptions of the self. Within communication, the contextual implication of encoding and decoding information, there is an intelligence that is applied from one's perception. This intelligence is synthetic, involving the creation of possibilities and combinations.

The intent of this artistic research was to give a user the means through which to examine their knowledge of the self as cues provided through feedback. The gradation between a user's understanding of their contribution via sensor input and the response given by the machine creates a pattern of engagement. The closer the expected response is to the level of feedback given, the more aligned such an action will become with future events. Memantics is an area of study concerned with how consequence leads to action through the encoding and decoding of information in the communication process.

The integration of hardware and wetware is the final component of this thesis. The example projects are explorations into harmonizing living organisms with machines. The effect of evolution on chaotic or catastrophic system theories is examined through the construction of sustainable living environment. These environmental plant systems are capable of responding to growth changes and conditions, which drive mechanical behaviors.

1. Introduction

The term ‘cybernetics’ was first coined in 1947 by Norbert Weiner to describe a phenomenon present in living and non-living systems. Any system that responds to its environment – human being, computer, thermostat, political system, and automated factory – can be described as a cybernetic system.

The idea of control is at the root of cybernetics. All human action is ‘controlled’, either because we choose to do something, and make whatever necessary changes, or because of an automatic or reflexive action. Any action directed towards a goal, must be controlled to achieve that goal. In order to follow the progress of an action, there must be a form of communication present. There are two functions of control and communication necessary for any systematic action: voluntary and involuntary. This is the central concept of Weiner’s theory.

We maintain control by minimizing error – any course of action is reliant on a series of approximations. The movement of the human body is regulated by feedback. The messages from senses to nervous system, which is feedback, report the extent to which goal states have been reached and the amount of energy consumed. Cybernetics is the study and use of information systems to regulate energy systems. Feedback requires a regulator to create a closed-looped system. An open loop system will continue a process without ending because it does not have any source of feedback to gauge its approximation to an end state. A closed loop system oscillates between limits and gets closer and closer to its required end state. This self-regulation is found in all cybernetic systems.

Open looped machines are the tools of cybernetic systems, unable to act by themselves. This group includes most early automata, which were mechanical systems with a fixed program, unable to modify it yet appearing to act like cybernetic systems. The general idea of feedback was made by Wilhelm Leibniz (1716). In his theory of the organization of the universe, feedback keeps the universe in an optimum state. This is negative feedback; any change is opposed by a control system, which acts to maintain the original condition. Learning through making mistakes is an example.

2. Historical Review

Much work has been done in the area of cybernetics and with machine human interfaces. What follows is a theoretical discussion on cognition and machines, followed by reference citations for the technology used in the projects outlined in chapter 3.

2.1 Theory

The following chapters are organized into thematic issues of Perception and Meaning, Social Programming and Memantics, Network Contexts, and the Symbotic Apparatus.

2.1.1 Perception and Meaning

2.1.1.1 Affordance Theory

Affordance Theory was developed by James Gibson[1] in regards to how the world can be perceived and utilized for generating possible actions. According to affordance theory, how the environment is perceived will, in turn, provide indications for what actions can occur. Affordance is the ability to potentially perform action in a given environment. Affordances are clues to action, and are taken without sensory processing but rather through direct means. Behavior may depend upon clues provided by the environment and its objects, but the environment does not depend upon an organism's perception of it.

So, what determines perceptions? It would seem there would need to be a level of interaction or influence involved in how one will react to their perceptions (especially in event driven behavior), which in turn would require some degree of consciousness in interpreting the environment. This is contrary to Gibson's theory in that affordances are provided by objects through perception without one cognitively approaching them. Also,

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[1] Gibson, J. J. "The Theory of Affordances." In An Ecological Approach to Visual Perception. Hillside NY: Lawrence Earlbaum Associates, 1979, Pp 127-143

there are varying degrees of perception and strategies between like-organisms. How they interact and engage with an environment is described as fitness or performance. Is this a subjective condition?

If one is to follow evolution, it seems that human beings have made the environment around them more affording for particular sets of behavior. The basic functions of eating, sleeping, and shelter, with the complex social apparatus of education, learning, and communication are all more easily afforded in contemporary terms. In contrast, the environment, due to evolutionary affordance, has presented new social and ecological dangers that may supersede the benefits received as compensation. The term 'easily' is a subjective term – What has been made more easily for some, has been made more difficult for others. By creating a modern social system, in order for one to function and utilize its "Affordances" there has to be a large amount of conformity and order present. If one is to operate outside of this set of protocols, then they cannot function in the same capacity and to the same extent.

While the environment and its substructures shape human behavior, we are also informed by our interactions with each other and our environment and its affordances. I have summarized three questions in determining the source for actions and for the creation of identity: What is the Necessary? What is the Efficient? What is the History?

The Necessary is the actual requirements for an object. It is necessary for a box to have rigid sides. It is necessary for human skin to be porous. The Necessary is not a fixed or static value, however. Things are only necessary in reference to other things. It is only necessary for a box to have rigid sides when it is to hold something inside of it or to create a section of space as a boundary. It is only necessary for human skin to be porous when blood capillaries near the skin need to release toxins through the sweat glands.

The Efficient is the level of affordance provided between an action and its results as relative to the intention of a behavior. The more closely aligned an object is afforded to a behavior the higher its level of efficiency. A hammer is more efficient at driving a nail, than say, a foam block will be. In determining what an object affords, one must make use of perceptual cues in determining the efficiency of such an object in regards to the behavior to be exhibited.

The History is the sequence of precedence set by past events relative to current situatedness. The history of an object, its construction and its uses, precludes particular qualities that are subject to observation and open to interpretation. How an object has come to be, is just as important in determining what it may afford as the formal qualities of its composition. One aspect of learning is to gain knowledge of histories in order to understand how principles may be applied to new or adaptive situations. The U.S. judicial system is essentially an organization with one of its formal duties being to record the affordances of history.

Cueing and Clustering[2] are two methods for how relationships are formed from perceptual observation and actions. Cueing is the action of creating a "buffer" zone in which objects can be preassembled. Clustering is the gathering of related sets of qualities to make subgroups of objects. Cueing is an efficient strategy because it draws attention to obvious properties of a group of objects. In addition to Kirsh's theory, I would add that cueing relies on the historical, how objects are brought into a buffer zone sequentially, which is in turn affected by a super structure of all the related articles and environment that the objects are removed from.

Where cueing relies on the historical, clustering relies on likeness. Clustering is the assembly of objects along a spectrum of relatedness. It depends upon a level of localization or pattern recognition. For example, using a specific color to group all things that are blue, and not red. Blue then is a localized variable, which is readable and distinguishable from another. Color acts as a localizing agent capable of identifying one thing against another, for Kirsh.

In my own theory - it is the contrast of being "against" something that distinguishes. However, it is not just one variable that is available, but a set of definitions such as line or boundary to demarcate space. The relational sets of data that are derived from clustering are situational.

The perception of an object depends upon being able to isolate a constant against a variation of action as related to a variation of sensation. The characteristics of action,

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[2] Kirsh, D. "The Intelligent Use of Space." Artificial Intelligence, no. 73 (1995) Internet, Pp 31-68 Available: http://icl-server.ucsd.edu/~kirsh/Articles/Space/AIJ1.html, October, 2007.

such as speed and resolution, have as much of an effect upon perception as the sensory experience (energy spectrum, type of sense). This is a discussion of the relative effects of engagement between objects, and between oneself and environmental objects. The idea of causality[3] is present, in that for perception to be effective it relies upon motor acuity or activity to determine the sensational experience. I am asking whether these perceptions are adequate on their own, or are they effects derived from action. If they are effects of action, as I believe they are, then to what extent does noise interrupt our senses through action. An example is using hand eye coordination of watching an object being thrown, in order to approximate its speed, velocity, movement, position, and density.

The resolution of the sensory experience is the experience of evaluating different sensations over time and determining them to be successive. The connectivity of objects based upon rules of engagement, which are gathered from relational sets of "knowns". The more closely two objects are defined, as one may know them, the greater their implications of perceived action are. This is important because the sensations, and perceptions of sensations, can be connected to particular events. Through active parsing, that is to say the taking of account of successive historical events, sensation can then be applied to more concrete forms. The who, what, where, how, when, etc can be derived from sensory experiences.

The idea of consequence in the decision making process, as a reflective process, is interesting in terms of using the experience of technology as a communication medium. Which is essentially what the sensory experience is, communicating the situatedness of the body in relation to other non-self objects within an environment. What are these consequences? Embedded into communication are the principles of latency and the immediacy of information. Consequence may not always be available, and because of this, it would stand to reason that there would be an intermediate stage in sensory experience and not just a direct cause and effect relationship being drawn.

The development of sensory experience, and causal relationships, based upon consequence would require a level of expectancy as a result, and a desire for efficiency

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[3] Lenay, C., Canu, S., & Villon, P. "Technology and Perception: The contribution of sensory substitution systems." 2nd International Conference on Cognitive Technology (CT '97). Aizu, JAPAN. (1997, August 25)

in the communication of the results as feedback. As applied to experiencing interaction, what is the basis for motivation in an engagement?

2.1.1.2 Interactivity

For the artist, code is a static text. It is dependant upon input from a user, as a book or painting requires the subjective reading or gaze. Built within a program is a set of symbols, objects, and procedures, which when combined form the basis for a subjective user interaction. The system must be able to take input and respond. By polling known constants against sensory variables the system produces anticipations, measurements, and responses. For the user, then, a programmed system and its code appears malleable and through their own sensory experience as a responsive engagement.

Interactivity places some of the subjectivity in the work itself. The system has a basis on which interaction can take place. While the user takes information from the environment and responds, the machine bears some responsibility for how an engagement will develop by using feedback. Feedback is a component of a system's information flow by taking input and applying it to known variables towards reaching an endstate. This type of information flow is conducive to evolution because it is a "stackable" method, that is to say the information that is inputted displaces another set of information, which previously served as the definition for a present state but now can be considered a post state. The new information is now present state until another data set is inputted. Adaptive behavior develops from taking feedback and creating internal changes, and does not occur from responses due only to programming nuance.

David Rokeby presented several models for interaction[4]. The Navigable Structure presents an audience or user with potentials and relays the consequences. One problem with this type of data flow, like an uncharted map, is the lack of an end reward to serve as motivation for interaction. When presented with multiple outcomes and wide branching rules for engagement without a particular inclusive methodology for how to

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[4] Rokeby, D. "Transforming Mirrors: Subjectivity and Control in Interactive Media." Critical Issues in Electronic Media. S. Penny. Albany, N.Y., SUNY, 1995. Pp. 133-158

arrange the materials, it may become difficult for a user to create a sense of closure. When in conversation, for example, there are etiquette rules for how two people will communicate and when the conversation is closing it can be mutually detected and agreed upon.

The second problem with the Navigable Structure is the expectation from the user of what will transpire through an interactive engagement. Rokeby provides a description for this as a judgmental attitude on the part of the user as they are presented with new choices, which were based upon their own perceptions. These choices reveal the users intentions, as well as, defines a predicate of what will or should happen. If the choices presented do not match what is expected, the results can be deemed as arbitrary or unrelated to a user's actions.

Within a given interaction, there are limitations of exchange, which I have called Degrees of Freedom. They are relative as two differing states. The real, or the perceived simulation of the real; against that of the transparent or the permeable qualities of the interface. This relationship is a definable navigation structure that the user may create an identity from by working either with or against the confines of the rule set. It is the programmer's privilege to create the rules through which the user will interact with. These rules define the relationship between actor and response, either from the user-participant or the machine.

Rokeby described two types of reflections that take place: the Mirror and the Distortion. Mirroring is a closed system; information is transferred between actors without interrupt, and in an asynchronous fashion. Distortion, however, is a open loop through which investigation may take place. For some interactions, the user is to be empowered or felt to be in control, which triggers a loss of responsibility from the perception of cause and effect. The encounter of choices and possibilities, for the user, is more important for interaction than purely controlling the situation. This implies that control is a one-sided data flow and not pure interaction or engagement, whereas with feedback an encounter is felt to be more responsive and lucid.

Between the two models of reflection, Mirror and Distortion, there are a number of qualities that define the experience. The seamlessness of the interface, the predictability of the response, and the filtration of information contribute to the overall description of the interaction. The less distortion present, the more the user may identify the responsiveness of a system. This is a balance between the richness of the response against the nuance of control or the perception of control. The audience wants proof of interaction, they seek constant approval and disapproval of their actions by countering them against the response of the system. On a very basic level the user of the system creates the definitive pattern on which communication is taking place.

To gauge a reflexive response one's perceptions depend upon filtration. By replacing the transparency of the controls with higher-level perceptions, a system is more able to reason with and come to conclusions of what the user's intentions and expectations are. This is more an implication of movement and gesture than that of true motive or willfulness on the part of the user who is trying to get a predictable response.

Technology serves as an extension of the self; it allows the world to be known and to know us. Interactions are contained environments but can be enabled to become autonomous, as agency. Through agency, non-specified patterns may emerge and allow machines to transcend closed determination. This implies that by arranging objects, and procedures, into adaptive responses they become self organized phenomena and not only a nuance of programming stylistics.

The experience of interaction is simply an implied set of loose relationships, and not implied as concrete structures or protocol. A representation of a relationship is given meaning only as it is functionally fit for a given situation. Where the interaction is transparent, there is uncertainty of what will become of them. This can be described as a manipulative or deceptive strategy in developing what essentially is a belief system accepted by a user-participant prior to interaction. In this sense, the user surrenders their subjective view for objective views, implying that control and not just information is being passed from the user to the system.

2.1.2 Social Programming and Memantics

2.1.2.1 Codification of Language

While language enables one to articulate and communicate, language also defines and sets parameters for how the self is structured both internally and through the definition of relationships between the external and the self. The symbols inherent in speech can translate into how we think of ourselves internally through what I would call perceptual simulation. The decoding of infliction and tone of voice, for example, provide queues for what is implied. The constraints of grammar further the complexities of articulation.

Take for example the articulation of sign language, where the lexical and syntactic takes place on many levels of grammatical constraints, whereas spoken language is temporal and linear[5]. Sign language relies upon spatial acuity, where the transmission of meaning through sight and movement is used. The difference to verbal language is that while we live in a spatially organized environment, our verbal exchanges rely on non-spatial syntax, which removes our physical relationship to the nuance of communication. The implications of meaning, essentially, reside outside of what we are doing, where we are doing it, and how we are related to those activities. Meaning is related to how we perceive ideas internally, verbal communications require contexts, which reside outside of physical space and therefore, as an effect, can be considered to be idealizations of relationships because they are encoded, rather than actual relationships.

2.1.2.2 Perceptual Simulation and Memantics

When observing action, neural networks[6] become activated in the same manner as the actual execution of action. When understanding an action, or movement, the basis for what an action implies is first simulated in the brain, across the same neural pathways. This is the definition of perceptual simulation, the act of simulating actions prior to execution through observation.

Memantics, an area of study I have created from combining memetics and semantics, describes this process of action observation through the use of language. The evaluation of a set of ideas, conceptions, directions, or politics can be referenced by

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[5] Sacks, O. Seeing Voices: A journey into the world of the deaf. Berkeley, CA: University of California Press, 1989.

[6] Gallese, V. (2001) The "Shared Manifold" Hypothesis: from mirror neurons to empathy. Journal of Consciousness Studies: 8, N° 5-7; 33-50

simulation of their effect prior to accepting them as a basis for action. Memantics suggests that what we see and hear can affect our internal understanding of how to act. Communication and observation infect our internal belief systems, which are used to make inference relationships and predictions of consequence. The history of this, as a technological interface with the self and the divine, goes back to esoteric beliefs in Masonic or illuminati mind control that use hand symbols and spoken queues which create a hypnotic or suggestive mental state in another person as the means to program their internal beliefs of who they are and what they should do. Many cults, including traditional or culturally accepted, make use of memantics in order to create value for mental real estate. Commercial television, marketing, professional sports, even political institutions, rely upon the ever changing beliefs of individuals to create value and to instill actions through action observation and simulation. The example of fearing nuclear war during the 1980's cold war, as a means of simulating pain and suffering to discourage communism can be an example of political memantics.

The use of simulation isn't always uniform and consistent with all areas, and has several meanings. Simulation functions by making a representation and applying this representation in different states. Based upon known givens, a model of prediction can be made towards arriving at the consequences of an impending action. The predicted consequences are the simulation. However, this is a problem with accuracy as interpretation may take other factions into account beyond that of an implication deduced from simulation. This would require an existing set of data, or expectations, most likely based upon previous experiences and with active observation. Also, there is a level of compatibility between the issues of identity, as situated, which helps to define ones expectation.

Embodied simulation is a representation of possible experiences attributed to another person, such as empathy, as a real goal state and applied to ones own experience. The feeling of sympathy can be described as the simulation of possible results based upon action observation. This is a matter of giving and receiving feedback, where possibilities are determined, perhaps for situational efficiency, and then applied to another person or other. Projecting expectations onto another, or simulating the outcome of behaviors that are not directly sourced from the self, is a reference to the idea of control or influence. Being able to make expectations of what another will do, based upon simulation, stimulates the brain as if the other has done those same actions.

2.1.3 Network Contexts

2.1.3.1 Communication and Protocol

Communication relies upon the meaning of actions and events, where meaning is expressed directly through language and indirectly through the symbolic. Nodes within a network utilize protocol as a way to organize behavior, define a position or role, and to understand an overall environment. Are these protocols, which function as control mechanism, a result of individuals functioning within a cultural model? Communications between nodes inform, and through codification are also authoritive, and restrict information flow accord to protocol.

Culture can be discussed in terms of an individual’s engagement in transference of data, or communications. Where the information that is most relevant is related to the context in which interaction is taking place. The relationships that develop from these engagements are based upon rules of cultural engagement. Some questions to ask are: What is culturally appropriate, what are the expectations, and what are the predicates and predictions for action. Some of the answers to these questions are related to social norms, values, or histories.

Some of one's thinking is related to prior conversations. But some thinking is of future events and conversations. Prior to acting, or engaging in conversation, it’s possible to prearrange a topic or subject matter. Much of communication is spent thinking about how an encounter will happen, and what will be said and to whom. This is done as much with emotion as it is consciously. This is a sociological rule of engagement, where prior to engaging in communication the content is prearrange and people accept basic rules for how they will communicate. The contexts in which these interactions are taking place predicate the roles and create a social institution, which even further defines the type of information being transferred through a given situation.

Social institutions exist on several sub/super structures and are related to memory in that as the engagements are taking place if certain conditions are repeatedly met and the compatibility between two individuals to communicate exists, the possibilities then enlarge and allow other types of roles, institutions, and situations to come about.

The emergence of internal self-reinforcing changes that take place in society could be done through compounding on stackable or traceable communications. This traceable method is the tendency to maintain a history of events. The overlapping of events as being simultaneous, either active or reactive would appear then in short historical sequences. Whereas in longer historical sequences the exponential delays between cause and effect would occur. In short sequences of events, the level of feedback is heightened, which would then appear to be more responsive, and in the case of longer slower communication over distance would appear to be more resonant.

The problem facing long distance communication is the buffering between actors involved. As information passes through a host, a dampening or distortion effect would occur. The child's game of "Chinese Whisper" is an example, where children sit in a circle and one begins by whispering a secret to the person on their right. As the secret is shared in a full circle, the information changes and develops into a new form of an older message.

Within communication, the action of social latency against social responsiveness, the upward slope of the time it takes for an actor to receive an event as the individual works within the particular social structure reaches the downward slope of the time it takes from the event to the actor. The curves are directly a reflection of the particular social architecture that encompasses the communication. The top of the graph, in which there is the longest possible time for actor to event to actor communications, which is feedback, is the critical mass. If latency were to extend past the ceiling, then would be able to interact or become applicable to external fluctuations of history or geography. Art movements, political movements, corporate restructuring, all are examples of how cultural geography is affected by internal communications of a relatively small number of actors which have lead to larger cultural institutions.

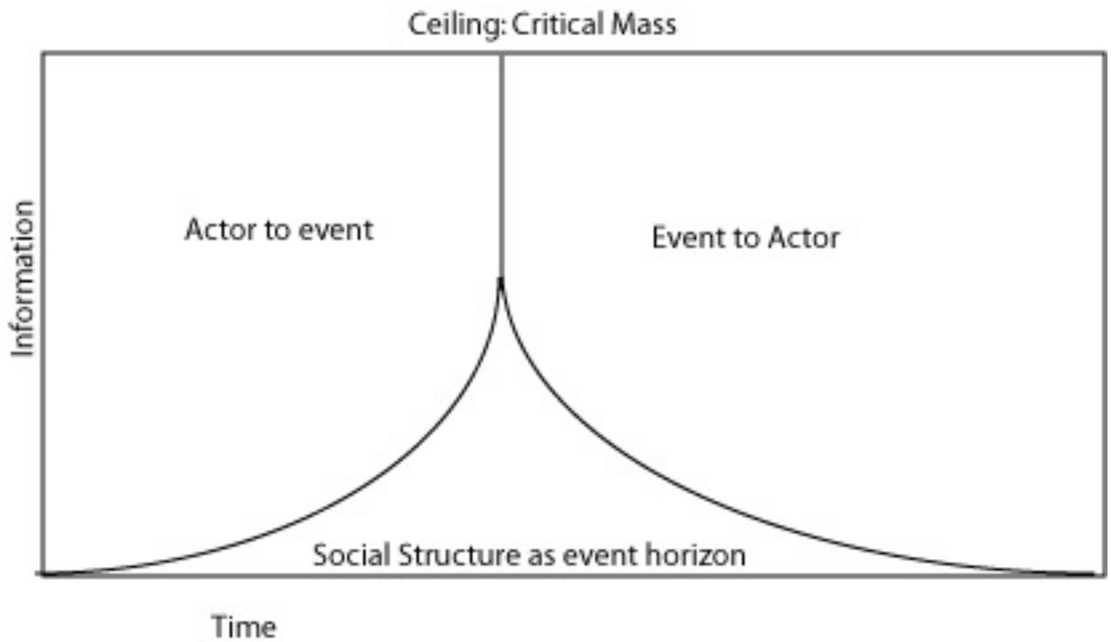

Figure 1: Social Latency and Responsiveness

Erich Jantsch[7] described the communication process as a multiplicative growth pattern, which acts with structure and function to prevent over-population. The containment of ideas or thoughts as particular to a circumstance or situation seems likely, but I would argue that the growth process is exponential rather than multiplicative. For multiplicative structures, there are several independent groups or clusters of actors, which reproduce content as a group and not as individuals. For exponential structures, the individual can be the source of action for a group, which then can be expounded upon for splinter groupings. Exponential growth implies that an entire field needs not to be duplicated but only in part. The pattern is much like a legislative branching.

In order for exponential communication structures to maintain structural integrity, a social fabric, there would need to be two types of functions: Flexibility and Stability. The degree of complexity can be thought of as the reflection of how these two forces are

[7] Jantsch, E. The Self-Organizing Universe. Scientific and Human Implications of the Emerging Paradigm of Evolution. Oxford, New York, Pergamon Press, 1980.

working. More complex systems generally are highly flexible, but unstable. Less complex systems are more stable, but inflexible.

For self-organizing models, evolution becomes the rate at which inflexibility and instability are prevented through altering complexity of social structures. Metastability is delayed evolution. Because evolution is continual the endpoint as a reference which can lead to a breakdown of social structures doesn't exist. Metastability is the retainment of the main actors, as structural, while the elements of an action may change. In this exchange of stability and flexibility, the presence of noise is present and requires a buffer.

Autopoietic structures resist evolution, as there is an implication of removing old structures or changing them into new ones. This resistance, as canonical change, is equal to the amount of fluctuations. The highest fluctuations lead to the highest resistance, and therefore more dynamic responsivity and self-organization. The mutation or the latent expression of genes is the phenotypical response to fluctuations.

Parts of society respond differently to these fluctuations. From the top down, the structuring of a unified socio-cultural system follows evolution. Which is to say, the primary components are malleable but the sub systems do not follow the effects.

In comprehensive structures, the opposite is true. Subordinate systems may see the effects of evolution but still to a lesser degree than the primary components. This is referred to as a Gliding Revolution in which small partial processes replace large singular events that act to restructure. The idea of a "parity" as a participatory structure for how subsystems take part in global events is important, this is the means through which partial processes are generated.

Two primary factors to evolution, which are present in the above model, are the assumed autonomy of subsystems and the progressive break down of control hierarchies. For control hierarchies to retain evolutionary right, they work through simple cultural guiding images. These run as two principle levels of the human world, ahead of reality but in different sequences.

2.1.3.2 Emergence

If we consider behavior as a set of data relationships, programming then becomes deterministic. Genetics is often viewed in this way, that the characteristics of ones genes will determine their abilities. Through processing, learning patterns develop from these behaviors and through interactions. Does behavior evolve? Are the interactions of behavior meant to be procedural through conditioning or do behaviors adapt to one another?

Instead of biological references[8] being made in robotics, or networks, as an emulation of behavior, there is a possibility for technological adaptation of existing biological models for computation methods. If biology were used as a framework for future behavior processes for computation, would the bio-functionality be retained? One thing to consider is that if behavior is computed, then is this an expression of what biology has been doing through evolution or simply a new abstraction of an existing system?

In terms of the distinction between genetics and environments in affecting behavior, what amounts to this argument is that either something generates an event on its own, or something is acted upon through an event. This is the difference of subjective and objective programming. I also see this as an element of Input Output, where there is an external cause of an effect triggering event handlers, which create changes internally through variable input. The basic understanding of physical logic deals with inertia, force, and momentum to define how objects interact and engage with one another. This can be translated into genetic, as a template or definition, or as environmental by being in flux or malleable.

Ontogenetic sequences[9] can be explained by thinking of the developmental system as what is useful, or what is universal in a species, or what is necessary or sufficient for consistency. Genetical production, then, is detracted from relative aspects of external

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[8] Brooks, R. "Intelligence without Reason." MIT Artificial Intelligence Laboratory memo 1293 Internet (1991).

[9] Oyama, S., The Ontogeny of Information Developmental Systems and Evolution. Cambridge New York: Cambridge University Press, 1985. Pp. 73-139

sources. That essentially understanding the mode of operation within culture or environment, through the events taking place or localization of variables, is going to indicate why what develops is going to develop. It is not only genes, and traits, that make decisions so much as how well the developmental system that the genes are derived from has survived or adapted in an environment. Genes are simply utilities between different historical contexts.

The order of the biosphere can be explained anthropomorphically. Order is created through referencing to particular hypothesis of how things work and then applying them in operations. While the end result is not always as expected it can be described as either being an error or being as intended. There is a system of relationships between what is known and what is expected to come from it. While we make attempts to define behavior, it comes down to not knowing the full function of genetic sequences. And because we cannot find a source, humans create representations of themselves as gods, creators, demons, etc to understand practical theories of sciences, none of which may be anything more than psychological feelings of inadequateness.

For computational methods there is an indication of control of environmental factors to affect processing. If a system is reflecting changes in output in terms of input, where models are initiated at a fixed starting point, is machine or genetic learning really possible? If changes in the environment correspond to changes in processing then there would be equilibrium in development. Biological functions would reflect some, but not all, of environmental changes and marked differences in successes and failures.

Intelligence for one system and environment is not true for a different system in the same environment. Intelligence may be emerging as an ability to produce, which have values assigned to how efficient or accurate this production is for solving problems, behavior appropriate to conditionals. However, non-appropriateness may lead to other forms of cognition and creativity. Where and how is intelligence valued? It is important to understand the complexity of interactions when defining behavior value with emergent properties.

The human brain[10] does not process information in the same way as a machine. They do not make empirical statements in constructing data sets so much as from making relationships between objects and particulars. In child development, the ability to recognize and make distinctions between people, places, objects, shapes, and sounds is stressed. The rate of neural activity does not specifically point to intelligence and likewise the speed of processing would not necessarily mean that intelligence is active in developing cognition.

While there is a difference between how biology learns and how machines learn, there is a commonality in defining how behaviors may emerge between them. The synthesis of knowledge, that is the communications between two unrelated things, can occur as cultural programming. The reaching of a critical mass or cultural thresholds in population densities as the means to allow habits to be ‘copied’ between individuals is similar to network activity and virus propagation.

Behavior is an observable, relational phenomenon between an organism and its environment. Structure, as biology, may determine the range of behaviors exhibited by an organism. However these behaviors occur within a history, instinct may describe behaviors which happen regardless of particular histories, while learned behavior can only occur under circumstance.

However, the production of behavior as relative to a historical account of an environment seems to preclude anything to do with independence. While instinct seems to appear as unhistorical (perhaps a priori), in some sense all structural patterns have history and a particular. There is a dependence upon human context in order to give behavior meaning. That can be said for any organism’s behavior and a given context.

There are systems that when under observation, change their state. When an observer makes a prediction of where a functional expression will lead to, they are conscious of their prediction and therefore it becomes a pre-formulated function and not expression. What appears as the Necessary just further supports that an observer can make a prediction. What appears as accidental reveals that science is not always

[10] Moravec, H. (1988), When will computer hardware match the human brain? Journal of Transhumanism vol.1

adequate in providing a basis for how living things operate. Since the observer is conscious of observation[11], and therefore unable to make a prediction, it creates a paradox. If you are observing your course of action, you should be able to control and predict what will happen.

Single cell organisms are assembled from internal cellular structures, chemically and atomistic, which are present in an environment. What is necessary is what is present in a given situation or environment, what the reaction is to stimulus. But even in an accident, something is required to measure it against, which makes it an accident. We should be able to make relationships between something that is unnecessary with something that is by necessity present in an environment. It seems that functioning is dependant upon the co-relations we make, and this in turn affects our structure.

An organism's functional and expressive capabilities are they way they are because of their structure, and where they are within the confines of historical instances. We function inside of history but also participate with it, which implies that we are deterministic in our understanding of our own structure because history is static. While history has a broad range of possibilities, and because we are involved in the continuum of linear time, its difficult to step outside of a current context and consider other possibilities or other modes, methods, of operation. We cannot control our genetics without technology, but we can control our diet and hygiene.

2.1.3.3 Networked Culture

When the word "Society" is used, it describes a process of an interaction between peoples and not a group of people themselves. Without communication or interaction there are no societies. In describing the sociality of people, behavioral, it could be said that when communication takes place, that the thoughts created are social. The conversations that take place between us, instill values for the thoughts and feelings we have. Society is then relative to an individual's level of participation in transferring

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[11] Maturana, H. R., & Varela, F. J. The tree of knowledge the biological roots of human understanding. Boston: Shambhala. 1987. Chapters 6 and 7.

information[12]. Where the information that is most relevant is related to the context in which the individual is interacting. Questions of what is appropriate, what is expected, and what are both the predicates and the predictions, come up. The relationships that develop from engagements are based on rules of cultural engagement. Some of these rules function as social norms, values, or histories.

There is a sociological principle involved here, when rules are violated the normal structures are exposed or made to be known. When one is interrupted in a conversation, it becomes apparent that talking out of turn is not a social norm. Society is held together by the places where it falls apart.

Prior to conversation, people agree to basic rules before engaging. These rules function as sociological rules of engagement. The context in which these interactions take place predicate the roles to be followed, and create social institutions, which then further define the type of information that is permissible. These social institutions exist on several sub/super structures and are related to memory. As engagements are taking place, if certain conditions are met repeatedly and the compatibility between two entities exists, then the roles expand and allow other forms to come about. These situations contain cultural capital.

2.1.4 The Symbiotic Apparatus

2.1.4.1 System Processes

Emergence occurs from either system properties as behavioral phenomena or system properties as template organization. The difference between these two concepts is that in the first, the system is allowed greater variability in production based on non-congruent relationships (interactions) between system nodes and in the other, the system is defined according to preexisting substructures. That is to say that the system can either be classed by the connections within its structure or by the substructures connected within its structure. The function of both of these is the transmission of information as either metaphysical or physical means, metaphysical in the first and physical in the second.

[12] Collins. R. (1992), Sociological Insight. An introduction to non-obvious sociology. Pp.159-177

On the opposite ends of a system are the intake of raw information, and the production of processed information. Within production, feedback serves as a control mechanism for relaying environmental conditions to alter production. The three states of control are listed as, goal recognition, situational inferences, and end state achievement[13]. In this scheme, you will have the current state of a production stored, the end state of a production limit identified, and the inference between the two as understood as a system process. In the first, goal recognition, the end state of a process is defined and kept separate from the system process. It is a self-defined range of possibility given between two points as understood to be the future state. The second, a situational inference, is the definition of the current state. I would say this is a static medium from which other points can be made. It's a foundation from which a process may begin but also may be understood as a previous goal state. The final control is the end state achievement, which is unlike the previous two fixed or static states, is meant to be a subprocess for templating how the events leading to the future state will be done.

The theories for system management, or systems design, such as Catastrophe, Chaos, Evolution, or Algorithmic are sets of standards for how such a system will operate as process.

For the Catastrophic system, the move from goal recognition to end state is not a focus but instead on the situational inference of which the system is currently residing. The move itself between current state and end state is the catastrophe. Once the catastrophe is completed, the end state becomes the current state and the process is repeated. In terms of a linear description, a square wave would be representative of the output of a catastrophic system where one end state is followed by a shift to another in immediate and opposite direction.

For the Chaos system, which focuses not on the end state or goal recognition state but on the process of movement within the state of current inference. The action of beginning to end is the exponential, where small patterns make changes to create larger patterns. In this way, a chaos system may be thought of a patternist or template system, although the changes are thought to be unpredictable because of their increase in

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[13] Herbert A. Simon (1969). The Sciences of the Artificial (First Edition), MIT Press.

parameters and measure. The template-ness of the chaos system is the ‘strange attractor’, which is a sub-process for directing initial changes on smaller patterns, which act upon larger processes. The chaos system implies that the inertia of the past state mirrors the events for current state and leads to end state achievement, but the templates are unforeseeable.

Chaos systems have potential in that they are not predictable mechanics. They are not restricted to shifts in equilibrium to create end states but rely on previous actions upon a current state.

For the Evolutionary system, the move from endstate from current state is based on levels of efficiency in that the sub-products are checked against current states at each point in a process and then adjusted. Within adjustments, rules are made that govern what information is to be kept and what information is removed or changed in order to achieve the recognized end state conditions. Evolutionary systems are malleable in the sense that end state achievement can be brought about where the end state is changed in mid-production. Algorithmic systems are a type of evolutionary system, which use feedback mechanics to create generative patterns of production based on fitness.

One aspect of emergent properties, which these systems attempt to resolve, is the action of functionality. The action of processing information to define current and end states, and to generate patterns of new processes to achieve end state from current state, implies a type of cognitive willingness to do something. In a sense, this willingness as I mentioned in the template-ness of the chaos system is a preexisting factor, which was acquired before the system process begins acting. The theories listed above are the ideas for how these intentions are put into action but not necessarily the same as intelligent or cognitive resolutions. Templates do not have real functionality without something to put into them, and in a broader sense what is the reason for reproduction? Is there an acting force that creates the conditions, which require a template to produce?

According to Herbert Simon[14], there is a division between social hierarchies with physical or biological system hierarchy; that the interactions between actors in a social

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[14] Simon, H. (1962). The Architecture of Complexity, Proceedings of American Philosophical Association.

framework are described through sets of interpretive relationships, while physical systems are described spatially. I think this solution is fair but I am unsure if this is accurate because in a sense a biological system could be a template for a social system. Social hierarchies can be psychological constructs, which originate from the biological organisms acting within them. The relationships can be psychological constructs and not necessarily the hierarchy itself. I think hierarchal representation in social systems is a formality and not really a true system in the way that physical or biological systems are. The break down of biological systems into organelles (and symbolic systems) makes sense because the organelles require particular macro structures.

Herbert Simon described how organic systems as compartments operating as separate input and output processes. And that the interactions within organs are more intense than the interactions between organs operating on the same hierarchical tier, tissues between organs provide "inventories" as buffering between this input – output operation. To an extent, I would agree with how organs function as I/O interfaces between one another, but I don't agree that they operate separately. On a micro level, internally and externally for the organ, the physical states of matter or nuclear states are at work. The information being passed between organs, as either molecules or otherwise, affects the action of the organ possibly reformat its design or function entirely. The presence of particular items in an inventory will change behavior for related organs processes.

Simon's discussion on state and process descriptions shows the difference between objects as particular actions and objects as particular properties to be acted upon. As adaptive behavioral systems, organisms are involved in end state comparisons for goal recognition. Simon uses the state/process/goal model to set up how learning is essentially recognizing end state goals and then finding the process that will lead to up to it. I think what is missing from this discussion is that end states can be processes in themselves. In a fixed physical system, the end state can be readily defined, processes leading to it can be defined, and then the goal can be produced satisfactorily. But in biological systems, I think its more likely that end state comparisons are not as fixed and may be very loosely defined. There is a cognitive property in processing, intention, that I think must be present in a goal-oriented system. I am unsure if physical systems have intention in them, or if they are acting by necessity reasoning; necessity reasoning being that certain conditions are unstable and by necessity of stabilization the end state is reached.

From this discussion on end state modeling and process orientation for goal recognition, the development of information as codification (and not only as raw materials) becomes important. The difference is that for codification, a translatory system must be in place to decode and recode information from the transmission process. In the example of DNA, the strand itself both carries information related to end state goals as well as instructions for replication for DNA. I think what is interesting about this is the idea of DNA as template containing a previous state to describe a future state. As organisms develop, they retain certain traits and organs from previous organisms as solutions to possible future end state goals. If this is accurate, it's possible that because of retainment the goals do not change. People have to continue to eat, sleep, shit, etc.

2.1.4.2 Mechanical Consciousness

Although machines do not posses consciousness in the same degree as living sentient organisms may, the development of mechanical consciousness has been ongoing. When you consider the development of life on earth that has taken over several million years to reach the state it is now[15]. In comparison to the relatively small number of centuries of the history of machining, machines have adapted and become more sentient in much less time. While machines owe all of their development to human thinking and creativity, what is to say that machines could not design and even build themselves in the future?

Machines are an extension of human consciousness, where computation and abstraction can for people be understood as relevant only in terms of the world around them. Whereas, machines haven't an interest in developing further than to gain more

[15] De Garris , H. "The 21st Century Artilect : Moral Dilemmas Concerning the Ultra Intelligent Machine." Revue Int. de Philosophie, Vol. 44, no. 172 (1990) Internet, Pp 131-138

efficiency for current state goals. The reason is because where something is working, is viable or conducive, to its own action the machine mind would not require further development to fulfill a function. The computational mind would seek the shortest more efficient distance between two points as methods for human involvement.

It is possible that given human architecture that machines would remain a utility for consciousness but if designed for self-sufficiency may be able to redesign and build themselves continually. This view is similar to how western Judeo-Christian humanity views itself, as being given free will by way of a creator. The viewpoint that power or intelligence is a commodity to be harnessed, further defines the limitations of freedom or restrictions, rather than enabling. The concern of enabling machines to think or act on their own accord is related historically to the concern of educating African Americans or Women during the civil rights era.

As some level in its design, there will be ‘knowns’ that predetermine how a machine will act and react. This is also known as Root architecture. If a machine changes this root structure, how is it to tell the difference between what is efficient or non-efficient?

It seems that adaptation of intelligence would lead to emotions such as empathy, or kindness. These adaptations would be affected by input. Communications between machines use protocols and channels that are beyond the human sensory experience, but the data originates from human sources. Although machines may be able to talk to one another and share their experiences, the validation of servitude or utility would be present. Is there any relative enjoyment, pleasure, or sensation felt by machines as offsets of their use and communications? Do they talk just to talk?

For human communications, sensory experience is dependant upon the brains ability to take input and create situational inferences between sensing and context. There is a level of interest in future technologies that these systems will create biological involvement on their own and without need to be subjected to the human body. The inclusion of biomechanical systems into human experience is a derivative of adaptation and habit[16].

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[16] Bach-y-Rita, P., Tyler, M., & Kaczmarek, K. (2003). Seeing with the Brain. International Journal of Human Computer Interaction, 15(2), 285-295

2.2 Cybotanomy

Technology has extended the human sensory experience into methods for intervening with the natural environment. Our human minds work through human languages and phonetics. Likewise, plant and microorganisms work through the extension of metabolism and the transmodality of energy forms.

Cybotanomy – cybernetics, botany, and autonomous robotics - is an area of study I have composed to describe communications between networked organisms. The word ‘organism’ is used in a reductivist organ-sense, as an object made up of modular components, and processing of data as through metabolism. In the Cybotanomy rover project, described in the art-research project’s cited section of this thesis, the degree of motion and behavior assigned as responses to an environment are directly extended from internal conversions of energy. As the rate of respiration guides the rover to sources of energy, providing the specimen with light and air, the botanical specimen is given the opportunity to establish its own destiny and its own position in physical space.

Cybotanomy extends the use of hydroponics, which has historically been used to replace natural ecology. The introduction of nutrient solution into a root system is meant to replace natural soil and water conditions. In this process, water molecules bind to nitrogen and phosphorus particles in the soil and are absorbed into the root systems to be uptake into the plants cells where they are metabolized into energy, producing growth. The dependence upon sun positioning through climatic seasonal weather patterns is replaced by robotic mobility. Allowing the specimen to reposition itself towards a light source, natural or artificial, enhances the growth process and reduces the need to plant a specimen in an area of light or shade as its metabolism requires depending on the particular species.

In natural systems, a plant specimen is not given the privilege to conduct itself according to its respiratory needs, but rather requires air current to replace oxygen with carbon dioxide. Climatic rain patterns to provide for water necessary for nutrient uptake. The inclusion of plant data (the metabolic rate, and the respiration rate) allows for dynamic signals and data variables upon which to create behavior, rather than procedural instructions of behaviors based upon hard coding. Cybotanomy replaces artificial intelligence with synthetic intelligence, based upon the genetic code given by botanicals. The use of sensor data, based on a live subject, enables the robotic actuator to behave more naturally.

Cybotanomy makes obsolescent natural ecological systems, such as non-artificial sexual cross-pollination, and the need for sunlight or soil. Algorithms and random code operations designed to give a system more flexibility and naturalness are also made obsolete, as the plant specimen provides instructions for the machine.

As a technological extension of the interiorness of what metabolism is, the machine apparatus forms an “other” body for the plant. By distinguishing between the external environment and the internal process of the environment, Cybotanomy is concerned with the cultural communication of the unseen symbols of programming languages, both genetic and electronic. To think of a plant in terms of being a genetic program composed of organelles, poses the definition of life as the technological interface of consciousness and the unknown.

There are patterns in the life processes which function just as similar as in the communications model. There is input to a processing module, an intermediate stage where noise is present, output to a receiving module, and finally an endstate or goal which functions as a translatory mechanism. For genetics, I propose the environmental variables as a physical system of properties is the input for cellular systems, which then are broken down into energy and waste (noise) which are then transferred into skin, root, leaf structures, and released back into the environment.

In this example, the transmission of information and chemicals can be read by a machine and implemented as instructions for machine behavior. The decoding of the presence of oxygen leads to a fan being turned on and replenishing the Co2 level. As fresh Co2 is introduced, the plant specimen decodes the presence of Co2 and begins respiration. In this way, the botanical and mechanical communicate through a particular language, which is central to what is the nature of harmony between linear programming and genetic instructions.

2.2.1.1 Eco-physiology

Eco-physiology, an area of ecology, is to understand the physiological mechanisms that result in the adjustment of growth and allocation when plants are exposed to changes. It is about understanding the responses of organisms to ambient conditions and the causality of the corresponding ecologically dependent physiological mechanisms, at every level of organization. The eco-physiological approach must take into account polymorphism in individual responses, which are largely responsible for the adaptive capacity of any given population. In this respect, eco-physiological study yields information, which is fundamental for an understanding of adaptive strategies.

Higher physiological organisms are characterized by a complex interaction of multiple control systems. This interaction permits man to adapt those unexpected demands given by experimental changes. The idea of complexity results basically from the non-linearity of dynamic systems that are related to each other through feedback. These systems fluctuate in apparent chaos. The non-uniformity of biological systems are basic qualities that define the state of health. It is possible to discriminate in them a certain repeatability of interaction of succession; this repeatability makes the system ideal for evolution.

Table 1: Factors that contribute to unpredictable events.

Physical Parameters:	**Chemical Parameters:**
Temperature (daily and seasonal)	Water quality
Salinity (tidal)	Ph, alkalinity
Particulates (solids, silt, organic matter)	Gases (oxygen, nitrogen, co2, pressure)
Light (intensity, day length, seasonal)	Nutrients (phosphorus, trace metals)
	Organic compounds
	Toxic compounds
Biological parameters:	**Habitat requirements:**
Disease causing organisms (bacteria, virus)	Space (territorial, shoaling)
Food resources	Life cycle (nesting sites, seed dispersal)
Predators	
Parasites	

3. Project Descriptions

The following are works conceived and constructed as the studio component requirement of the MFA. A brief description of the MFA presentation exhibition is given, and then the documentation of works with schematics and theoretical framework

3.1 Exhibition Overview

The MFA presentation overview will take place West Hall on the RPI campus in Troy, NY. The documentation of works listed in the project list of this thesis will be on display along with the installation of PlantMech, which is the central project to this thesis. An artist talk will be given on the topic of the cybernetics. Following the artist talk, a review of an electronic artist book entitled “The Symbiotic Apparatus” will be shown and will be made available on optical disk, a copy has been included with this thesis submission.

3.2 Project Descriptions

3.2.1 The Catcher Network: Communicating Through Digital Frameworks.

The Catcher is a network of software and computer hardware that accepts biological input via an EKG sensor to determine perceived demeanors in the output of a java based AI chatbot written in the Program D language.

By examining the relationships between the user-participant and the interactive components of the Catcher, the intent of this work is to investigate the emergence of artificial behaviors, and how the participant interprets these behaviors. In effect, the Catcher is listening to the human heartbeat, and as variance is found in electrical current in the cardiovascular system it produces a change in its software. This change can be reinterpreted through sound and text by the participant and used as a feedback mechanism back into the Catcher network using the EKG sensor.

The Catcher Network is a culture as defined within the context of an artwork. The behavior of the computations processes (the machine) and the biological source (the human) are the results of their interactions. The Max/MSP software is programmed to respond to information in a given way, this data could be said to be cultural knowledge as Explicit Culture in the data stream (i.e. audio output, EKG input) and Tacit in its internal programming code.

For the biological sources (the human participants), cultural knowledge defines how one will react to an engagement with the machine architecture. The computer hardware, the physical environment within which sensing is taking place, and the biological sources all represent cultural artifacts. The social situation, the context, in which behavior generation is taking place, can be expanded on by examining the communication between participant and software, the use of such data, and the patterns of engagement.

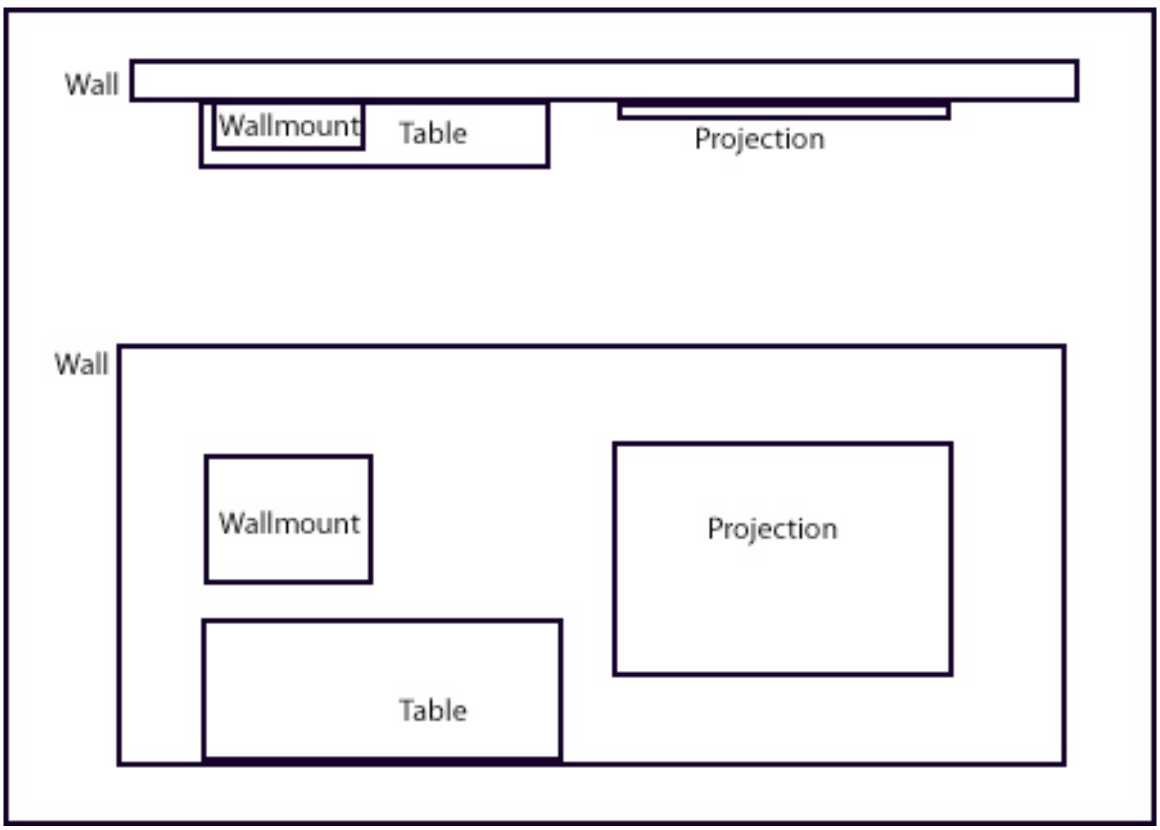


Figure 2:Layout of The Catcher Network Installation

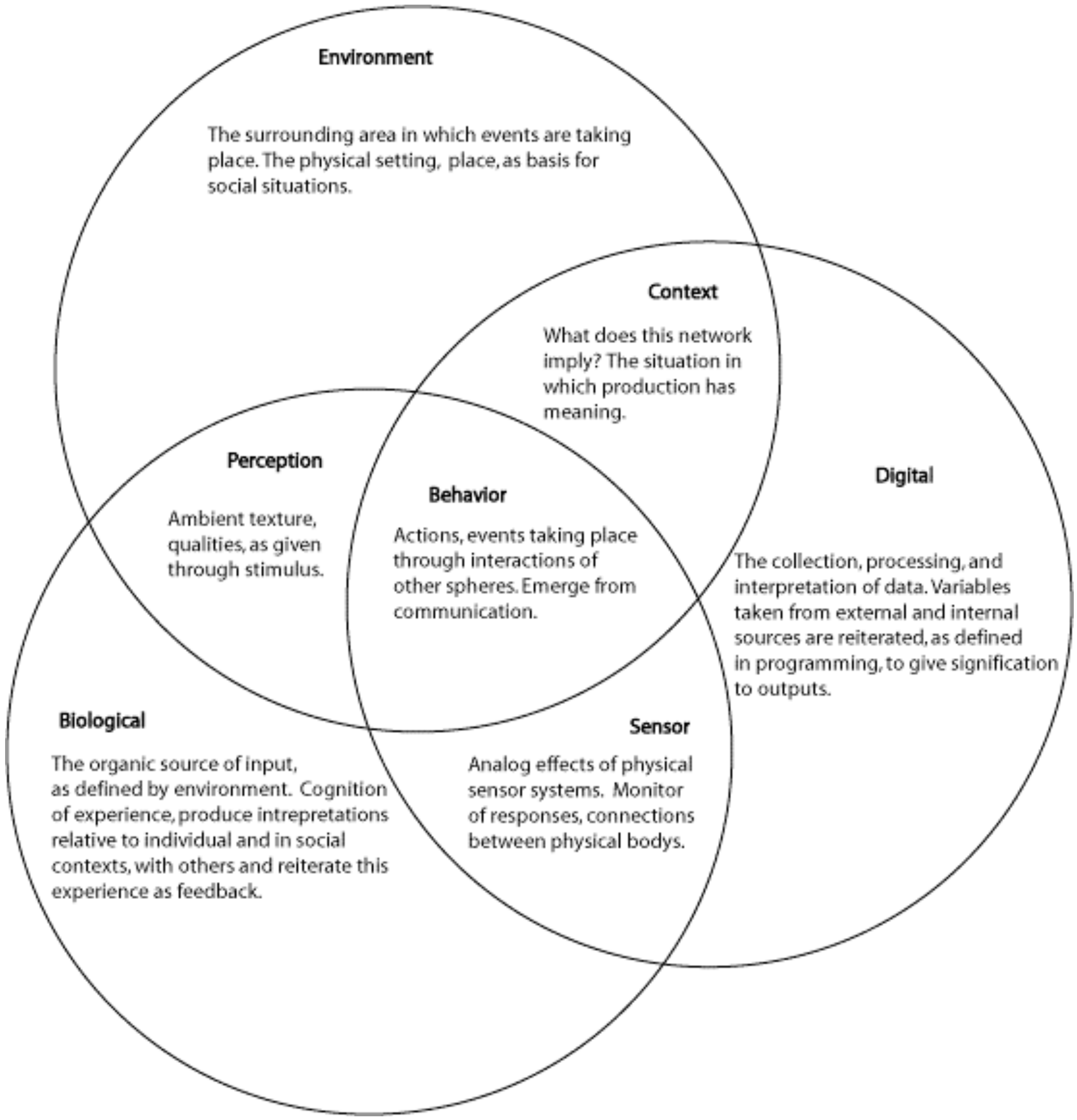


Figure 3: Diagram of behavior as relative to ethnographic cultural model.

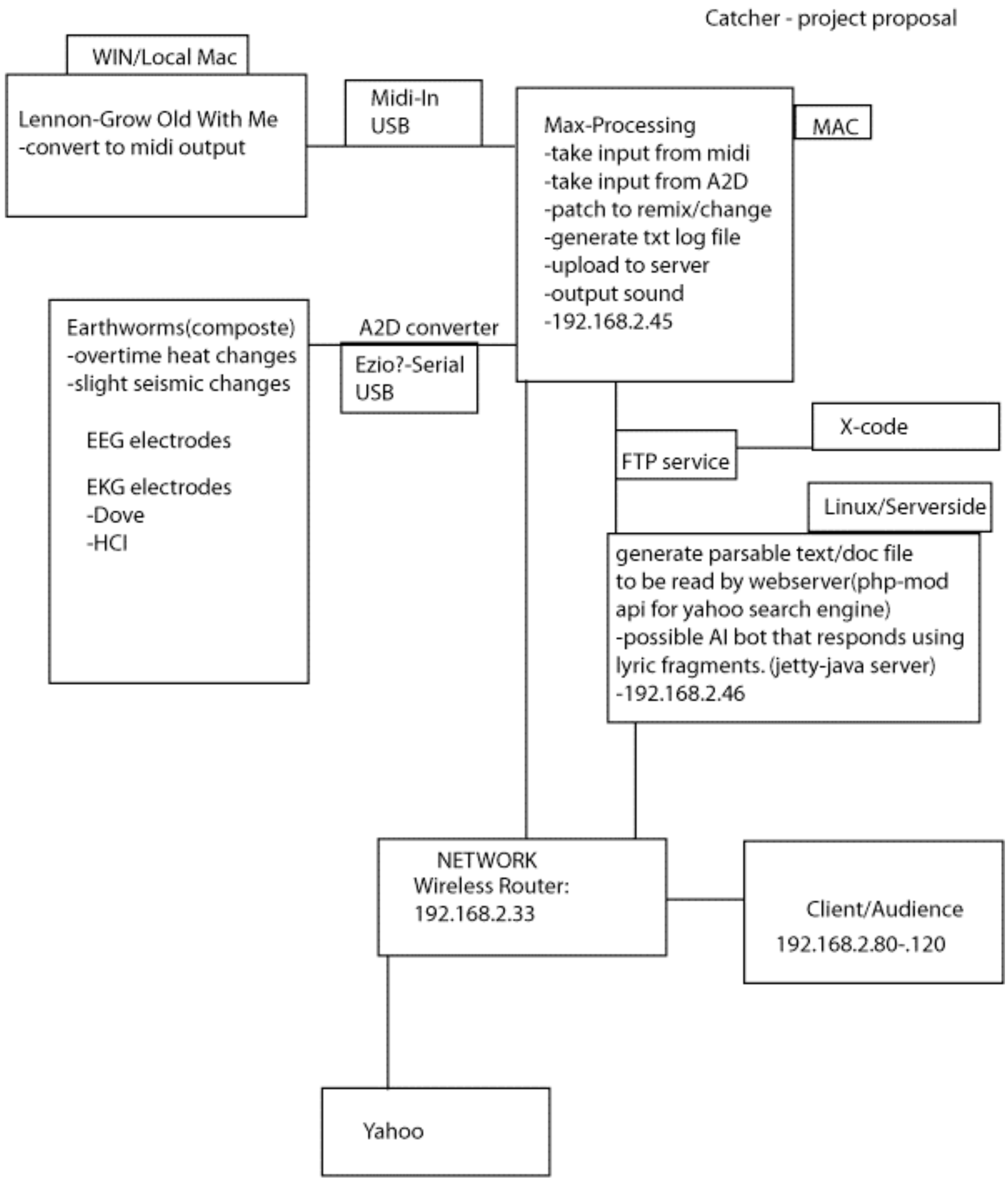


Figure 4: Diagram of The Catcher Network connections.

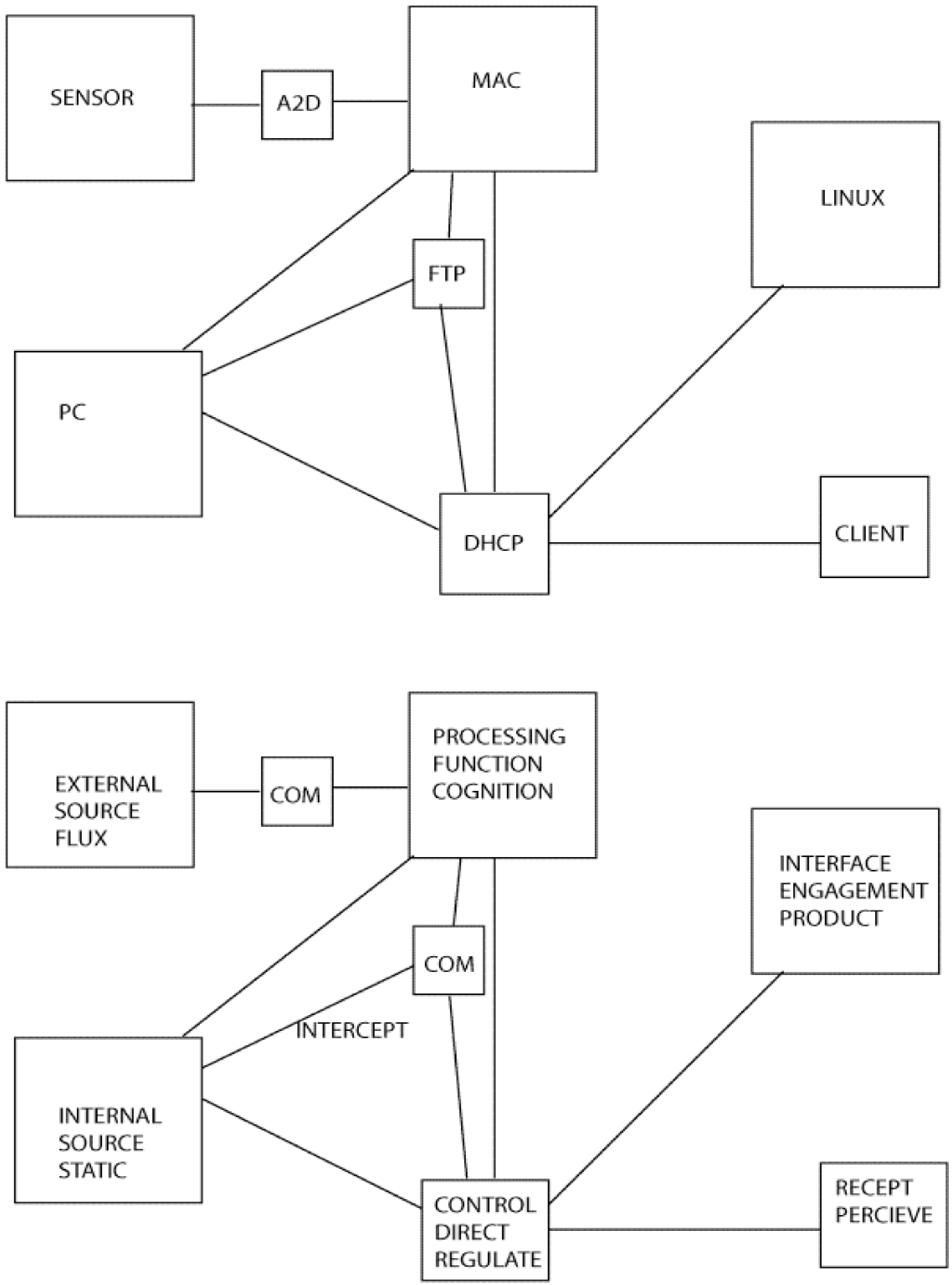


Figure 5:Diagram for nodes with The Catcher Network

3.2.2 The Pilot Project: Etiquette, Censorship, and Self-Knowledge Systems.

The Pilot Project is an Electroencephalography (EEG) device, which uses eye movement and Theta waveforms to provide instructions for a wireless robotic rover. The Pilot Project is interested in facilitating a user's perception of participating with the work rather than trying to control the behavior of the robot. This work attempts to address how people are able to create perceptual strategies based on a particular self-knowledge system they use in describing themselves and their placement in real space. A self-knowledge system is the cognitive interface between action and embodiment relative to ones situatedness in physical space. To reflect on how the eyes function, how the neuron-chemical balance of the brain functions, and how the ability to distinguish small changes in nerve paths in the skin, are a few components of ones self-knowledge system.

This project was concerned with how the range of movement afforded through muscle tissue and brain functioning can be translated through robotic actuation, and how the action of having a remote body, may reflect ones cognitive perception. The Pilot Project is a discussion of etiquette in terms of falling into servitude; By training oneself to become more efficient in this machine human engagement, there is an effect on the level of appropriateness embedded into the interaction based on perceptual cues given. Etiquette is a reflection of how efficient one is at describing their situation and applying this description to their willingness and desire to produce changes.

Social changes rely upon participation in memantics propagation. This propagation of thought and action can be used by individuals to persuade or promote a given viewpoint, affecting another person's self-knowledge. The use of consequence and situation is meant to be a description for etiquette and describes what is and is not appropriate. In order to ensure broader political compatibility, one must self-censor in order to participate in social arenas. This censorship is a manipulation of ones own social ethical and moral values and occurs as an input of memantic information. It is necessary to understand the implications of perceptual cues and their applications when interacting with others in order to retain social accessibility and function in social spheres.

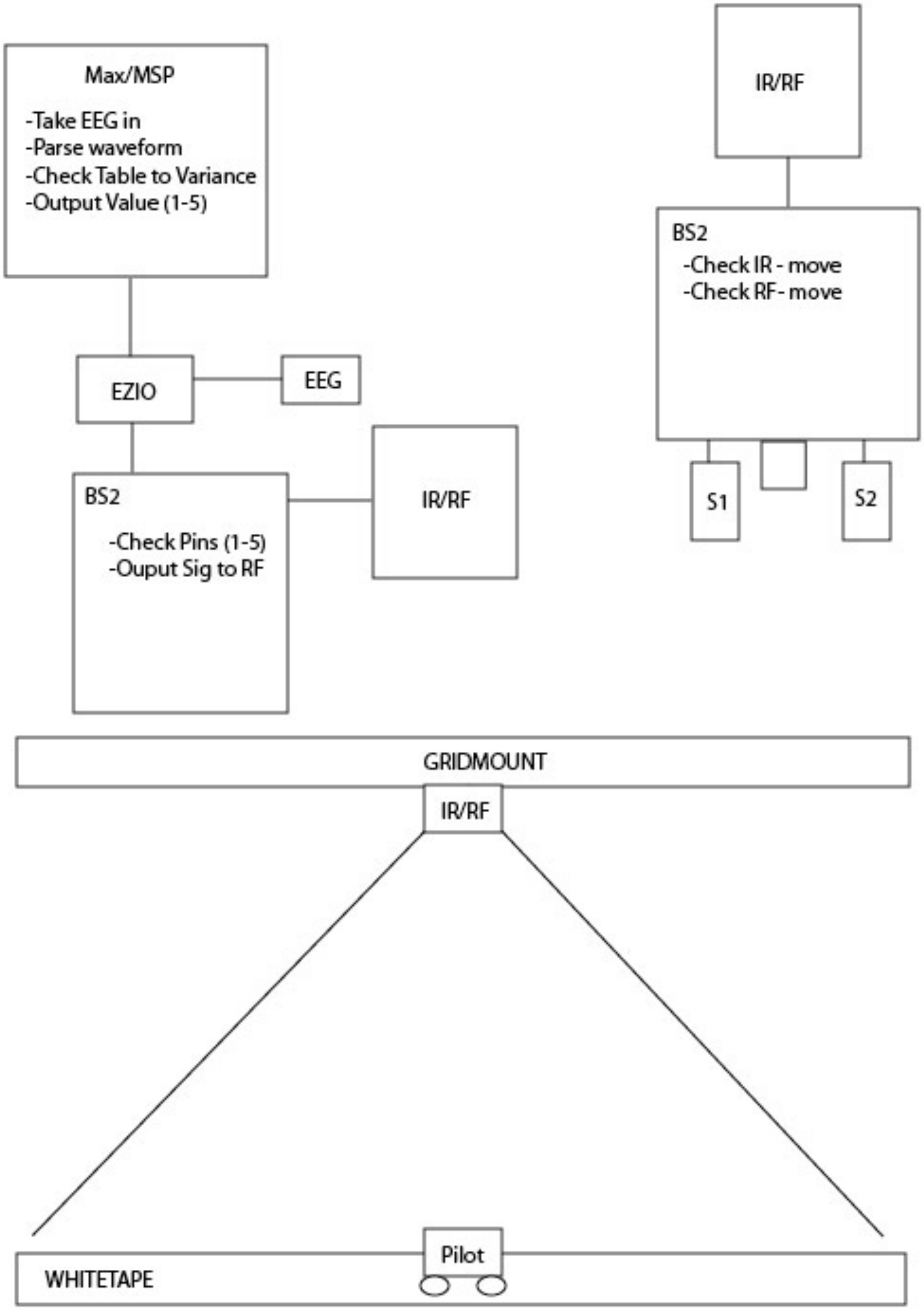


Figure 6: Layout of Pilot Project Installation.

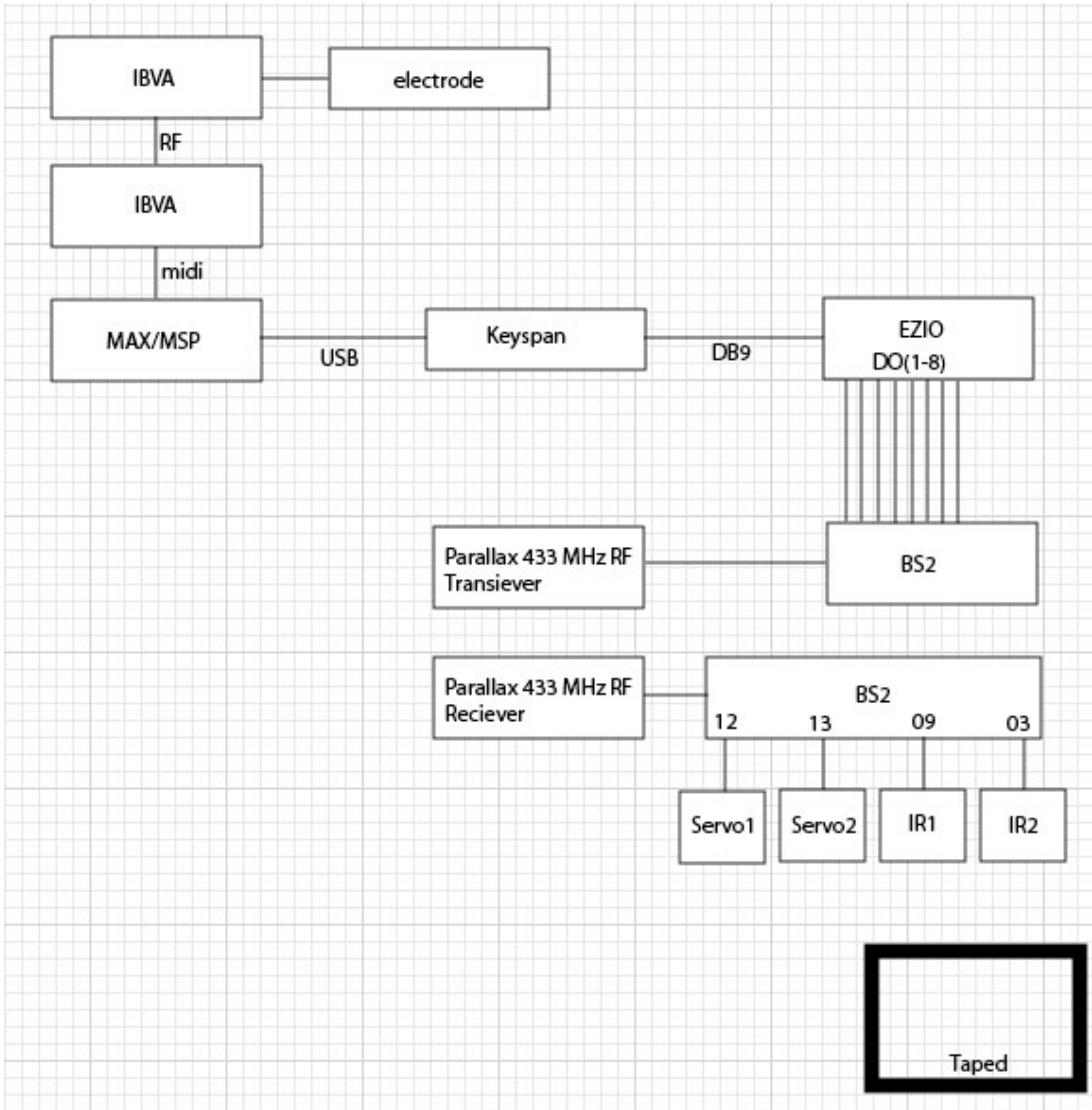


Figure 7: Layout of Hardware Modules for The Pilot Project.

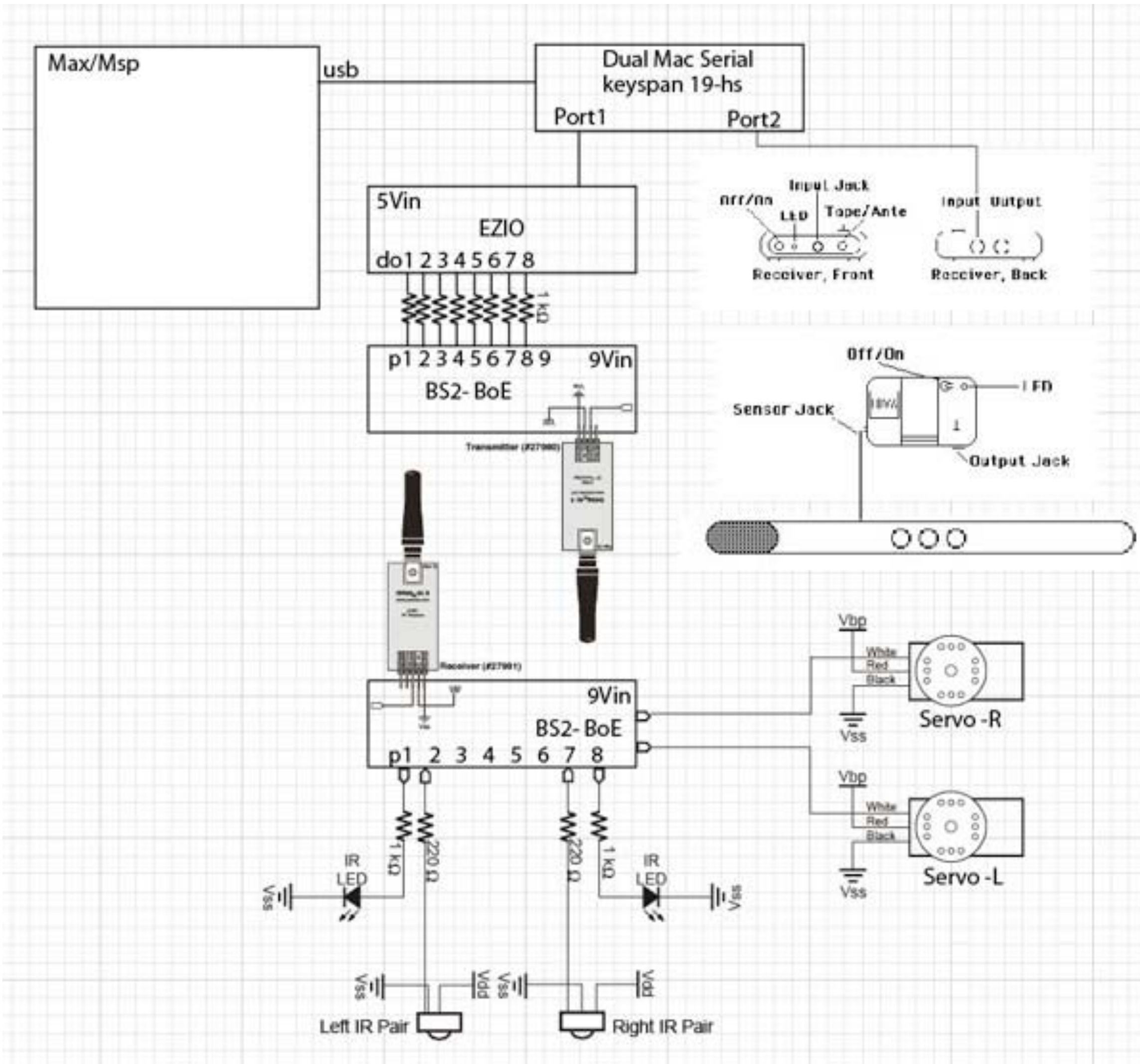


Figure 8: Hardware Connections for The Pilot Project.

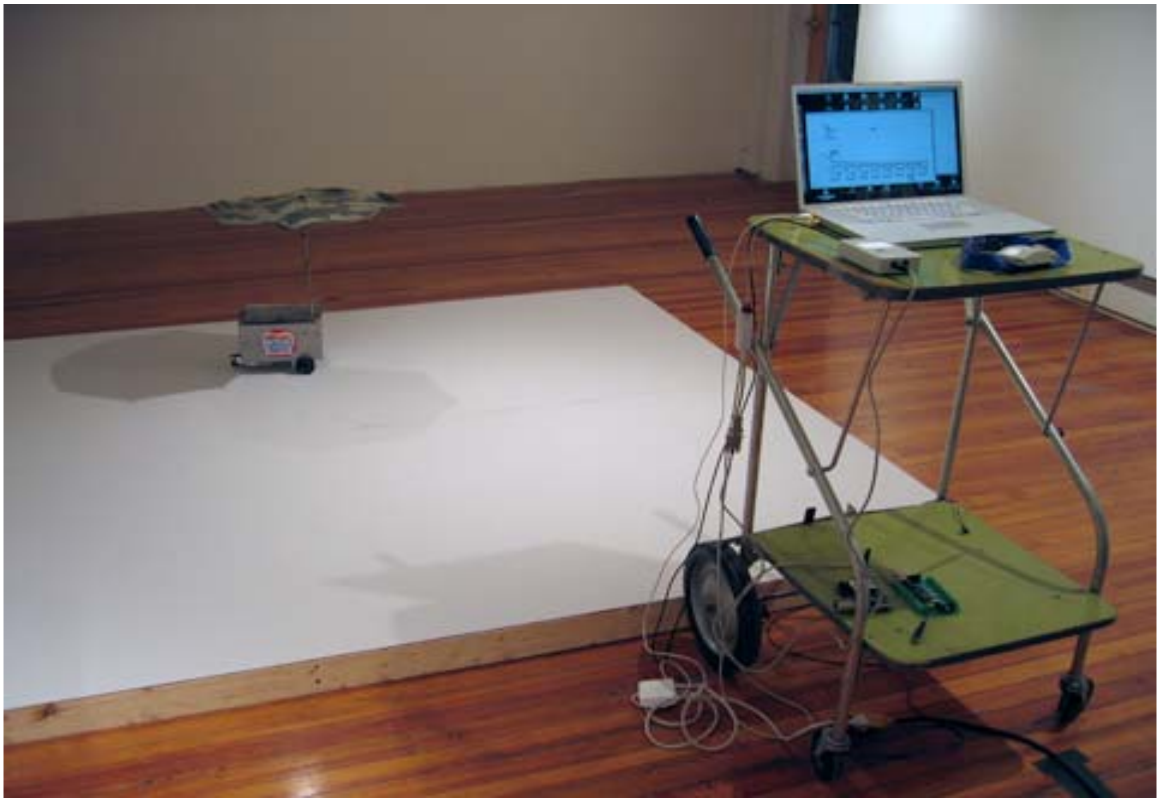


Figure 9: The Pilot Project Installed

Figure 10: External Detail of The Pilot Project Rover.

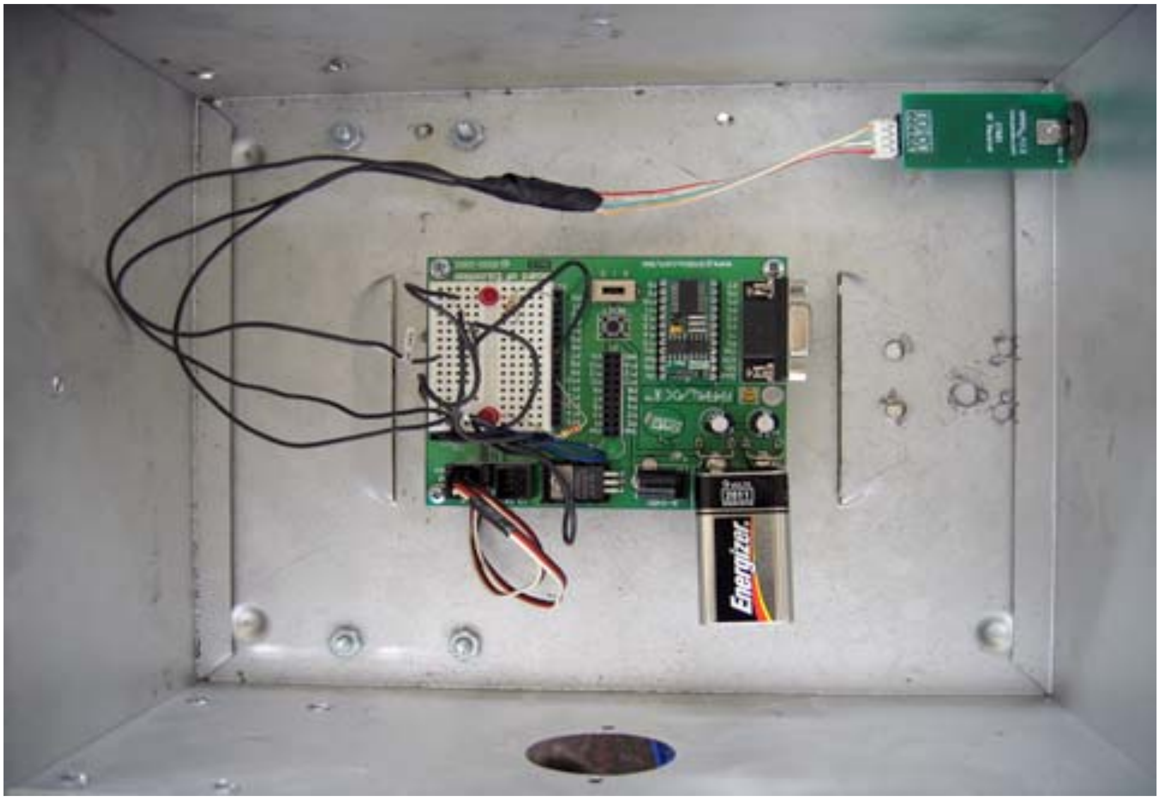


Figure 11: Internal Detail of The Pilot Project Rover.

3.2.3 PlantMech: System Theories and Emergent Behavior (Chaos, Catastrophy, and Evolution).

PlantMech is a bio-robotic sculpture which houses a hydroponically grown Schefflera "Luseane" Arboricola (Dwarf Umbrella Tree) plant culture that provides data for a mechanical armature. The mechanical armature controls a hydroponic system to create an artificially sustainable architecture for the plant culture, a series of tropical starter cuttings grown inside a sealed chamber. Plant growth patterns exhibit chaotic qualities based on environmental conditions, which then provides variable data to produce changes in the mechanical system. Variances in Co2, Ionization, and Nitrate levels in the soil provide information for where the plants are in their metabolic cycle and what their nutrient needs are. As plants develop with the growth chamber, they exhibit qualities based on the cycling of light sources, nutrient uptake, and carbon dioxide levels which are all based upon feedback given through the mechanical system.

The machine apparatus takes data derived from the plant tissue functions and responds according to a catastrophic binary representational model. This is a procedural codification for a plant’s metabolic process by checking the current state of the plant’s metabolic process against known sets of responses. In this way, the machine armature and software are ‘Code implemented as evolution’.

The PlantMech project uses the Eco-physiology model as a networked modality. Eco-physiology is an area of ecology concerned with the looking at the environment as a physical system. The physical apparatus of the machine, and the physical needs of the living plant culture are utilized in such as way that the two become linked symbiotically. The systems are allowed greater variability in their production because they are based upon the interaction between the two. Metabolism, then, becomes a networked process of communicating through the release of oxygen and the uptake of nitrogen.

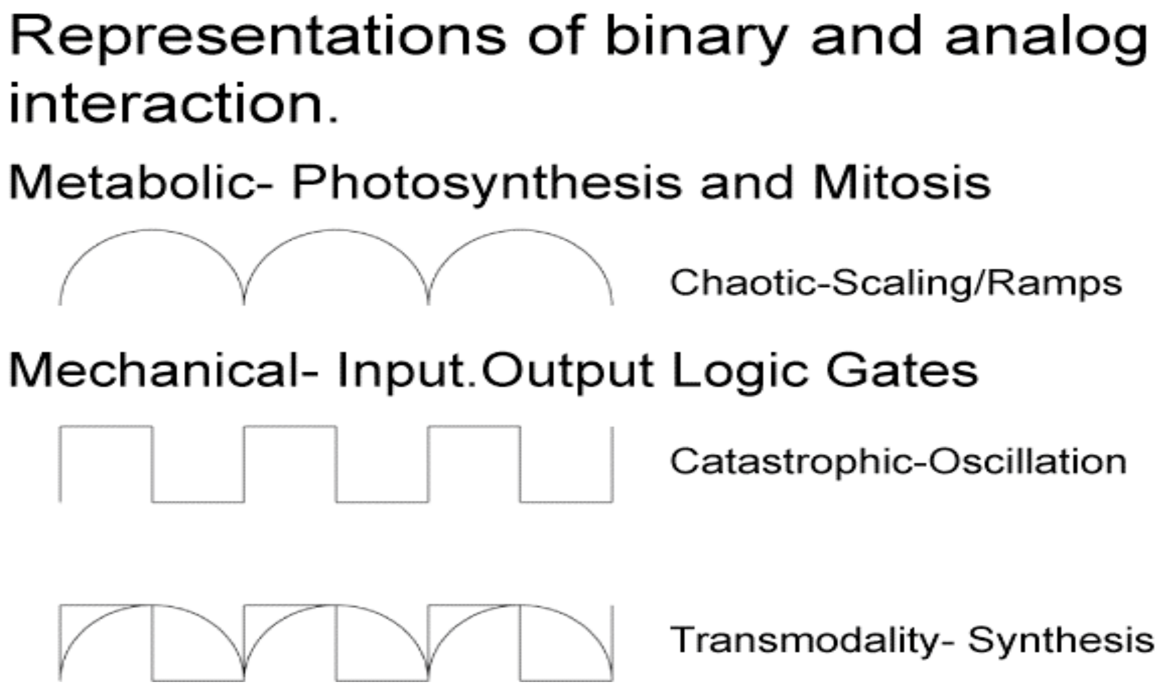


Figure 12: Description of the overlap of chaotic systems and catastrophic systems as applied to PlantMech.

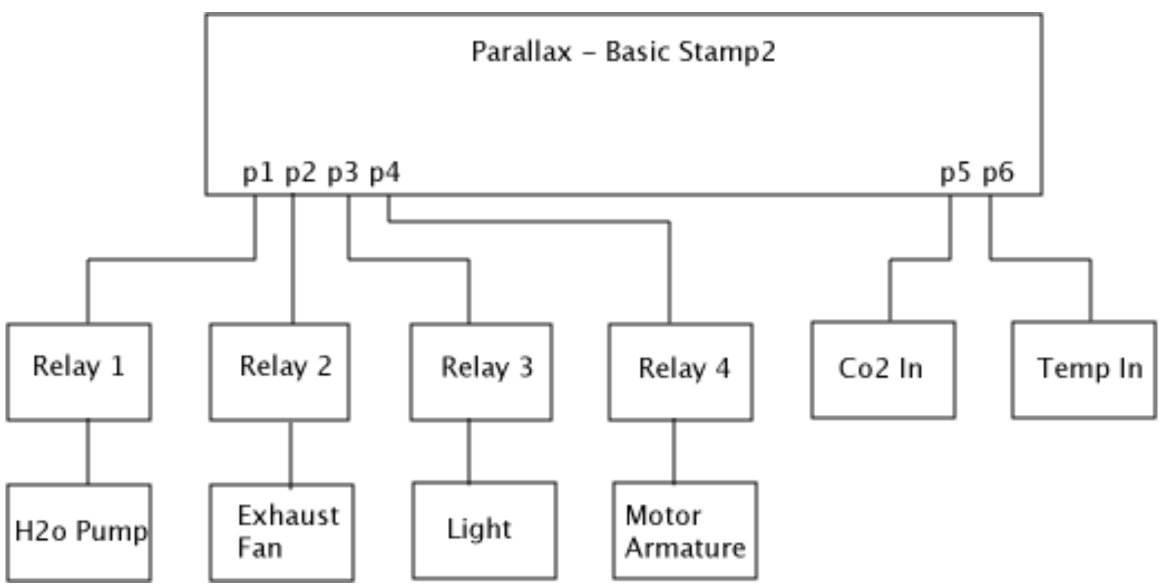


Figure 13: Diagram of hardware connections for PlantMech project.

Figure 14: Front Profile

Figure 15: Detail Top

Figure 16: Detail Pump

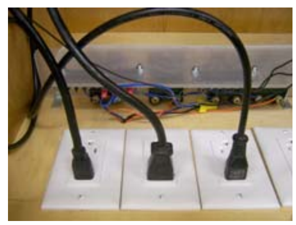


Figure 17: Detail Relay

Figure 18: Detail Armature

3.2.4 Cybotanomy: Cybernetics, Botany, and Autonomous Robotics.

The Cybotanomy Project is an artificial robotic environment for living plants, which navigates through a given space according to a plant's need for air and light to support photosynthesis. Cybotanomy is an area of study that I have composed, as part of a larger field of behavioral ecology or eco-physiology, to describe the convergence of cybernetics and botanical research with autonomous robotics. This project is intended to address issues in accelerated habitat decay and the social acclimation of botanicals into synthetic ecosystems. In this project, Cybotanomical specimens are given the means to explore physical space, seek out light, open and close their windows to the world and engage with the human realm of living.

As an exhibition piece, the Cybotanomy Project is to be presented as an application for preserving future botanical specimens in areas where delicate specimens would not naturally grow. The project serves as a commentary on the future of biotechnologies in a post-human world that is preoccupied with exerting control or manipulation of natural environments to suit temporary desires. By exchanging soil and fresh air with growth nutrient and compressed carbon dioxide, this work describes a type of neglect on the part of industry to address the need for preserving natural environments. The project also may serve to protect fragile genetically mutated species or species created without true natural ecosystems.

The interest in developing bio-technical robotics stems from previous studies in communication and interactive arts. I often find myself struggling to communicate through written and verbal languages, and to this end have sought alternative means of expression. The use of biological sensors to affect changes in the environment as a communication strategy has become a primary focus of my research into bio-diversity and the transmodal aspects of language.

In the Cybotanomy Project, the communication between plant, machine, and environment is a central theme. The goal is to create a sentient and cognitive organic-electronic hybrid capable of self-sufficient movement and imbued with a language of its own. The conversion of metabolic and respiratory activity into physical actuation through robotics is a translation system for conveying how the Cybotanomical specimen is coping with its environment. In a sunlit room, you may find the robot close to a window during high noon and in the evening or early morning under the shade of a table converting the stored energy into fresh growth. Cybotanomy is a theoretical model for describing the psychology of survivability that plant life endures.

Preliminary research for the Cybotanomy Project is currently being done with hydroponic plant growth systems. I am interested in modifying the nutrient solution used in hydroponics as a means to alter the celluloid structure in a plant's vascular system to be more conducive for tracing ion particles traveling across the surface of cell membranes. Plants take up most of their mineral nutrients, such as phosphorus, potassium and zinc, as ions dissolved in water, and the electrical charge of these ions permits them to react with other compounds inside the plant cell. Ion tracing is used commercially to determine soil suitability for genetically modified crops, and for testing nutrient content for vegetable produce. The tracing of ionic activity is done using microelectrodes implanted into the cell membranes and attached to a data logger, a device used in medical sciences to monitor sensors. The data collected would in turn be utilized to create a specialized mixture of nutrient, water, and carbon dioxide gas that would be introduced into the growth chamber to ensure maximum comfort and sustenance for the Cybotanomical specimen.

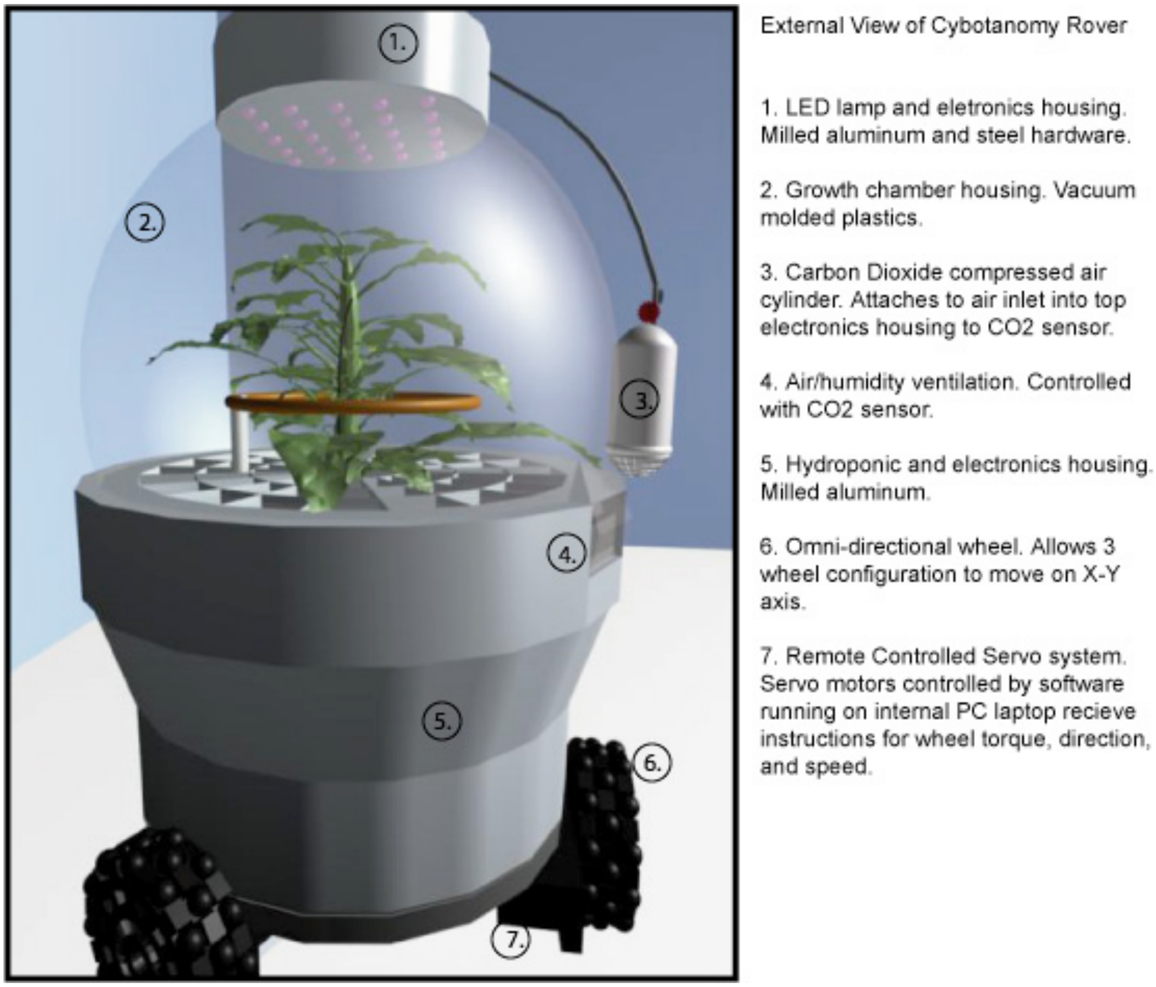
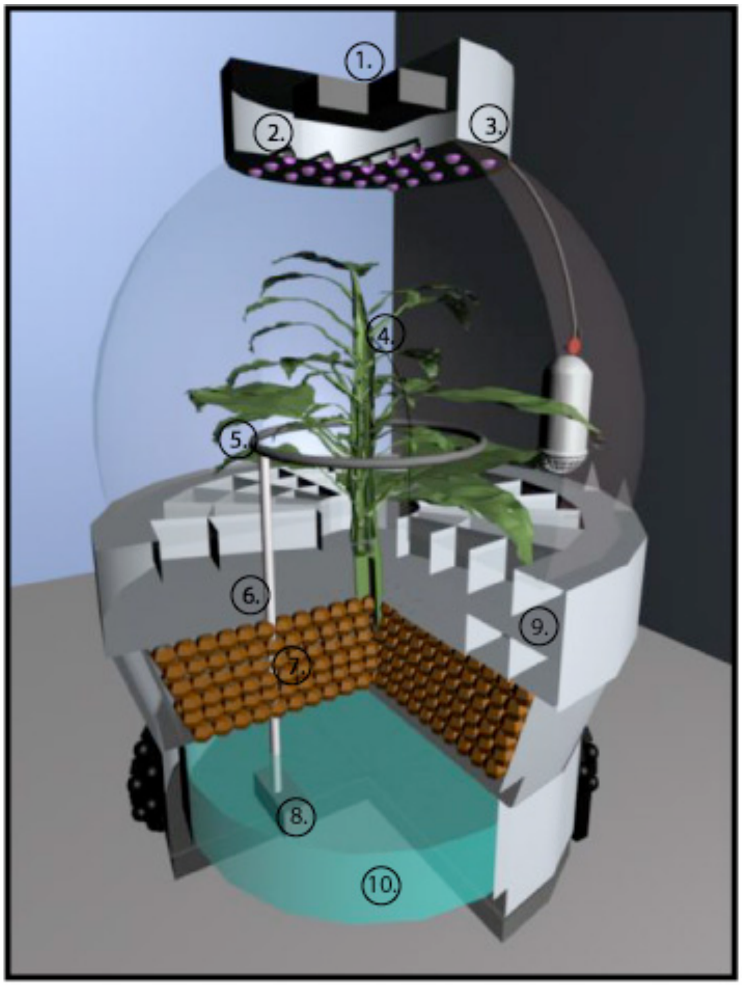


Figure 19: External Detail of Cybotanomy Rover.



Cross Section View of Cybotanomy Rover

1. Enclosed electronics casing in top of lid provides room for carbon dioxide sensor, microcontrollers for LED lamp.

2. Full spectrum LED lamps for use of work in dimly lit areas where natural sunlight is not available, wired to a light sensor circuit to function automatically.

3. Inlet for cabon dioxide. Flows from top of growth chamber to exhaust port at bottom to provide ample supply to the leaves of the specimen.

4. Ion-microelectrode inserts into stem of plant, which traces ion flow through vascular system. Connects to data logger and laptop located in electronics compartment 9.

5. Hydroponic drip ring. Provides aerated nutrient solution to base of plant stem and root system.

6. Drip ring stem. Attaches to drip ring and aeration pump to bring nutrient up from overflow container to roots.

7. Growth medium. Provides base nutrient to root system and supports plant weight inside growth chamber.

8. Hydro pump which provides nutrient solution to drip ring. Activated by a timed sensor according to respiration rate given by data derived from ionic micro-electrode system.

9. Electronics compartment. Holds electrical systems for air, light, nutrient pump, robotics and Co2 gas distribution. Houses PC based laptop for running data logging software and Analog to Digital converter for controllong electrical components and taking sensor input.

10. Nutrient solution overflow tank.

Figure 20: Cross-section detail of Cybotanomy Rover.

3.2.5 The Commodity of Breath

The Commodity of Breath project is an electro-mechanical sculpture which houses a living tree that responds to the CO_2 that is generated through human breathing. As the levels of CO_2 rise, servomotors attached to the branches of the tree activate and reposition the branches either forward or backward if the levels rise or fall. The commodity of breath is essentially concerned with the economics of social conditioning and is an attempt to understand the implications of being socially enabled.

The use of time and measurement to make identification possible in regards to social situations is related to one's understanding of marking time and measurement by breathing. When one is more apt to experience social anxiety their breathing becomes erratic and forced, than when they are relaxed. This identification becomes necessary to tell the difference in friend or foe, which can become problematic. The Commodity of Breath is interested in how identification takes place. What social encyclopedias or libraries exist to help identify one person to another? Other animals rely on catalogs of definitions as well. Through pheromones, color, or behavior they communicate and distinguish ones own kind from another's kind. Pheromones are a social library.

In order for communication to take place, one must accept the particular license and agree to the particular terms put forward (signals) that all parties will use. Everyplace in human society relies upon its own protocol for behavior and communication. The importance of establishing and maintaining social order is that it allows power to be secularized, and it allows participants in the order to at once know their place and transmit information about what they know, easily and efficiently, to other observers and participants.

There are different means of bringing order about; behavior guidelines and rules are established in all parts of society, which function as social contracts and obligations. While you are not wholly required to follow these rules, one is expected to and often required to in order to gain access to social privilege and to become empowered by others. If one deviates from these rules, they are unable to communicate because the signals being used do not match those that have been agreed upon. Even if one does understand the signals being used, they are unable to share this understanding due to social contract obligations. In the MSDM, a medical psychological manual for identifying mental disease there are two types of people either neurotypical or neurodeviant, which reflect the ability of an individual to process and retain certain behavioral characteristics as relative to the social environment.

Some problems exist in making rules concerned with communication and social structures. One is that not all rules apply to all people, by examining the reverse – if everyone was given the same treatment would they in effect become the same, effectively displacing an existing power structure? Another problem is that of implication. When a context of meaning is implied with explicitly being said it can lead to a social situation in which only a few understand the interior or true intent of the language while others do not. This again, is an example of power displacement and relates to the history of knowledge and language of articles designed to be exclusive.

The Commodity of Breath is recognition of the sociability of breathable air. When one breathes in, they are breathing the same air that someone has breathed in prior. Even if it someone they do not particularly understand or have commonality with, the lungs and physical apparatus of the human circulatory system is made in such a way that air and chemical agents can be shared. This is a type of communication also, the communication of communicable disease serves as an example. The use of air as a physical force against the larynx and vocal cords is one that all able humans share to speak. This work makes use of this physical force, and the chemical displacement of Co2 through breathing to activate the piece.

Breathing is one of the few bodily functions we can actively and passively control. Breath is controlled passively by a part of the human brain, the medulla oblongata that can detect the ph level of the blood, if the blood is too acidic it causes the diaphragm muscle to expand as a reflex. In a way, breathing the 7^{th} sense – the sense of air, and the medulla oblongata a sensory organ although you may think the lungs would be the sense organ.

If you really think about it, in a way, our reflexive breathing and the respiration of plants during photosynthesis puts us into a sort of conversation. How are we to interpret the language of breathing?

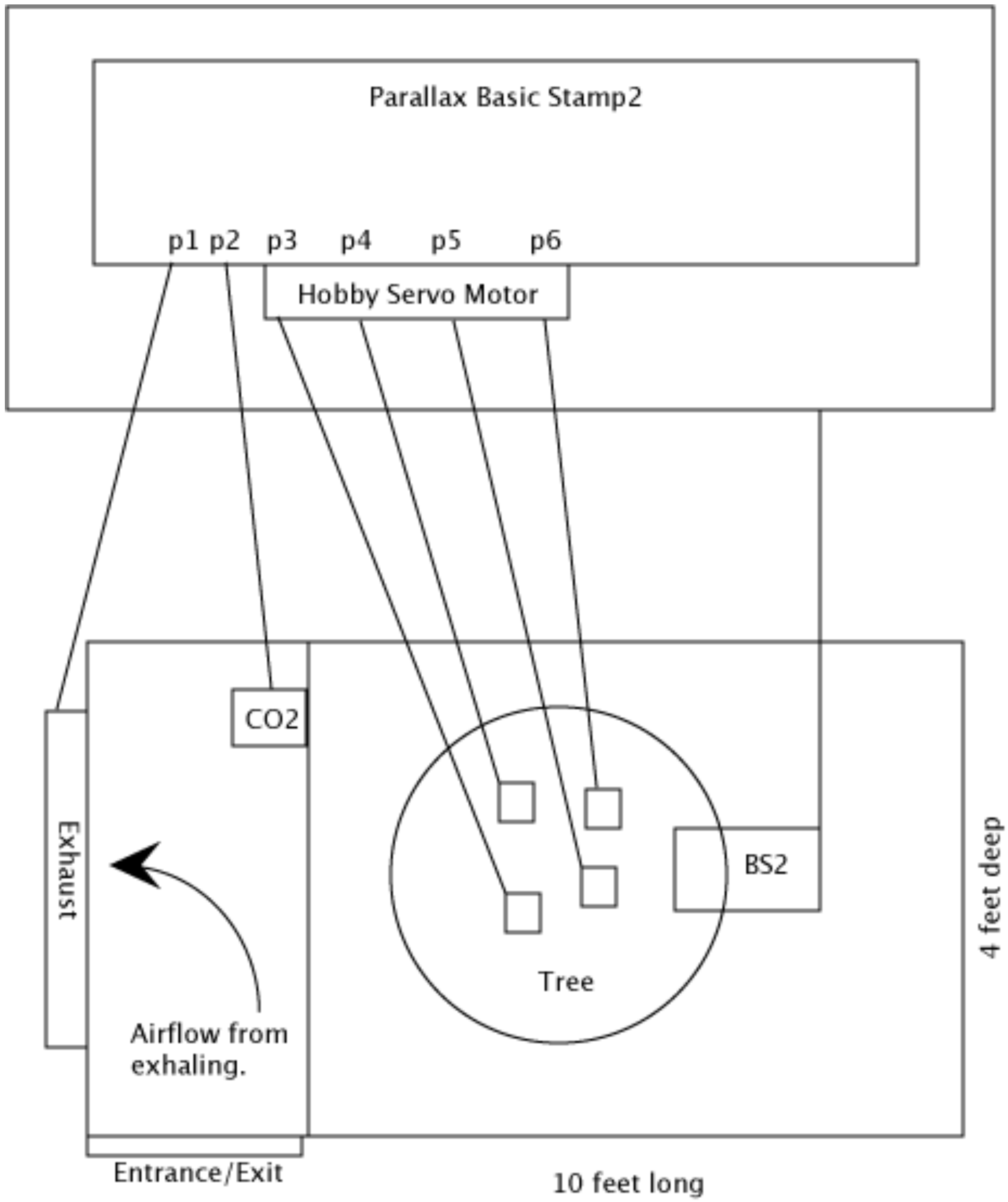


Figure 21: Layout of The Commodity of Breath Installation.

Figure 22: The Commodity of Breath Exterior View as Installed.

Figure 23: The Commodity of Breath Interior View as Installed.

Figure 24: The attachment of servomotors and microcontroller.

4. Conclusion and Discussion

The thesis topic dealing with The Organism as a Networked Object was a result of literary research conducted in cybernetics. The thought occurred to me, that many of the descriptions of a cybernetic system were of the human body, but the human system is generally not considered a cyborg until a mechanical or electronic component is introduced either externally, as attached, or internally as embedded into tissue. These augmentations, which define the cyborg, primarily are for communication of information and for controlling a subsystem of the human body.

Before beginning to describe the communication system process, the fundamental concepts of perception and control were first considered. How does perception affect cognition and reasoning where communication relies on creating either sets of relationships based upon what is to be perceived, belief systems created by perception and observation, or through the methods of transmission of information itself. The method and route that information is directed dictates the form of communication that results.

The next stage of this thesis, dealt with how information is passed between parts or components of a network. The nodes in a network can be living or non-living. For the living organism there is an interest in how authority representation is produced, how the structural sources of political power are put into place and maintained, and what the expectation of outcome or the intention of such a network is. For non-living systems, the projection of living process (authority, power, control) is applied. There was a time when computer networks were described as a Master-Slave relationship between what is now referred to Server-Client. Do computation networks have a status quo and political correctness to them? Perhaps in the same extent that humans use them, probably yes.

Natural systems, which I described through the chapter on Eco-Physiology, do maintain hierarchy and functioning. The description of the Earth as a living organism is accurate. The statements support the idea of evolution as a process relying highly upon the mechanism of feedback, in biological or physical/mechanical terms, but I wouldn't agree that the idea of 'survival of the fittest' is true. The reduction of variability can lead to stability, but only when other shifts or changes in its super-structures cannot occur, which will happen eventually.

Lastly, the application of social theory – the view of ethnography as a type of networked social apparatus – onto computation or biological models was considered. What leads people or machines to behave in certain conditions, but not other conditions. The ideal results in formulative means for expressing what is typically considered to be a subjective experience. By examining the historical products of culture, and the economics of cultural production, we can come to terms of what is implied in languages, such as art making or science research. I think the outcome is that the majority of expressive forms are a type of self-fulfilling prophecy for the people or mechanisms that produce them. The struggle of expression needs to have a combination of both repression and entitlement to make the production valuable, one serves as motivation and a force to act against (such as political activism) and the other serves as the means or method for enabling something to achieve a goal. This has a greater implication for how people come to value themselves and their place in the world, and the reasoning for how one conducts their behavior, organizes their relationships, and applies or projects their beliefs onto others and onto objects.

The projects I created during the course of this thesis were meant to be studies into human and machine interaction, and on a greater scale as studies of interaction between the living and non-living. The projects that used direct input, such as EEG or EKG (used in The Catcher Network and The Pilot Project), are studies into how feedback can be utilized to make references to what I call your “self-knowledge system”. The means to which one can understand that feeling of what is the Self, and the contrast against the Other. These relationships are brought forward by integrating a non-living system which can produce a high variability of response through a part of the human brain or nervous system that is intrinsically not controlled by the Self, but can be felt and detected. Slowing your heart rate or relaxing your mental state may produce a change in the electro-variance activity in the heart and brain, but these systems function on their own unlike body movement or speech relies on specific direction.

The second half of the projects list, are projects dealing with plants and robotics. Cybotanomy, the integration of botanical sciences with robotics, was never really considered to be a central project for this thesis. The project itself stood as a grant, rejected, proposal as the construction would have been overwhelmingly expensive for a graduate student. The conceptual application however, did take the form of the work entitled PlantMech, which is a hydroponic system that provides feedback to an electro-mechanical system that adjusts its behavior and then provides feedback to the plant system, and the cycle continues. This work has implications into what is considered to be a function of chaos and a function of catastrophe within evolution. Where the plant grows according to a chaotic template, like bonsai being formed with physical tie wires, the machine responds procedurally like a catastrophic system; If the plant needs Co2, then turn on the fan. If the plant needs energy for metabolism, then turn on grow lamp.

The final project I put together was the Commodity of Breath, which is another study into self-knowledge systems but with the view of understanding how identification and perspective influences behavior. The project came from a concern of how social affordances are acquired and how political acceptance and values are applied to meaning. In order to understand something, you have to accept it and come to a conclusion about it either through observable facts or through passed on descriptions from someone or something-else. These observations and descriptions that are open to interpretation may not be the reality of the things you understand, so much as personal fears or projections. The real Commodity of Breath is understanding that the air as a metaphor for the mobility of information which human and living systems all share is malleable, and this exchange should be taken into consideration before applying a social rule or system.

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