EIDEA

AN EMERGENT INTERACTIVE INSTALLATION

ENVIRONMENT FOR THE INTERACTIVE DESIGN OF EMERGENT ART

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Abstract

The EIDEA project evolved out of the movement sensing research conducted at Arizona State University's Institute for Studies in the Arts. Described is a system that combines the emergent phenomena associated with artificial life and real-time local weather input to create an autonomous interactive installation. A multi-channel sound environment provides a direct link between the movement of the life forms in the artificial world and current local weather information. A visual mural is produced by the artificial life world representing a composite of the creatures movements and interactions. Current plans will link these elements enabling the viewer to interact directly with the aural and visual elements of the work.

The EIDEA installation is created to explore emergent phenomena commonly associated with artificial life systems by means of an interactive sound and image installation. The work occupies a space of approximately 20 feet square, completely enclosing viewers. It is possible to visually navigate through the artificial world and its associated soundscape or choose to "travel" through a three dimensional image of life form paths that trace the movement history of the cyber-entities over time. The A-life aspect of the work is created to explore the possible interactions between life forms in the artificial world and between external influences such as local weather and viewers. The local weather has a subtle influence on the life forms, affecting their on-going life processes, while current plans allow for the viewers to navigate through this artificial world by means of a movement-sensing system designed by Lovell and Mitchell[1]. The life forms can be sensitized to the viewers presence, and ultimately fashion a response to the presence of people in their world. The work will be described in its four parts; the artificial life world itself, the sound generation mechanism, the weather station, and the role of the viewers or interactors.

Description

A–LIFE

The artificial life world at the core of EIDEA exists as a mathematical plane floating in a vast space. Three artificial entities exist on this plane (referred to as birds, wolves, and trees) and interact to form a closed ecosystem[2]. Trees, formed by a simple L-system[3], grow slowly and over time bear fruit for the birds and wolves to eat. The L-system grammar consists of branch lengths and angles out to a limited length creating a "fractal" shape. Birds consume the fruit of the trees, move in a flocking fashion, and breed to create offspring that then join the flock. The cyberspace predator, a wolf-like creature called a turoid (after computer scientist Allen Turing), feeds on the birds and has its own breeding and life cycle.

Breeding is accomplished in a cycle of mating, gestation, and birth. The two creatures involved in mating must be willing participants. If one of the creatures is pregnant already or if an excitation factor (which grows over time) is too low, they will not mate. (Thus the excitation factor is reduced upon completion of the mating ritual.) Once two creatures have mated, one or both of the creatures can become pregnant. This is determined as a probability based upon the creatures fertility and constitution. Length of pregnancy varies also according to a "chromosome" and at birth a new creature is created which represents a composite of the parents. A crossover point is generated combining both parent's genes and during the process, some genes may be randomly mutated in order to maintain diversity. Occuring at a very low probability, (on the order of one in 100 births) gene mutation is used as part of the genetic world model to maintain adequate genetic diversity. Without this mutation all the animals would tend toward a single genetic makeup.

Artificial life is a study into the inner workings of nature through the use of technology. The earliest tool technologies allowed man to manipulate the world around him to alter the natural order to suit his purposes. However, some things about nature can't be modified, only tested, observed, and modeled, allowing predictions to be made about the outcomes of particular events such as the advent of floods, or the change of seasons. In the past, artists used simple technologies to recreate nature, using music, painting, dance, and sculpture to capture the static or semi-static forms of living things.

Early technology, including pneumatic devices such as floats, siphons, and the water-wheel, were used by the early Egyptians in Alexandria to model time and create gadgets in the shape of animals. Later, with the invention of the mechanical escapement and the pendulum, artifacts consisting of complex behaviors allowed for a more precise modeling of time. As technology improved, man's models of nature progressed and became more complicated. Over time, more and more complicated mechanical systems were devised such as levers which converted circular motion of a cam into linear motions. This provided the means for the creation of complicated mechanical automata which looked and acted like real animals or humans. An example of such an animal is Jacques de Vaucanson's duck, circa 1735, which was described as "an artificial duck made of gilded copper that drinks, eats, quacks, splashes about on the water, and digests his food like a living duck".[4] One wing of the duck contained over 400 articulated pieces.

Finally, with the invention of the multipurpose modeler, the computer, and the formulation of the notion of an algorithm being the logic underlying a model, regardless of the model's physical manifestation, (Church, Kleen, Gödel, Turing, and Post), allowed the blooming of the modern incarnation of Artificial Life. John von Neumann was on of the first pioneers to formulate a computational approach to the generation of lifelike behaviors. His idea was to formulate an automaton capable of reproducing itself and he proved that machines could be formulated with the capability of self-reproduction [5]. Many other experiments have been carried out since that time which recreate elements of life as computer models. Cellular automata, L-systems, and genetic automata are some of the technological tools of the artificial life modeler. This tremendous advancement in the technology used to observe nature has given the artist the capability to not only represent nature in static states, but to recreate it dynamically.

In EIDEA, life forms breed through a process of natural selection. Each form has a genetic make up which determines how well it survives in the environment. A set of behavior genes are assigned values to determine how well or to what extent each animal can accomplish living tasks. As animals mate and their genes are combined, their characteristics are passed on to future generations. Less fit animals tend to be unable to breed and die off because they do not have the tools to survive. Death can occur from aging or from being consumed by another animal, so that animal behaviors adapt over time to environmental conditions.

The behaviors, or in this case movement of the life forms, are modeled to give them unique characteristics. Animal motions are determined through two types of algorithms: a flocking algorithm for bird motion, and an inherited Turing program for wolf motion. Each bird has ten chromosomes which determine its movement capability: eyesight, dexterity, maximum number of other birds that can be tracked, fleeweight, veerweight, follow weight, maximum speed, and acceleration. The flocking is achieved by the bird's instinct to stay close to other birds and yet avoid objects. Birds are also bred to avoid predators (wolves), and fly close to the center of their group. Two global constraints are also imposed upon bird movement; the birds must stay within the boundaries of the world and stay above or on the ground. Because the birds are not given any instructions about where to fly but rather are given ways to behave, they develop a collective behavior of moving about the world as a flock. The algorithm used is similar to an algorithm invented by Craig Reynolds in 1989 that produces flocking type motions.[6] Specifically, each bird keeps track of where two to five birds in its immediate area are located. (The number of birds tracked depends upon the birds perception gene.) If a bird falls behind the center of its group of birds it accelerates; if it gets ahead it decelerates. Each bird is always moving toward the center of a local group. But should some external object come to the birds attention, it modifies its motions by including a desire to move away (or toward, depending on whether the object is food) the external object. The two motion vectors, flocking and external object avoidance are added together to produce a composite motion.

Wolves, on the other hand, are much more independent, moving alone and in a pattern specified by their own genetic code. They move according to an inherited Turing program, which consists of a list of motions and an ordering of those motions. In 1936 the British mathematician Alen Turing created a theory describing the simplest type of computer [7]. In the theory this computer, although simple in construction, was able to produce any computation. The machine consists of a tape of memory cells and a processing unit called a head which can move up and down the tape storing or erasing a 0 or 1 on the tape according to a list of instructions called a program. Eidea uses this same concept for the motions of the wolf like life forms. A wolf's Turing program consists of a finite list of quintuples of the form <current state, read color, write color, new state, move direction>. Instead of a tape, a plane is used for the storage device and instead of only forward and backward motions, turns are allowed. In addition, the number of states possible is expanded from 0 and 1 to hunt, sleep, eat, mate, and explore. Each wolf has part of its genetic code dedicated to describing the possible motions for that wolf to use. Wolves are also required to stay away from the edges of the world, above ground, and wolves are not able to fly. Each generation of wolves produces new movement programs which are composites of the parent's programs so that the movement algorithms of wolves evolve through natural selection. As wolves breed over time and more fit algorithms are combined, their strategies for surviving adapt.

Sound

The sound generation mechanism consists of a pre-sampled palette of sounds used to create a sound space. This is done partially through the use of a non-linear chaotic function, $x_{i+1}=rx_i(1-x_i)$, which Mitchell Feigenbaum used to while formulating his theories on chaos while working at Los Alamos.[8] This function is interesting in the interval where r is in the range from 0 to 1 and chaotic when r is > 0.86. To generate a series of notes, an initial x value is fed into the equation and a new x is generated. This x value is then scaled to match an audible pitch in a 48 tone per octave tuning system and played. The new x value is then fed back into the equation generating a new note. The process continues at a certain metronomic rate creating a melodic line. During the feed back cycle, values for metronomic rate and the r constant can be changed forcing the function to travel into new chaotic fields and structures. In the EIDEA system, several chaotic functions playing various sample instruments are used to create a thick texture of complex interactions. These functions are made more complex by linking various sound parameters to real-time weather data as described below.

The music sound-space is controlled by both weather events and statistics from the artificial world. Specifically, the locations of one of the bird flocks controls the location and the balance of particular sounds in the multi-channel sound system. Thus, an observer can hear the sound moving from one side of the room to another following the birds around their environment. Population statistics of each of the colonies are used to add instruments to an on-going orchestration. As breeding outpaces dying, the sound score becomes increasingly more complex. If dying is greater than breeding the reverse is true. The remainder of the score is based upon current weather information including temperature, relative humidity, barometric pressure, wind speed and wind direction. These elements are mapped directly to the sound generation algorithms, created in MAX[9], and act as a looking glass by reflecting the cycles and patterns of the local weather then translating these cycles and patterns into aspects of the soundscape. It is possible for the viewer to literally hear changes in temperature, humidity or barometric pressure. The multi-channel soundscape, generated from a combination of external weather data and statistical information from the cyber-world, then becomes an intermediary or crossing point between cyber reality and the natural or outside world, placing the viewers at this nexus.

Weather

A weather station links the computer-generated life forms to local temperature, wind speed, wind velocity, barometric pressure and relative humidity. In the same way that cosmic forces influence the weather of the earth, and eventually our own day to day existence, local weather has an impact on the behavior of the cyber-entities and on the development or evolution of their world. It is possible to see our weather cycles, such as the regular temperature fluctuation in a 24 hour period, as epochs or eras of the artificial world's evolution. The weather of our outside world influences the behaviors and abilities of the creatures in the artificial world where wind velocity, for example, causes the birds to have some trouble flying, actually blowing them around at times. Creatures hunt and eat more during warm periods, and more breeding occurs during cold. These changes, of course, also provide a secondary effect upon the sound score.

Viewers

Viewers can interact with the installation in two very direct manners. A three dimensional electronic mural records the movement of the life forms in the world, providing a history of their activities. Constructed as a record of the motions of the animals math space, the mural results from recording the paths of the life forms and then sampling a set of images based upon their genetic makeup. This image, updated continuously, reflecting the evolution of the life forms, their genealogy, and showing how the different movement strategies develop. Viewers can move through this image by changing their position in the installation, or they can choose to explore the artificial world directly. The EIDEA artificial life environment is displayed in real-time, continually showing the movement, growth, birth, and death of the creatures within. Current plans include using the Virtual Sensing Environment[1] to connect viewers to the artificial world. By displaying one half of the EIDEA world on each side of the viewer, we hope to provide the viewer with the experience of actually being a part of this artificial environment.

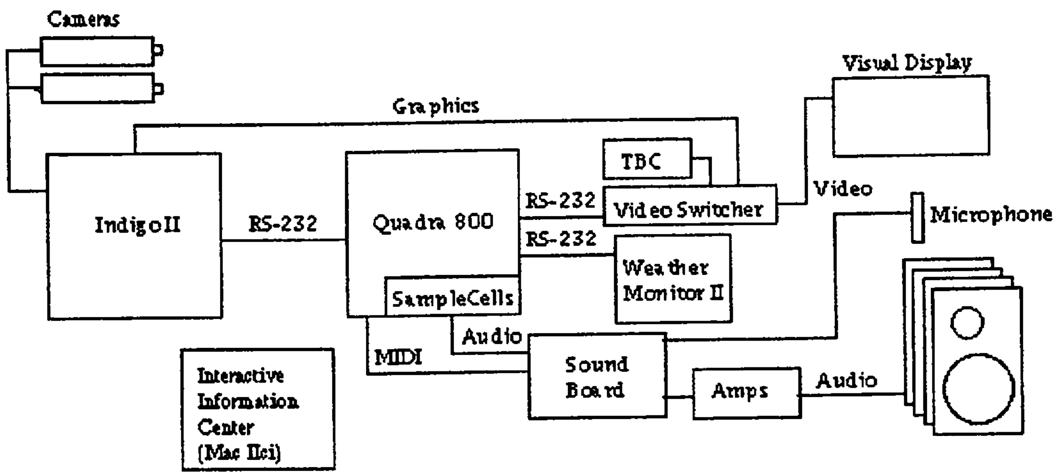
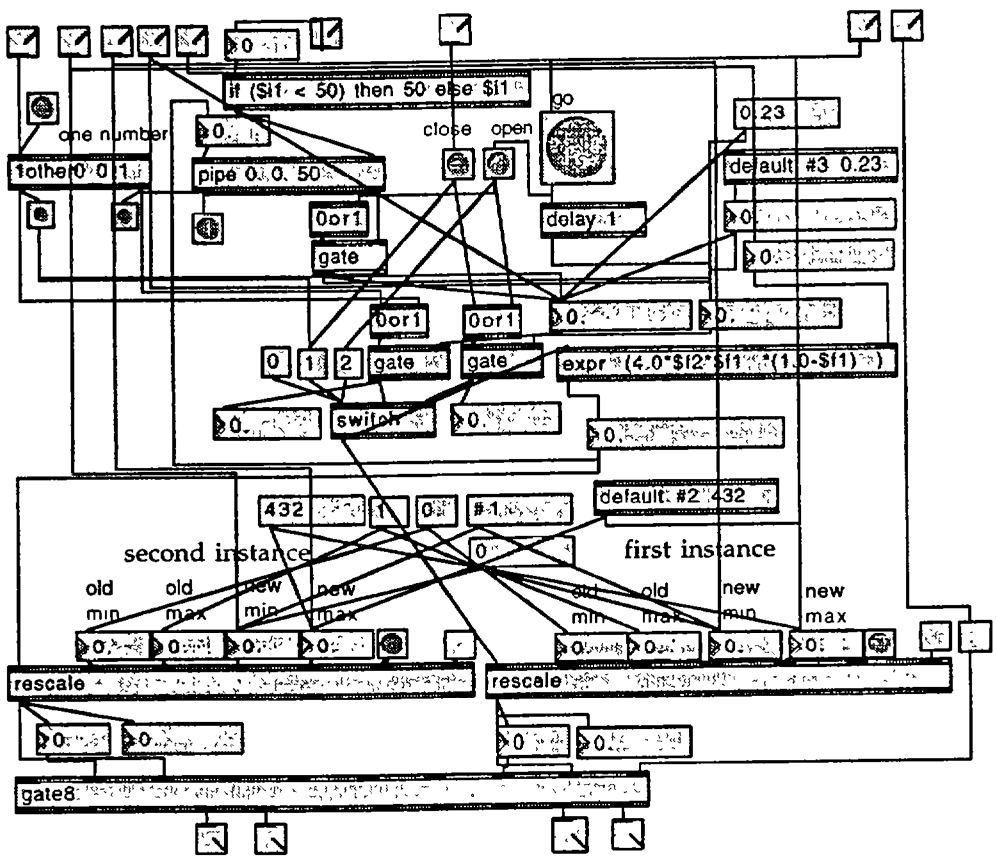


Figure 1. System Overview

The work's duration can be a minimum of several hours to a maximum of several weeks. Once the world is initiated, the score is self generating and will continue to run until the world is ended. Sound sources include two SampleCell cards in a Macintosh computer, an outboard analog synthesizer module, and a microphone. Sound generation and control are based on data obtained in real-time from two sources; a Davis Weather Monitor and the artificial world running on an Indigo II.



example of a chaos function realized in MAX

Conclusion

The concept of monitoring weather information stems from the artists' fascination with performance events based on real-time data input and an interest in exploring the rhythm of the natural world. The artists plan to continue working with artificial life as an aspect of a larger vision of contemporary installation art.

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Notes

[1] Lovell, R. and Mitchell, J. (1995) "Using Human Movement to Control Activities in Theatrical Environments", The *Fifth Biennial Conference for Arts and Technology*, Connecticut College.
[2] The artificial world in EIDEA is not designed to model any specific biological ecosystem but has been created specifically to explore the interactions possible in the installation.
[3] Dutch biologist Arstid Lindenmeyer pointed out that with just one trivial rule you could describe the developments of a hypothetical plant from seedling to complex bush. And by adding just a few more rules, you could model the step-by-step development of branches, leaves, and flowers in three dimensions, as well as the steady spread of hormones and other regulatory compounds from one part of the plant to another. Called L- (for Lindenmeyer) systems, advanced graphics workstations can easily convert these symbolic expressions into realistic on-screen images of leaves, flowers, and stems. M. Mitchell Waldrop, "Artificial Life's Rich Harvest", *Science*, V257, pp. 1040, August 1992.
[4] Chapuis, A., and E. Droz (1958), "Automata: A Historical and Technological Study", trans. A. Reid (London: B.T. Batsford Ltd.).
[5] von Neumann, J. (1966) "Theory of Self-Reproducing Automata", edited and completed by A. W. Burks, (Urbana, IL: U. Illinois Press).
[6] Reynolds, Craig W., "Flocks, Herds, and Schools: A Distributed Behavioral Model", *Computer Graphics*, V21, N4, pp. 25-34, July 1987.
[7] Alan Turing, "On computable Numbers..." reprinted in Martin Davis, ed. The Undecidable, *Raven Press*, 1965.
[8] "Physicist Mitchell Feigenbaum, predicted that at the critical point when an ordered system begins to breakdown into chaos, a consistent sequence of period-doubling transitions would be observed. This so called 'period-doubling route to chaos' was thereafter observed experimentally by various investigators. Feigenbaum went on to calculate a numerical constant that governs the doubling process (Feigenbaum's number) and showed that his results were applicable to a wide range of chaotic systems. In fact, an infinite number of possible routes to chaos can be described, several of which are 'universal,' or broadly applicable, in the sense of obeying proportionality laws that do not depend on details of the physical system." Gollub, Jerry and Solomon, Thomas. "Chaos Theory", *The American Encyclopedia*. Grolier Electronic Publishing, Inc. 1992
[9] OPCODE Systems object-oriented programming language specifically designed to work with MIDI data is called MAX.