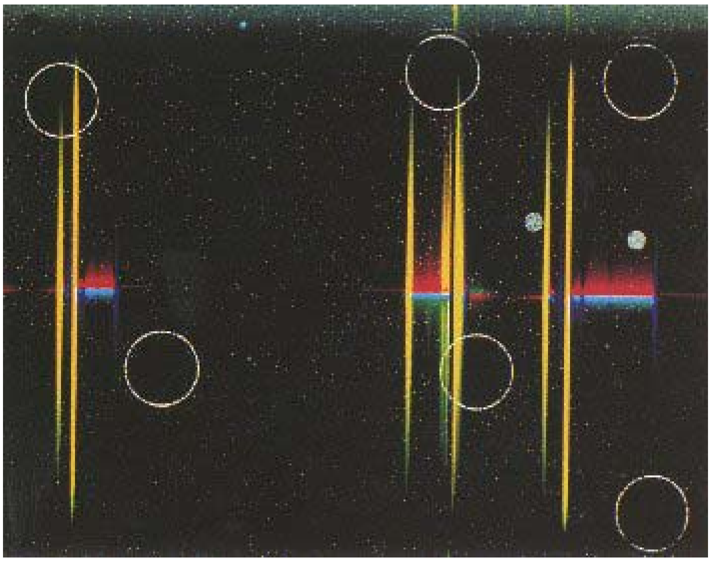
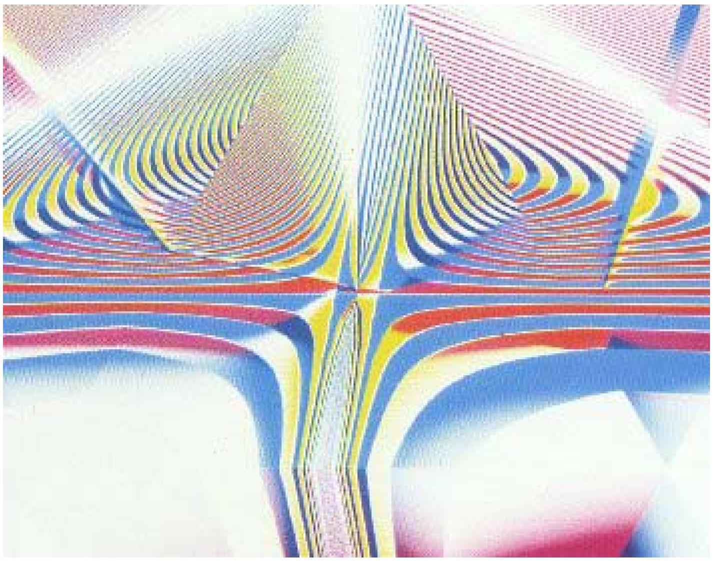
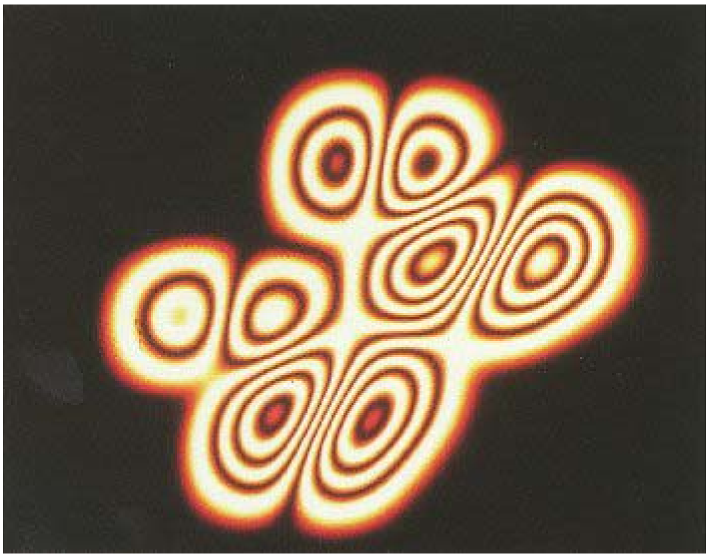
GENETIC IMAGES
KARL SIMS







EVOLUTION

Darwinian evolution is a natural process of variation and selection, often summarized by the phrase: "survival of the fittest." It consists of a simple cycle. The most "fit" entities in a population survive and reproduce. The resulting offspring are copies or combinations of their parents, often with random alterations or mutations. Some offspring may be improvements on their parents, and as only the most fit of each new generation of offspring continue to reproduce, the population as a whole can slowly improve.

We are aware of this process as it relates to biological organisms, but these same principles are also at work in other evolutionary systems. They have led to the creation of many of the complex and wonderful phenomena of our world, including life, consciousness, and language. Many things propagate through the medium of human minds in a way resembling Darwinian evolution. Those scientific theories, religious beliefs, or even artistic styles most fit for spreading from person to person, continue to exist.

ARTIFICIAL EVOLUTION

Darwinian evolution can be simulated on computers. Populations of virtual entities specified by coded descriptions in the computer can be evolved by applying these same natural rules of variation and selection. The definition of fitness can even be altered as the programmer desires. Natural evolution can be a very slow process — life on earth has taken almost four billion years to evolve to its current condition — but as computers steadily become faster, artificial evolution can be a practical and fascinating tool that can be applied in new ways. It is helpful as a method for studying the evolutionary process itself. It can also be used as a powerful device for searching for solutions to complicated problems, and as a technique for exploration in virtual worlds.

INTERACTIVE EVOLUTION

The viewers at this exhibit can observe a computer-simulated evolution in progress: an evolution of images. But in this evolution, the viewers are not just observers: they cause the evolution and direct its course.

A population of images is displayed by the computer on an arc of 16 video screens. The viewers determine which images will survive by standing on sensors in front of those they think are the most aesthetically interesting. The pictures that are not selected are removed and replaced by offspring from the surviving images. The new images are copies and combinations of their parents, with various alterations. This is an artificial evolution in which the viewers themselves interactively determine the "fitness" of the pictures by standing on the related sensors. As the cycle continues, the viewers of this simulated evolution collectively determine the pathway to previously unseen populations of pictures.

This interactive installation is an unusual collaboration between humans and machine: the humans supply decisions of visual aesthetics, and the computer supplies the mathematical ability for generating, mating, and mutating complex textures and patterns. The viewers are not required to understand the technical equations involved. The computer can only experiment at random with no sense of aesthetics — but the combination of human and machine abilities permits the creation of results that neither of the two could produce alone.

And analogy can be made between these images and biological organisms. The are both synthesized from "genetic" descriptions and are both subjected to the forces of evolution. An organism is grown from the coded instructions of its DNA. Similarly, these images are generated from the coded instructions of its DNA. Similarly, these images are generated from instructions in the form of computer coded mathematical equations. The computer code (or DNA) is the genotype, and the resulting images (or organism) is the phenotype.

When one or more of these images are chosen for survival, they reproduce by copying and combining their genetic descriptions, often acquiring some random mutations in the process. The new genetic descriptions produce offspring images that look similar to their parents, but often have significant alterations. Some mutations can increase the complexity of the genetic descriptions and cause the resulting images to increase in visual complexity. Complex equations can sometimes evolve that would be quite difficult for any human to design or even understand.

During the course of the exhibit, the computer remembers those images that have been chosen multiple times by the viewers. Upon request, the computer can recall these previous favorites and continue evolving them. In this way, visitors can start the evolutionary process at points where visitors from previous days left off. In addition, the best results from different evolutions can be combined to further generate new breeds of images. This permits the collective evolution of a larger population of images, which all visitors can contribute to and improve upon, throughout the entire period of the installation.

At any time, the viewers can also request the computer to start over and begin a new evolution from scratch. In this case, the computer generates an initial population of fairly simple images from brief, randomly assembled genetic descriptions. The viewers then choose which of these will reproduce, and the evolution proceeds.

CREATIVITY

Can this interactive evolution of images be considered a creative process? The participants are just repeatedly choosing among groups of 16 images presented to them. However, after only five selections, the users choose one out of over a million possible paths. This is a large enough number of paths that users with different tastes usually do end up with quite different results. This is certainly a different type of process from the execution or realization of a preconceived visual concept, but an element of chance can be an important component in some modes of creativity.

Perhaps the process here can be compared to an artist attempting to improve upon an existing style or searching for new ideas by experimenting at random, inspecting the results, and then discarding all but a small subset. Or maybe it is similar to the way society accepts or rejects certain fashions or styles of art, and those that are accepted are then copied and modified in what seems like random ways, to generate new styles with slight variations. In this simulated evolution, however, the random alterations are succinctly executed by the computer. None of the random experimentation or realization effort is performed by the user, only the aesthetic decisions of preference are required. A designer seems absent in this process, and yet very complex and interesting results can still arise. If enough selections are made by the user and the number of possibilities is large enough, is the user actually being creative, or is the presence of a purposeful designer necessary?

In his book The Blind Watchmaker, biologist Richard Dawkins comments on the remarkable ability of evolution to create complexity without any apparent designer involved. It is possible that these types of techniques will challenge yet another aspect of our anthropocentric tendencies. We have difficulty believing that we ourselves were not designed by a god, but arose by accident via natural evolution. Similarly, we may also find it difficult to believe that artifical evolution can compete with our design abilities, and perhaps even surpass them.

Hopefully, this exhibit will at least provoke an awareness of the power of the evolutionary process in general — in simulation, as well as in its many forms in the world around us. Maybe it will also encourage an aesthetic awareness in some participants who might not otherwise be able to explore it. The potential of tools such as this will increase as faster and faster computers continue to be built, and this may be just a simple taste of things to come.

ACKNOWLEDGMENTS

Thinking Machines Corporation provided the Connection Machine supercomputer for this installation. This Massachusetts-based firm is the creator of some of the world's most powerful computers. The Connection Machine system achieves its speed from data-parallel computation — many processing nodes working together at once. The Connection Machine model used for this project contains 32,768 processors.

John Watlington, Design Engineer at the MIT Media Lab in Cambridge Massachusetts, designed and built the video hardware "FreezeFrame" that allows images from the Connection Machine computer to be displayed on the array of monitors. It also interprets the signals from the step pad sensors.

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