Memory Association Machine: Growing Form from Context

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ABSTRACT

This text is a summary of the realization and interpretation of the autonomous responsive electronic media artwork "Memory Association Machine" (MAM). Realization and interpretation are components of the creative process that braids conceptual, site-specific, electronic media art and artificial intelligence practises. MAM relates *itself* to its context using three primary processes: *perception*, the *integration* of sense data into a field of experience, and the *free-association* through that field. MAM perceives through a video camera, integrates using a Kohonen Self-Organizing Map, and free-associates through an implementation of Liane M. Gabora's model of memory and creativity. These processes are as important as MAM's physical appearance, are composed of computational elements, and allow the system to respond to context autonomously.

1. INTRODUCTION

"Memory Association Machine" (MAM) is an autonomous responsive site-specific installation. [1] The artistic practise resulting in MAM is less a drive for personal expression, and more a way of understanding the world—a method of asking questions, and imagining the possible. MAM is composed of a collection of computational processes that are considered the material of the artwork. By focusing the research on MAM's process, artistic authorship, the art object and its context are reconsidered.

The initial drive for the project was to create an autonomous system that would be capable of creating its *own* relationship to its physical context. In order for MAM to be creative, its development is approached through a braided practise. The research, pictured in Figure 1, combines artistic practises with computational techniques from artificial intelligence that are informed by creativity theory. The context of production, pictured on the left, nourishes the research. The physical traces of that knowledge are pictured on the right. Realization is the process of manifesting the context in tangible artifacts. Interpretation is the reconsideration of these artifacts in light of the context. This Realization→Interpretation formalization has resulted from the artistic practise.

[1] For more information on MAM and its research context, see [4, 5].

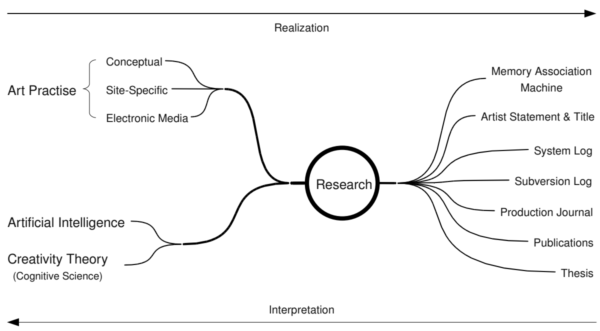

Figure 1: The braided practise and its major components. Research is the connective tissue that relates the contextual, theoretical and conceptual ideas that have informed it (on the left) to the physical traces of the research (on the right).

2. CONTEXT

2.1 Artistic Practise

A number of contemporary artistic practises are concerned with the deconstruction of the relationship between the artwork and the author. This research braids the practises of conceptual, site-specific, and electronic media art. The essence of conceptual art is that "[i]deas can be works of art; they are in a chain of development that may eventually find some form. All ideas need not be made physical" [11]. Just as the site of conceptual art development happens at the level of the concept, the central development of MAM happens in software, which encodes the artistic concept.

Site-specific artwork gives "...itself up to its environmental context, being formally determined or directed by it" [10]. Such artworks are often installed in a public setting and refer to elements of that site. The relationship between the site-specific artwork and its context is activated in MAM as the artwork collects impressions of its context to be used as material in its own creative process.

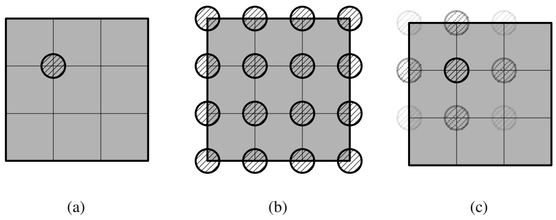

Figure 2: Types of Memory Distribution. Non-distributed memory (a) stores each stimulus, the hatched circle, in a single location. Fully distributed memory (b) stores each stimulus in every location. Distributed, but constrained, memory (c) stores each stimulus, to a degree, shown as transparency, in a limited number of locations.

The essential character of electronic media art, also known as "new media" [12], and "information art" [16], is that the material of the artwork is, or depends on, a technological apparatus. [14] describes the nature of generative electronic media artwork: "…[A]rtists create artworks that are not intended to be an extension of the interactor; their creations are essentially self-motivated and autonomous. These automata survey and maneuver through their environment, of which the spectators are only one aspect." As MAM is realized in computational form it cannot be considered outside of the tradition of electronic media art.

2.2 Creativity Theory

Is it possible for a machine to be creative? [2] argues that machines can be *"considered"* creative in the same way that machines can be thought of as intelligent according to the "Turing Test" [15]. [1] states that "[c]reativity is a fundamental feature of human intelligence…". Creativity is an integral part of the human mind and not just of intelligence. The major influence on this research is the model of creativity proposed by Liane M. Gabora [7, 6, 8].

The design of the processes that relate MAM to its context are directly inspired by "The Cognitive Mechanisms Underlying the Creative Process" [8]. The foundation of this theory is that a creative "thought process" can be broken up into a number of incremental associative steps. Each step may be an obvious association, but when chained, a seemingly unpredictable meta-association emerges. The key to Gabora's theory is a model of human memory characterized by three features: memory is content addressable, distributed (but constrained), and sparse.

Memory is content addressable as the stimulus is organized by its content. The location of a memory with certain features is already known, as features are mapped directly to locations. In distributed (but constrained) memory, each location corresponds to multiple memories, each to a varying degree, as pictured in Figure 2. A memory can be retrieved even if its properties are a partial match. The distribution of memories reflects the sparse distribution of the properties of the stimulus.

3. THE SYSTEM

Figure 3: Installation of MAM for the 2007 Pure Data Conference. The left display shows the current stimulus—a feed directly from the camera in the upper left. The centre display is a visualization of the field of experience. The right display is a cinematic montage representation of the process of free-association.

A photograph of MAM[2] is pictured in Figure 3. Visualizations of MAM's processes appear on the installation's three displays. The camera's sensor impressions (images) are presented on the left display. The system's integration of remembered sensor impressions is visualized on the centre display. Both the centre and right displays present the process of free-association. The centre display visualizes the activation of memory locations while the right display presents a cinematic montage that reflects the sequence of free-association.

MAM is autonomous in that it operates without the need for an interactor. The system is responsive as it is continuously collecting sensor impressions in order to change its appearance. MAM is site-specific as the system's appearance results from its negotiation with context. This negotiation is enabled by the artist's encoded intention. This mechanism is composed of three parallel processes: *Perception*, the *integration* of experience,[3] and the *free-association* through the field of remembered experience (memory). These processes allow the system to consider elements of its context in relation to one and other and originate associations between those elements.

MAM is composed of two primary subsystems: the "Memory System" and the "Free-Association System". These systems correspond to the processes of memory integration and free-association. They are independent networks of numerous identical units. In addition to these systems is a storage area that archives collected sensor impressions. Figure 4 shows an overview of the system's major components. Each sensor impression is sent to the left display, the abstraction mech-

[2]This version of the project was exhibited under MAM's former title "Self-Other Organizing Structure #1" (SOOS1) [3].
[3]An experience is the result of perception considered in light of memory.

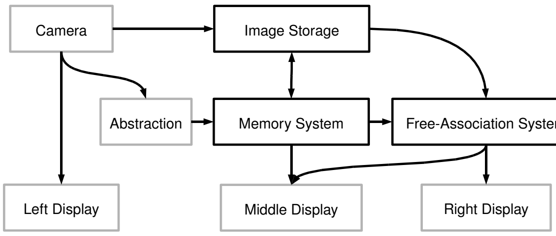

Figure 4: The Architecture of "Memory Association Machine"

anism and image storage. Abstraction feeds a sub-sampled version of each sensor impression into the Memory System.

During the day the system explores its context by sending random pan/tilt/zoom commands to the camera. For each fixation,[4] a sensor impression is grabbed and a unit of the free-association system is activated. This perturbs the memory field and results in a cascade of associative activations in the system's previous experience. Sensor impressions are not collected at night. At a fixed interval a random element in the memory field is activated, leading to free-associations not initiated by context.

The interaction between the memory and free-association networks generate the system's appearance. The Memory System stores and integrates MAM's sensory impressions using a Kohonen Self-Organizing Map (SOM) [9]. The SOM is an artificial neural network (ANN) that classifies arbitrary input patterns. In the case of MAM these patterns are sensor impressions, which are classified in relation to remembered experience.

The Free-Association System is a network of simple units that are independent of the SOM. This network allows activations to propagate between units and is similar to a cellular automata. The activation of units selects sensor impressions from the system's memory. These selections are an emergent result of the system's negotiation with its context.

3.1 Self-Organizing Maps

A SOM is an unsupervised ANN, an AI approach inspired by neurophysiology, designed for classification. An unsupervised ANN is able to classify inputs without the benefit of any information provided to it.[5] These networks restructure themselves in response to the input patterns presented during training. ANNs are characterized by being composed of numerous simple components, inspired by neurons, which are massively interconnected.[6] In mathematical terms, the SOM is a non-linear projection of a high-dimensional data-space onto a low dimensional "feature-map" that preserves topology. A SOM is able to categorize an arbitrary input pattern, with a finite number of dimensions, into a finite and

[4] A fixation is the moment the camera has reached the requested pan/tilt/zoom position.

[5] A supervised ANN learns by example. The correct answer is required for the network to learn.

[6] For a survey of ANNs see [13].

Figure 5: The representation of the field of experience.

fixed number of categories. The SOM is a projection as it maps sensor impressions from input space onto categories in output space. The memory locations of a SOM reorganize themselves in order to best represent the topology of the stimuli. Once the SOM reflects the topology of the input, similar inputs are associated with categories that are nearby in the feature-map.

3.2 Memory System

As MAM explores its context, the SOM integrates sensor impressions into a field of experience. The field is a feature-map representing the topology of the system's remembered sensor impressions. Once the SOM has determined the category of a particular sensor impression, it is stored in the corresponding storage location. If more than one impression is associated with the same category, the most recent replaces the existing impression. As a result, the memory for unusual impressions is longer than for common impressions.

The memory field is represented as a Euclidean lattice as pictured in Figure 5. Memories are represented as circles with Gaussian alpha channels. The "feathered" edge allows each memory to blend with its nearby neighbours. As a result, the topology of the impressions takes precedence over the structure of the lattice.

In MAM, the SOM is being trained continuously to incorporate new experiences in its structure. Normally a SOM is trained on a finite data-set and reaches convergence when the network reflects the topology of the input patterns. In MAM, the SOM is constantly converging, but is not meant to, and cannot, reach convergence. Allowing the SOM to converge implies that its process of relating to its context could be complete. Continuous training is enabled by cyclic functions that control the rate at which the self-organization progresses. They allow the SOM to respond to a continuous flow of new input patterns and integrate them into a constantly reorganizing field.

The relatively small number of units in the SOM—combined with the complexity of sensor impressions—results in a mem-

(a) Random Distribution

(b) Feature-Map Distribution

Figure 6: Comparison of the random association of sensor images to units (a) and feature-map trained using the MAM method (b).

ory field that is often interpreted as unorganized. The training method used in MAM results in a more complex, but not unorganized, feature-map. In Figure 6 (a), units are associated with a uniformly distributed random selection of images. In (b), units are associated with images using MAM's SOM. The structure of the memory field has a quality very different than that of evenly distributed randomness.

3.3 Free-Association System

The free-association is a traversal through MAM's field of experience. Figure 7 (a) shows a 5x5 lattice of free-association units. Each free-association unit corresponds to a stored memory. The purpose of the free-association network is to propagate activations to select stored memories. As the memories are organized by similarity, nearby free-association units are associated with similar sensor impressions.

For each camera fixation, the SOM selects the memory most similar to the current stimulus, which activates the corresponding free-association unit. This is pictured in Figure 7 (a) where unit 17 is activated. The activation then propagates through the network—selecting memories to varying degrees. Each step in the free-association selects memories that are similar to one and other, but where the similarity between the initially activated memory and subsequent activated memories decreases. The degree of activation falls off proportional to the distance between the initial activation and each unit receiving it—represented by the shading of the units in the figure. The direction of propagation is randomly determined. Once a unit has been activated it becomes inhibited. It will not propagate any signals for a fixed duration. The inhibition and directional control of propagation are required to keep the system from over-stimulating itself.

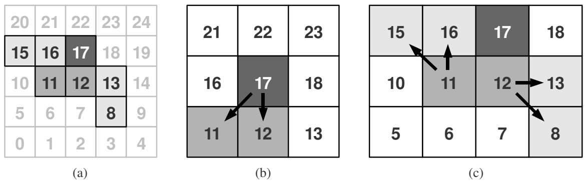

Figure 7: The propagation of free-association signals. Figure (a) shows a 5x5 lattice of free-association units. Unit 17 is activated by external stimulus. Unit 17 passes a degraded signal to units 11 and 12 (b). The signal is further degraded and passed to units 15, 16, 8 and 13 (c).

The cinematic montage represents the sequence of activated memories. The mechanism displays four sensor impressions simultaneously. As the free-association signal propagates through the network, the units' IDs and degrees of activation are stored in buffers—in the order of activation. For each item in a layer's buffer the corresponding sensor impression is retrieved, faded in, held for a duration, and then faded out. The sensor impression is visible for a duration, and with an opacity, proportional to the unit's degree of activation. The result is a montage of cascading sensor impressions—starting with similar and brighter images that are visible for longer. As the activation decays dissimilar impressions become more transparent and are visible for shorter periods.

4. CONCLUSION

MAM has been developed through a braided practise that combines computational processes from AI with creativity theory, where the goal of the research is the construction of a site-specific artistic work. MAM is contextualized within conceptual art as the artistic concept is of central importance, and implemented in the system's software, which places MAM in the tradition of electronic media art. The relation between the site-specific artwork and its context is made responsive and autonomous as MAM relates *itself* to its context. [8] provides a model of human creativity that serves as the basis of MAM's Free-Association System.

MAM relates to its context using three parallel processes: Firstly MAM perceives its visual context through a camera. These sensor impressions are integrated into a constantly

shifting field of experience through the use of a Kohonen Self-Organizing Map. MAM free-associates through these experiences by tracing the stimulus' perturbation of that field using Gabora's model. Each of these processes is visualized on the corresponding display arranged in a triptych. The combination of the SOM and model of free-association is a novel method of organizing and relating the constantly changing external context of a site-specific artwork.

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