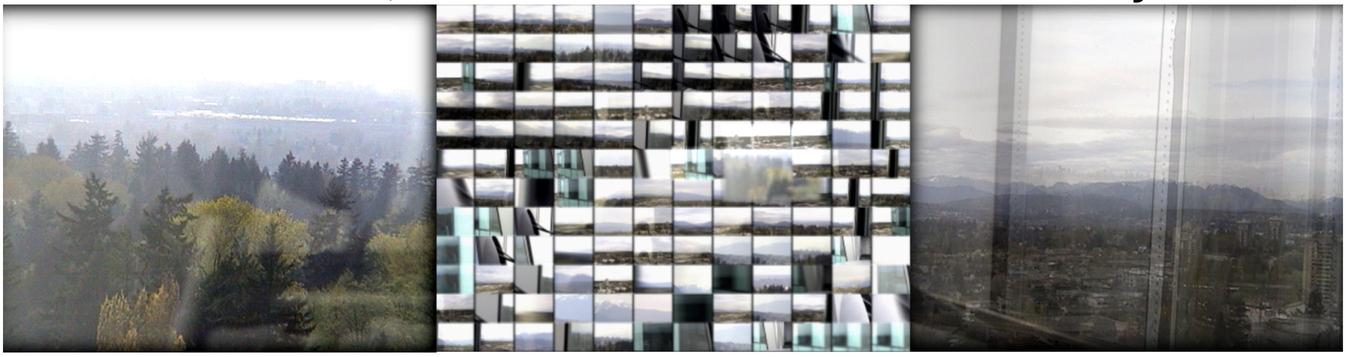
Self-Other Organizing Structure #1
Seizures, Blindness & Short-Term Memory



Ben Bogart
Simon Fraser University / Goto10
bbogart@goto10.org

ABSTRACT

"Self-Other Organizing Structure #1" (SOOS1) is the first in a series of site-specific responsive installations. Rather than depending on the creator to define how these works relate to their site, the task is given to the artwork itself. The creator provides a mechanism that allows the structure of the artwork to change in response to a continuous stimulus from its context. Context is those parameters of the environment that are perceivable by the system and make its place in space and time unique.

As viewers enter the installation space they are able to see out onto a public street through a large window. Hanging in front of the window is a triptych of screens. The centre screen shows an abstracted grid of images from the street beyond. On the right screen a montage of images free associate and evolve continuously. The left screen is a live feed from a small robot camera that pans and tilts to examine the world around it.

1. INTRODUCTION

This paper describes and frames the first artifact in a body of work that aims to create artworks that find their own relationship to their context. These artifacts are embodied, meaning that they are manifested in a physical form and are effected by the world around them. These artifacts could be creative machines in that they use the material from their context and transform it into a new representation. It is the machine that creates this representation through a mechanism provided by the creator. My research aims to use artistic inquiry to develop theory that binds ideas from responsive artworks, artificial intelligence, the philosophy of embodiment (Phenomenology) and site-specific art through the practice of creating embodied artifacts-as-processes. Artifacts-as-processes are artifacts–objects created as a result of human activity–where their material is language that encodes a particular process (software). The system's processes are causally connected to the outside world through sensors and/or actuators. How can an artifact–even a process–find a relationship to its context? Artifacts such as SOOS1 form an embodied relationship with their context in two ways; firstly, by being embodied so they can have access to their context, and secondly by having their structure altered through the process of embodiment.

The paper begins by weaving the theory which has been, and is still being, developed in this research project. The theory is focused on the fundamental relationship between an artwork (artifact), the creator (author) and the world in which they are embodied.

1.1 The Realization→Interpretation Loop

The process of the creation of artifacts is made up of two iterative sub-processes; realization and interpretation. Realization is the path of intention from the creator to the world, whereas interpretation is the path of intention from the world back to the creator. Realization happens when the creator chooses to effect the world in some way, to make a choice than manifests physically (for example, choosing the colour yellow for a particular region of a painting). The assumption is that this manifestation somehow encodes the intentions of the creator (i.e. a yellow colour in a particular spot means something for the creator and is meant to represent that meaning to others). Though it is not the colour that is meaningful but the process of realization and interpretation that makes a causal connection between the

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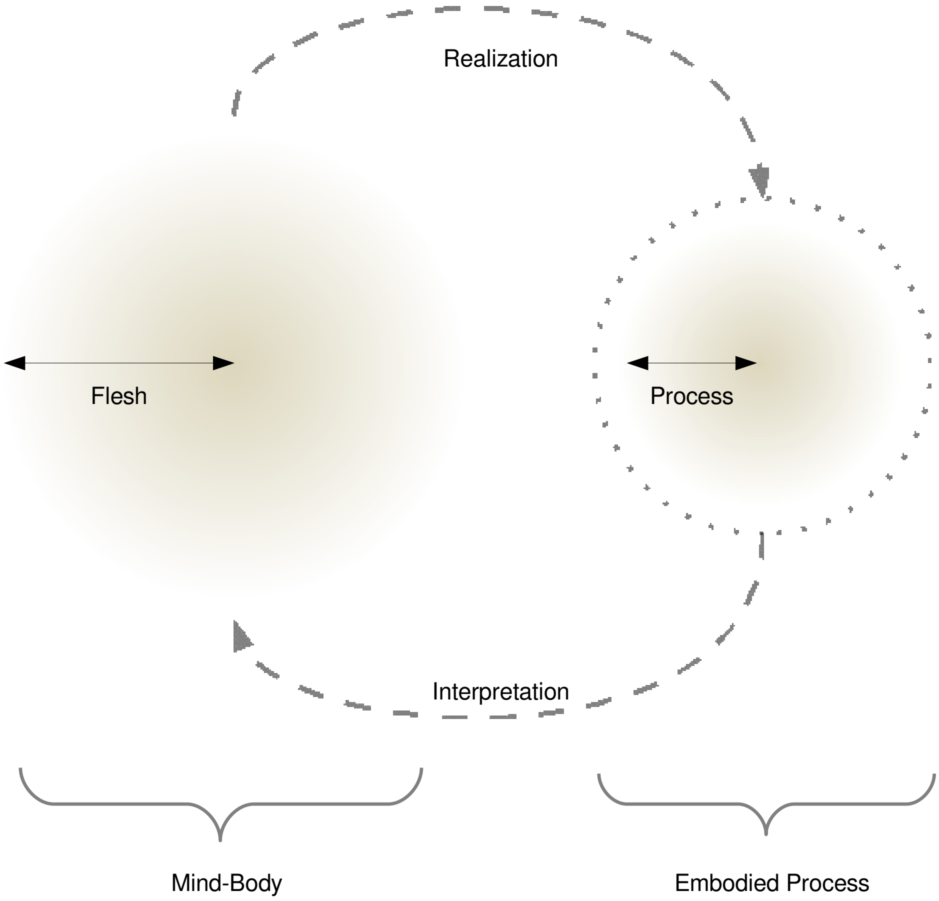

Figure 1: The Embodied Process (Artifact) in Relation to the Mind-Body (Creator)

creator and the artifact.

Interpretation is when the creator observes and experiences the results of the realization (for example, seeing yellow in a particular spot on a canvas). The tension between what the creator intended and what the artifact is actually offering is the context in which the next actions of realization (choices) are framed. The painter may decide that the tone of yellow is not quite what he or she wanted and adds more white to the paint. The artifact is then iterated through the dialectic between realization and interpretation. Future choices are framed, not just by the current interpretation, but also in light of the entire process of realizations and interpretations. The creator's concept, and experience of realization, colours his or her subjective interpretation of the artifact. An artifact composed of physical materials is but a snapshot in time of a process that, often, only the creator has access to. The creator then may interpret the artifact in a way that may only be valid for his or herself. Those subjects who were not part of the realization→interpretation loop are likely to interpret the artwork differently than the creator. The creation of artifacts-as-processes on the other hand does not aim to create a single snapshot of this iterative process, but to create an artifact that enacts a process in itself.

Figure 1 contains two sections, one is the Mind-Body, the subjectivity of the creator, the second is the process embodied in the artifact-as-process. Arrows show the loop of realization→interpretation and its directionality between the creator and the artifact.

1.2 Artistic Inquiry

Historically, the artifacts of Modernist artwork are often seen as products of artistic genius. There is a mythology surrounding the "creative genius" and the artifacts the, predominantly male, artist creates. The artifact is a record of genius which is collected and fetishized. Since the artifact is manifested in the physical[1] world, why should the artist have more authority to define the meaning of an artifact than those subjects not privy to knowledge exposed within the realization→interpretation loop?

Some contemporary approaches to art practice reject this notion of artwork as expression of genius and break the

[1]The phenomenological assumption is that the physical world is a shared between subjects.

mythos of creativity by shifting the emphasis away from the artifact toward the process itself [5]. What is produced when the purpose of the work is not the creation of an artifact but an exploration of creative process itself? The creative process of the artifact-as-process includes not only the process the creator goes through, but also the process the artifact-as-process embodies. There are two products of this inquiry. The first is the artifact-as-process itself. The second is the knowledge that results from the artistic inquiry. This knowledge is manifested in the artifact-as-process and around it through documentation, rhetoric, sharing and discussion.

This artistic inquiry is centered on the artistic practices of responsive electronic media and site-specificity. For a survey of electronic media art see "Information Arts" [11]. The discipline of site-specific artwork aims to create work that gives "... itself up to its environmental context, being formally determined or directed by it" [7]. Minon Kwon [7] and Nick Kaye [8] provide a background on the site-specificity. Since the aim of this body of work is to explore the qualities of embodied creativity–through the development of artifacts-as-processes that find their own relationship to their context–it is only through artistic inquiry, as apposed to scientific inquiry, that this subject can be appropriately explored.

1.3 Embodiment

SOOS1 is an *embodied* system. It is realized as a physical structure in the physical world and is effected by the world it inhabits. Once embodied, the material–the software that encodes the system's process–ceases to be a representation and is executed in the physical context. The material shifts from the representation of a process to action in the physical world. This embodiment is informed by the phenomenology of Maurice Merleau-Ponty where the mind (realm of the concept / software) is not independent of the body (realm of the world / hardware). I apply Merleau-Ponty's rejection of dualism, in the mind-body, to the dualism between the creative intention (concept) and the meaning of the artifact.

Figure 1 represents the relationship between the physical world (white-space) and the subjective world (the point at the centre of the gradient) in the Mind-Body. Merleau-Ponty describes the relation between the physical world and the internal mind as the "flesh". The "flesh" contains both the mind and body[2], and in the author's interpretation, allows a causal connection between the mind and the physical world. There is no threshold that divides the mind and body, both the body and mind coexist but to differing degrees.

In order to unify the creative intention and the meaning of the artifact, the creator must be able to accept the artifact-as-process as it acts in the world, and encode ones intentions in a formal language[3]. The interaction between the software and the physical world is not totally deterministic–as it is in a simulated environment–the creator must relinquish control and allow the process to be driven equally by the software (thesis) and by the context (antithesis), the synthesis of which is the interplay between the encoded creative intention, and the embodied context of the artifact-as-process. This embodied process is the "flesh" of the machine, the mechanism that causally connects the physical world to the systems software. In the case of SOOS1, the entire project is dependent on the artifact-as-process acting beyond of the intentions of the creator.

[2]To even say the mind and body are separate is to assume Cartesian dualism. The phenomenology of Merleau-Ponty rejects this notion and refuses to see them as separate. The author uses these terms separately to express the problem, but not to accept a dualist perspective.

[3]In the case of SOOS1 the language is software.

2. GROWING FORM FROM CONTEXT

In order to have SOOS1 find its own relationship to its context–and since the umbrella of this work is about exploring creative processes–it is natural to look to cognitive science as a source for how an embodied entity can both relate to its context and act in a way that is not externally predetermined. For this project the most relevant application of cognitive science happens in the discipline of artificial intelligence which seeks to create software that exhibits some of the properties of human beings. In order for SOOS1 to find its relationship to its own context the use of unsupervised connectionist artificial intelligence approaches are appropriate, as the behaviour of the system is not dependent on an external knowledge-base provided to it. Since SOOS1 is an embodied system, the physical environment becomes the "training" data for the artificial intelligence.

2.1 Methodology of Artistic Inquiry

As this research project is contextualized as a primarily artistic inquiry, it is important to describe how the creation of these artifacts is approached. The software development process happens in an embodied context–the software is built up piece-by-piece while the system is connected to its context. The system's components are initially developed in isolation and attached to the rest of the system as early as possible. Software development occurs in two modes. The first mode will be an intuitive approach[4] that serves to get the basics of the system up and running–with arbitrary choices, random variables and placeholders–so that the system can be quickly evaluated in context. The second mode of grounded refinement involves going back over the results produced in the first mode, and removing arbitrary choices by situating them in theory. For SOOS1, the source of theory comes from two main sources; connectionist artificial intelligence, specifically Kohonen "Self-Organized Maps", and theories of creativity, specifically those present in the "Cognitive Mechanisms Underlying the Creative Process" [4]. Arbitrary and random variables are replaced by variables that refer to aspects of the embodied context. The software development happens in the Pure-Data visual programming system, where each step of development is managed by the subversion[5] version control system. Each iteration (change of software) is evaluated on two bases: Firstly, the creator's phenomenological experience of the behaviour of the artwork, and secondly the creator's phenomenological experience of the software development process itself.

2.2 Why use Artificial Intelligence?

In order to answer this question one must first define Artificial Intelligence (AI). A general definition from [1] states that AI is "part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in

[4]The intuitive approach involves the use of tacit knowledge in order to get a component functioning in the embodied system as quickly as possible.

[5]http://subversion.tigris.org

human behavior—understanding language, learning, reasoning, solving problems and so on." Although this definition does not directly mention creativity, Boden argues that machines can *"appear"* to be creative [6] in the same way that machines could be thought of as intelligent according to Turing. Stephen Wilson considers AI's relationship to art:

> Artificial Intelligence is one of these fields of inquiry that reaches beyond its technical boundaries. At its root it is an investigation into the nature of being human, the nature of intelligence, the limits of machines, and our limits as artifact[6] makers. I felt that, in spite of falling in and out of public favor, it was one of the grand intellectual undertakings of our times and that the arts ought to address the questions, challenges, and opportunities it generated.[10]

In this project I expect the system to be creative by it defining its *own* relationship to its context. Furthermore, I expect that the artwork makes creative choices that manifest themselves through the physical context of the work. AI is the only discipline–with its roots in cognitive science–that explores those questions of creativity through the creation of systems that embody aspects of the human mind. For this reason, AI is the first logical discipline to consider for technique and theory.

What techniques and processes from AI could allow an artwork to form its own relationship to context? To use non-AI software techniques, I, as the creator, would still be determining how the work relates to its context rather than it finding its own connection. Those AI techniques, such as self-organizing maps–that allow the system to reorganize itself based on sensor input–are a likely requirement to build the mechanisms for indeterminate contextual response.

3. SOOS1 ARCHITECTURE

The SOOS1 architecture is made up two interrelated mechanisms that work together to allow a creative response to the artifact-as-process's embodied context. The memory system is the mechanism through which the system stores its previous experience. The memory system is based on a Kohonen Self-Organizing Map which compares all of its previous experience to its current experience in order to situate current experience in terms of previous experience. On top of the memory system is an independent connectionist network. The purpose of this connectionist network is to allow a creative free-association to propagate through the memories and is based on the work of Liane Gabora [4].

The direction the camera looks at is currently controlled by a random variable which is seeded by the time. A new camera position is stimulated when there is no activity in the free-association system. The longer the free-association, the longer the camera will stare at the stimulus that initiated it[7]. Figure 2 shows an overview of the entire SOOS1 architecture.

[6]Note that Wilson's characterization of creators as "artifact makers" indicates that even in the technological arts that the object is the centre, rather than the process the artifact implements.

[7]This feature is a recent addition to the system. Previously, the stimulus that caused the camera to look at a new point in space was a fixed four-second cycle.

3.1 Memory System (SOM)

As the camera explores its context, the system creates a field of experience which is organized using a class of Artificial Neural Networks (ANNs), known as Kohonen Self-Organizing Maps (SOMs). The camera image is fed into the computer as a full-frame 30fps video stream. At four second intervals, the 12x12 node SOM is fed with a twelve pixel (4x3) RGB sub-sampled abstraction of the video stream. A SOM[8] associates each input image with a particular output[9]. The outputs can be thought of as categories of experience. When the outputs (categories) are plotted on a 2D Cartesian grid, the inputs are then represented as a "feature" map where images that are similar tend to move closer together and images that are dissimilar tend to get repelled. This organizes the experience into a series of regions that contain similar experiences that are separated from areas of dissimilar experiences.

Since the system is constantly experiencing its context, the SOM must be continuously training in order to incorporate new experiences into its structure. To accomplish this, both the learning and neighborhood functions–those functions that control the rate at which the self-organization evolves and is refined–are controlled by a cosine equation, scaled in order to range from 0 to 1, that operates on a cycle of approximately 42 minutes. The learning and neighborhood rates control how many nodes should be changed for each new input. In a typical SOM the learning and neighborhood rates start high–where each new input changes the weights of all the nodes–and slowly decrease; so, fewer and fewer nodes are changed by new stimulus as training continues. The learning rate eventually hits 0 when training is considered complete and the SOM accurately represents its training data. The approach of using cyclical learning and neighborhood functions allows for the SOM to respond to a continuous, and never-ending, flow of new data and still be able to effectively–though not always perfectly–sort it into a constantly reorganizing field of memory. Kohonen networks were intended to work on a finite data-set. By using a cyclical symmetrical function for the learning rate, which allows the integration of new experience, there is an equal amount of time the network is undoing its previous work (based on previous experience) as it is contributing to it (based on current experience). This is due to the learning rate increasing over time during some cycles rather than constantly decreasing. The effect of this is that the network moves between cycles of large (approximate) and small (refined) placement of items on the map. SOOS1 currently uses the same decreasing cosine equation for both neighborhood and learning rates.

A single unsubsampled image is stored for each node in the network, which is represented as a grid of captured images on one of the screens. The low resolution of the abstracted image, that is fed into the SOM, makes the system very poor at differentiating spacial relationships between images. A sharp image and blurry image are seen as identical to the SOM. Since the camera video stream is sampled each 4

[8]SOMs are usually presented with much more input patterns than they have outputs. This makes them ideal for visually representing high-dimensional data in a low-dimensional space.

[9]The output of a SOM is the BMU (Best Matching Unit) the BMU is the output that is most similar to a particular input.

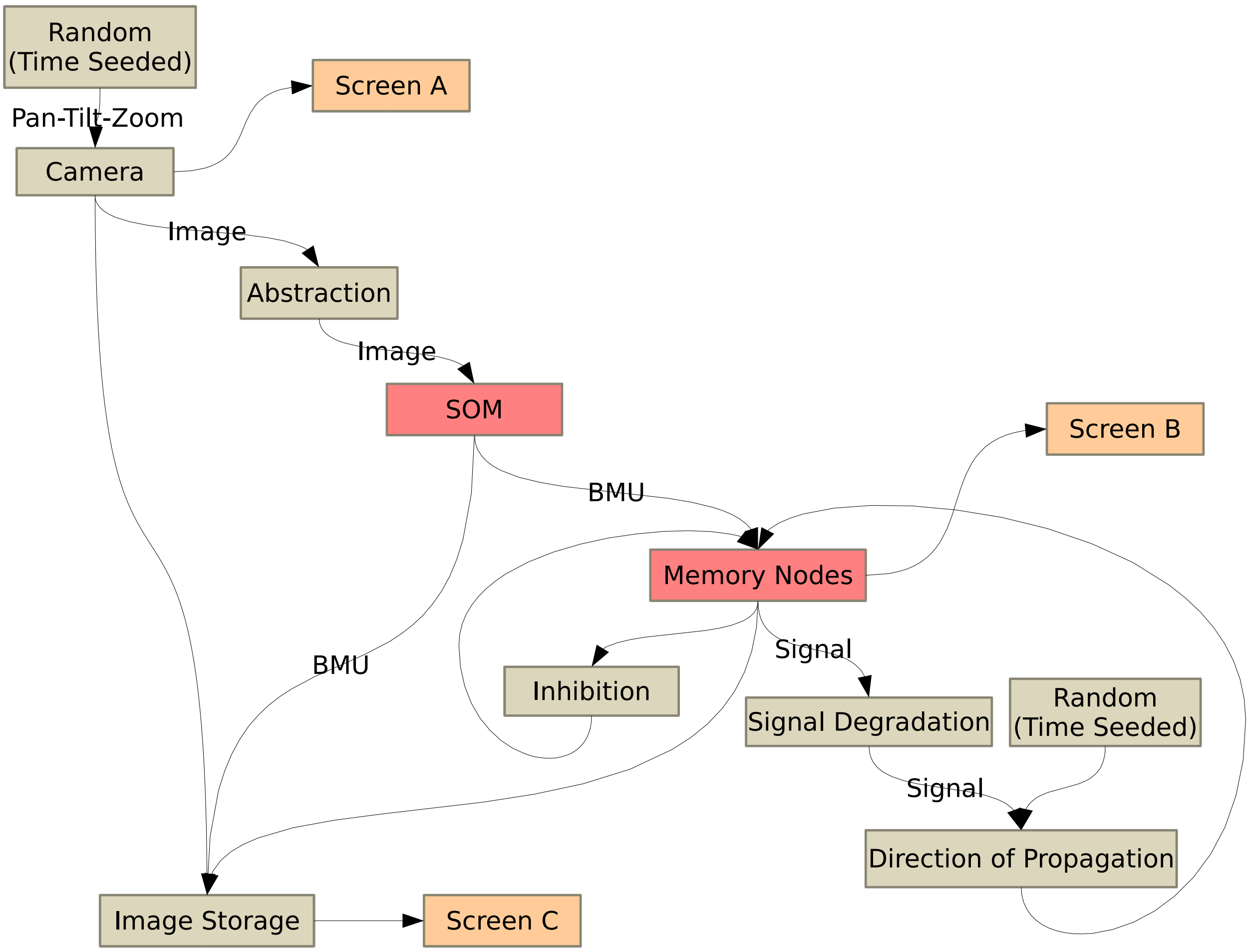

Figure 2: The System Architecture of SOOS1

seconds the 12x12 unit SOM is only able to store approximately 10min worth of experience. Since the SOM selectively replaces previous experience with new experiences–selected when the new experience is similar enough to the past experience that it fits in the same category–the memory is greatly increased for those experiences that are the most dissimilar to the most frequently occurring experiences.

3.2 Free Association System (Memory Activation Nodes)

Each time a new experience is perceived that perception sets forth a stimulation within the content of the memory, calling up similar experiences from the past. These new stimuli in turn stimulate other experiences, traversing the memory from the similar to the dissimilar. As the traversal progresses the energy in each stimulation decreases. Each subsequent experience is stimulated less than the previous one. As the free association traces a branching path through the systems experience the memories intersected by that path are visualized as a cinematic montage on one of the screens.

The model of stimulation and propagation is a custom connectionist network made up of Pure-Data abstractions. When the camera looks in a direction in physical space, but before its image is added to the SOM, the SOM node that most resembles that input is sent a signal which activates it. Each node that is activated chooses a range of directions at random in which to propagate the signal. As the signal is transferred to its neighbors it is decreased by a percentage so that the cascade of activations falls off proportional to the distance between the initial activation and each node. In addition when a node is activated it sends an inhibition signal to the node which activated it. For a temporal delay that node will not propagate any new signals. The inhibition and directional control of propagation was needed to keep the system from over-stimulating itself. Early implementations simply used up all the resources of the hardware only moments after the initial stimulation. This over-stimulation behaviour corresponds to seizure activity in the human brain.

The mechanism behind this process is inspired by the work of Liane Gabora on the “Cognitive Mechanisms Underlying the Creative Process”. Gabora’s theory considers creativity as a controlled form of free-association. The cascade of activations resemble how free association could work in the human mind. In Gabora's theory the network of memories is different in two ways compared to what has been implemented in SOOS1. Firstly, Gabora considers memory as sparse, whereas the SOM organizes content into an organized spacial grid where all nodes are associated with some input during training. Secondly, SOOS1 stores entire images whereas Gabora's model of creativity considers each memory node as micro-features of stimulus rather than as entire regions of stimulus.

4. MACHINE CREATIVITY

Boden defines creativity as "...the ability to come up with ideas or artifacts that are *new*, *surprising* and *valuable*" [6]. In my research domain the aspect of newness is the focus above surprise and value. As SOOS1 is meant to structure itself based on its embodied negotiation in its environment, newness comes from its ability to be different for each new context, as well as to change over time as its context shifts. The diversity and complexity of the real-world environment should guarantee that the system never receives an identical stimulus twice. The system should exhibit "surprise" only to the same extent as its context. The value of the project is not in its creative act, but in the process that makes it possible. Boden specifies three classes of creativity:

- Combinatorial creativity is linking together known ideas that are not already associated.
- Exploratory creativity is accomplished by moving through the space of possibilities.
- Transformational creativity is the alteration of the space of possibilities.

Combinatorial creativity is inevitable in a connectionist network that supports learning. This is because the shift of the unit weights changes the topology of the network, which is combining the stimulus from the inputs in various ways. Exploratory creativity is also present in these systems, since the space of possibilities is limited by the number of units in the network. In order for a connectionist network to exhibit transformational creativity it would have to be able to change the space of possibilities. SOOS1's current combination of the SOM and a model of free-association allow it to be exploratorally creative since the free-association traverses through its memory. At the very least the memory, at a snapshot in time, serves as the space of possibilities from which it can choose to be creative. Since the space of possibilities in the memory system is a constantly shifting field of experience SOOS1 is also transformationally creative through its ability to add to, and remove from, its space of possibilities over time. Due to this the same memory traversal (which is already unlikely to repeat itself) occurring at different times would to yield entirely different results. As the SOM is 12x12 grid of possibilities at a fixed moment in time it has a fixed space of possibilities. The use of an Adaptive Resonance Theory (ART) network would allow the memory system to create a new category for a new stimulus without effecting the categories of previous experiences. Then the space of possibilities would increase over time as the system gains more experiences.

Consider creativity as a two step process. Some generator, the kernel of creativity, creates a "new" stimulus. This stimulus then goes through a process of evaluation that filters all but the most "fit" ideas. In my case the generator for creativity is the context. Boden largely concentrates on the evaluation aspects of creativity and spends little time on the generator. Boden's conception of creativity in fact sets up an emphasis on the evaluation of creativity above the seed that makes it possible. In SOOS1 there is no mechanism that serves the role of the evaluator. That is not to say that SOOS1 should not be able to evaluate its own creativity, but that that evaluation should not be specified in advance but come as a result of its embodied process. It is unclear at this stage how context could provide criteria for evaluation. SOOS1 is a generator for creativity. Boden's argument can be summed up in one statement: A creation can only be considered "creative" if it has been successfully *evaluated* as such.[10] Of course these two steps are *both* required for a creative result. Emphasizing one over the other is to only create a partial model of creativity. Worse still would be to reduce creativity to evaluation since without the seed the mechanism of evaluation has nothing to evaluate. The result of the first step in isolation may not create something *highly* creative, but the result of the second step in isolation creates *nothing* at all. Without the evaluation the seed cannot produce something that is "new, surprising and valuable". The hierarchy is clear, creation (if not creativity), is the domain of the generator, not the evaluator. As a counter to most of the literature in the area I aim to put more focus on the seed of creativity as apposed to its evaluation. The long-term challenge SOOS1 aims to address is the possibility of a seed of creativity not based on randomness but on an embodied process. This aspect of the research connected with artificial life research which is tied to abiogenisis[11]. The seed→evaluation problem is analogous to a central concern of abiogenisis. Was it random fluctuations of early organic molecules, or some form of self-organization, or natural selection, or a process as of yet undiscovered, that made life possible? The theories in abiogenisis are a potential source of technical and philosophical ideas important to the creation of artworks that relate to their context and are not predetermined in structure.

4.1 Machines That are Intended to be Creative

This section will discuss a small subset of artistic projects that involve aspects of machine creativity. They are all systems that have been implemented in computer systems. These projects involve both connectionist and non-connectionist approaches.

One of the most notable examples of a "creative" machine are the AARON programs written by Harold Cohen starting in 1973 and continuing to the present. As a collective of programs AARON can "create" in a number of different painting styles. Each style uses a different variant of AARON which implements a different set of compositional rules. Some examples of these variants are "abstract AARON" which creates abstract landscapes, "acrobat AARON" which creates acrobatic figures, and "jungle AARON" that creates scenes of figures in a complex jungle ground that evoke Gauguin.

[10] For Boden the creativity is the result of the two-step process, so before the evaluation the "newness" should not be considered creative at all, but simply as an unclassified response.

[11] The study of the origin of life.

AARON programs contain sets of rules that encode specific compositional and stylistic rules that are specified by Cohen. Each element in the paintings–the figures, grounds, and objects–is each a representation of the model those rules encode. These rules are chosen by the system based on weighted randomness[3] and applied to create paintings that are drawn by a robot. AARON has no feedback of the results of its actions on the canvas as is then totally blind. Due to this the painting has no effect on AARON's internal structure and therefore the system is not embodied and exhibits the ultimate example of modernist creation where the internal model (concept) is realized in that perfect theoretical vision–regardless of the actual properties of the artifact in the world–and there is no interpretation of the artifact in the machine's creative process. This fact shows AARON to be an extension of the modernist conception of the artistic genius. I would argue it could only be considered creative in a symbiotic relationship with *its* creator. Cohen believes that this software system is a natural approach to art-making because artistic composition is rule-based. While I can agree that graphic composition in a certain particular style of painting can be considered rule-based It does not follow that all aspects of artistic creation are. The AARON software exhibits combinatorial and exploratory creativity, but not transformational creativity since it is unable to compose any choice that has not already been defined by rules specified by Cohen. Further without an ability to perceive the results of its action in the world it will never be able to reflect on its own process.

In 1981 David Cope started writing "Emmy" or "Experiments in Musical Intelligence" in order to deal with a creative block in his own composition. The project started as an effort to automate the compositional process, by using the style of Cope's own compositions to date. The software uses a variation of Augmented Transition Networks (ATNs) which were created to model the syntax of natural languages. He used this as a basis of a system that models the structure of musical compositions and creates "signatures" from the common aspects of multiple compositions. These signatures are then used in a second process to combine the elements of the signature into a new work that exhibits the style of the source composer. Clearly using combinatorial creativity the software recombines the structures it sees in source-work. Since the space of possibility is limited to the "signature", created from data, the system is unable to perform exploratory or transformational creativity. The system is also only fed abstractions of compositions as source material, and is unable to perceive, let alone evaluate, the results of its processes.

David Rokeby has created two works that can be considered creative. "The Giver of Names" was first exhibited in Toronto, Canada in 1997. The system perceives the outside world through a video camera pointed at a pedestal. The floor around the pedestal is scattered with children's toys the audience is free to place in the camera's view. The software attempts to give names to the objects in its view. Associating the colour and shape with concepts in its knowledge-base the system creates a free writing passage inspired by those objects. The system certainly shows combinatorial creativity by pulling words from its relational database to create texts. It is unclear if the system exhibits exploratory creativity since it is unclear if its network of associations change in response to experience. Further the choice of where to begin within the associative database is not a result of agency in the system.

"n-Cha(n)t" was first installed in 2001 in Banff, Canada and builds on some of the ideas of language and interpretation that are embodied in "The Giver of Names". "n-Cha(n)t" is a cluster of independent systems that are connected in what could be considered a connectionist network through ambient audio. Each of the nodes is able to both hear[12] and speak[13] by accessing a relational database similar to the one used in "The Giver of Names". The hearing process attempts to interpret sound from a microphone input and translate it into text. When the system recognizes a word through the hearing process it is then passed onto the speaking process where a voice synthesizer recites it aloud. The hearing apparatus is a highly directional microphone that picks up only sounds nearby. Without any external interaction all nodes chant the same word over and over again, each node picking up the sound from other nodes forming a reinforcing pattern. When a sound from the non-local environment is heard, the nodes differentiate as each hears, and speaks, a different interpretation of the fluctuating environmental sound. Without further interference one of the interpretations takes dominance and eventually all nodes are repeating that dominant pattern. Both "Giver of names" and "n-Cha(n)t" are embodied systems that are both attached to the physical world through sensors that allow it to respond to their context. Going further "n-Cha(n)t" attempts to realize (through speech) and interpret (through speech recognition) the results of its collective action and therefore shows an example of embodied creativity.

George Legrady's "Pockets Full of Memories" was made possible by a commission from the Centre Pompidou Museum of Modern Art in 2001. Revised versions of the project were revisited in 2003 and exhibited in the Dutch Electronic Arts Festival in Rotterdam, Netherlands. "Pocket's Full of Memories" is one of the few artistic projects that makes use of a connectionist network. Specifically the system uses an implementation of the the Kohonen SOM to organize content provided by the audience. The installation consists of a large projection and a number of kiosks with flat-bed scanners. The audience is encouraged to scan an image of some artifact in their possession. The kiosk then prompts the participant to answer questions about the meaning of the artifact. The answers to those questions are then stored in a database bound, as meta-data, to the images from the scanner. This meta-data is fed into the Kohonen network which plots the images in a projection. The position of the artifact in the projection is a result of the categorization process of the Kohonen network. Artifacts attached to similar meta-data are plotted closer together than artifacts with dissimilar attributes. The Kohonen map used in this project is a collaboration between George Legrady and Dr. Timo Honkela, who conducts research into artificial systems to study cognitive processes.

5. CONNECTIONIST APPROACHES TO ARTIFICIAL INTELLIGENCE

In "A Brief History of Connectionism" [2] Medler traces the roots of connectionism from Aristotelian associationism

[12]"Hearing" is accomplished using a microphone and voice recognition

[13]"Speaking" is possible through speakers and voice synthesis.

to contemporary connectionist research. Connectionism is a revision of some ideas rooted in empiricism and associationism. Both associationism and empiricism consider the role of the environment as integral to human behavior:

> Empiricism emphasizes the role of culture, education and life experiences as determinants of human abilities and proclivities, while associationism identifies pairwise links between individual elements of experience, either subjective or behavioral, as the main process of such psychological change. [9]

In terms of the importance of context these roots of connectionism are methodologically compatible with my research interests. Connectionism in the contemporary sense, coined as “New Connectionism” by Thorndike, “is characterized by computationally powerful networks that can be fully trained” [2]. These networks act as both “. . . very powerful information processors. . . ” and as “. . . arbitrary pattern classifiers” [2].

Connectionist systems are networks of simple units that combine to form complex structures that act as Parallel Distributed Processors (PDPs). Connectionist networks are inspired by human neurophysiology.

5.1 How Do Connectionist Approaches Relate to this Project?

The central purpose of this research program, to allow artworks to define their own relationship to context without the creator defining them a priori, closely fits with connectionist approaches according to Walker:

> The recent origins of PDP are in "random self-organizing networks" and its goal frequently seems to be to account for perception with the minimum of innate preconditions. [9]

PDPs are “random self-organizing” in that the units are interconnected to a degree defined by a “weight” associated with each connection. The structure of the network is changed by the adjustment of the weights. The change of weights results in some units to be connected to a greater extent than others. Often initially randomized the weights are then tuned through a training process. The training process allows the network to learn by associating certain inputs with certain outputs. The memory system in SOOS1 is then a pattern classifier that aims to organize experience by classification. A connectionist model is also used in the free association module where the network is a medium through which signals are propagated. The nodes in the free association module are all connected to the same degree.[14]

6. CONCLUSION & FUTURE WORK

SOOS1 is the first in what I hope to be a long and varied body of work. The system is, at the time of writing, running in a long-term installation at Simon Fraser University where it will remain the platform of development for the author’s thesis work. This stage of development concludes the first phase of intuitive development. The next stage will be to reflect on the behaviour of the system, and using that knowledge go back through the software to reconsider the arbitrary and intuitive choices.

Short term goals for SOOS include increasing the size of the SOM (above 12x12 nodes) as a method to increase the short-term memory of the system. I will also explore how much data it is practical to send into the SOM beyond the 4x3 pixel image so that it is able to make a more fine-grained assessment of the relation between experiences. The free-association model needs to be reevaluated. At this time it is possible for a memory stimulation to activate only a single node, without that signal being propagated through the network, due to the random direction of propagation. In order to make the free-association model more closely resemble neuron function there needs to be a reinforcement of patterns that are often propagated through the network. Using such a model could be a hint to an approach for memories of creative experiences since the more often a particular node gets fired from a particular neighbor the more easily it would be able to do so in the future, which would store a particular pattern of free-association in the network.

The medium term goals are to remove the arbitrary and random variables, and replace those with variables from the sensed environment. The random variable that controls the direction of the camera should be connected to some, as of yet undetermined, result of the free-association. Then the choice of what the next stimulus, to the network, will be a result of the previous stimuli of the network.

In the long-term the SOOS installations are intended to become permanent and self-sufficient. This brings a whole range a new issues from a physical embodied stand-point to keep the installations up and running in the long term. By self-sufficient I mean that the installations should not be dependent on outside infrastructure, power nor telecommunications.

This exploration of embodied creative machines is highly suited to the use of connectionist approaches to artificial intelligence. In particular unsupervised PDP networks are ideal as they are literally design to change their structure in response to sensory input. These methods make the goal of creating systems that respond to their context without being depending on a priori knowledge possible.

[14] Future versions will have individual connection weights defined by the environment.

7. REFERENCES

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