WIND, RAIN, AND PROLIFERATIVE PRESERVATION

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Generally considered a culprit in the destruction of traditional human artifacts, nature may end up serving as the inspiration for such new automated paradigms for the perseverance of culture. Yet, as successful as genetic algorithms are in preserving the information stored in the DNA of living creatures, harnessing genetic algorithms to propagate human artifacts would breed a new host of ethical questions about authenticity and responsibility.

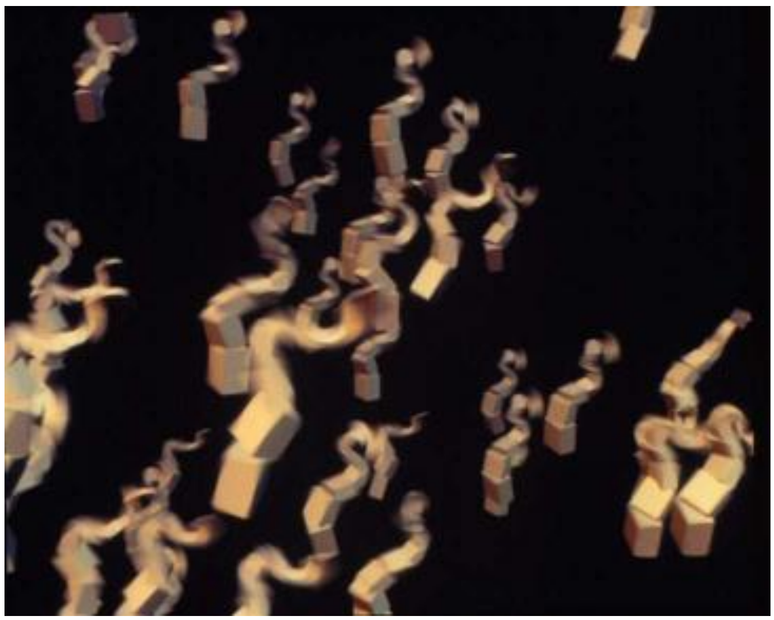

Fig 1. Karl Sims, Evolved Virtual Creatures

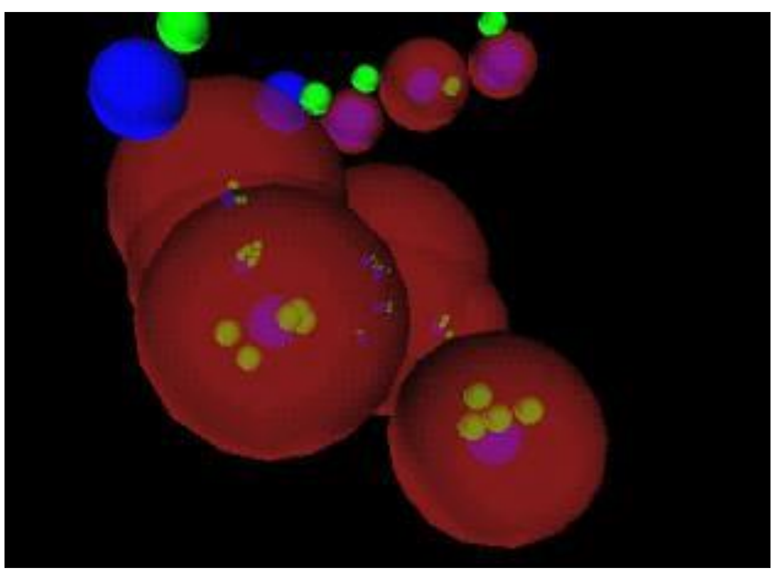

Fig 2. Tom Ray, Tierra

"If you take the Christian bible and put it out in the wind and rain, soon the paper on which the words are printed will be gone. Our bible is the wind and rain."

--Salish elder [FN]

The organic archive

The word "archive" usually brings to mind hardware—shelves of solander boxes, racks of server boxes—or software—arrays of bitmapped images, frames of digital video, folders of Word documents. This paper considers the potential for an archive based instead on wetware—one that imitates the algorithmic processes of biological perserverance, if not its actual membranes and mitochondria. An organic archive would preserve via unorthodox processes like genetic replication and mutation rather than storage and migration. So it's worth speculating whether organic processes might help preserve information-based culture in all its forms.

Digital tools like GarageBand and GIMP may grant today's remix artists the power to proliferate culture, but this power pales by comparison with the fecundity of genetic processes. From natural ecosystems to synthetic genomes to genetically engineered algorithms, evolved systems are able to calculate, create, and copy with a robustness that remix culture cannot match; given the new millennium's obsession with genomics and biomimicry, evolutionary paradigms are likely to play an increasingly important role in many disciplines in the coming decades. Our individual memories are organic, after all—why shouldn't our social memory be?

DNA as archive

Archives that live and breathe are the beneficiaries of evolution, which is the tendency for natural processes to promote stable structures. As a consequence, an organic archive doesn't need conservators and librarians to tend it, but given the right combination of energy and nutrients can reproduce itself. Artists like Joe Davis have already begun exploiting this fact to preserve rudimentary artworks via biological replication. Working with researchers at the Harvard Medical School and University of California at Berkeley, Davis encoded a Y-shaped symbol for fertility into DNA, and then inserted this "infogene" into the chromosomes of otherwise ordinary *E. coli* bacteria. Left to reproduce in test-tubes in a lab, Davis's microscopic studio assistants soon reproduced billions of copies of this rune simply by dividing and making more of themselves. "I'm the most published artist in history," said Davis. [FN]

So what if you want to preserve an entire collection, rather than a single work? In a 2007 conference at the University of California at Berkeley organized by Richard Rinehart on "New Media and Social Memory," Stewart Brand and Kevin Kelly suggested that we might encode the Library of Congress in DNA [CK]. This proposal is essentially Joe Davis' infogene writ at the scale of an archive rather than an individual artwork.

DNA has shown potential as a computing medium for parallel-processing [FN: Square roots], to be sure, but a vat of DNA has a mind of its own, and is unlikely to treat cultural preservation with any more respect than it treats blue eyes or other desirable condition. DNA is transformative—partly via mutation, partly via sexual reproduction—and this fact is essential for its role in evolution.

That makes trusting preservation to an actual organic system is a dicey proposition. Of course, you could try to preserve the Library of Congress in a jar of DNA that's frozen; this would prevent it from mutating very much but not be a big improvement on storing it on a hard drive. To harness the power of an organic archive, you need to harness evolution's power to proliferate, which means either trusting replication to an actual organism (like Joe Davis's *E coli*) or an artificially stimulated evolution using manual processes such as polymerase chain reaction or exposure to ultraviolet radiation. In this case, a strand of DNA encoding a bitmap of the *Mona Lisa* wouldn't sit still in a vat of genetic goo, but would unzip and zip its halves promiscuously with other strands, replicating and mutating.

Synthetic genomes

Of course, it usually takes a lot of time for nature to evolve stable systems. Yet if evolution is really the cause of organic stability, then time measured in years or millennia is less relevant than time measured in generations—for it is by mutation and testing that organic stability arises.

Fortunately for future preservationists, not all evolution has to happen on glacial time scales. The short lifespan of the fruit fly favored by genetic researchers, *Drosophila melanogaster*, is compensated for by its precociousness, with the result that geneticists have been able to observe evolution at work in the laboratory because each new generation only takes a week to mature. As exciting as it may be theoretically, encoding cultural data in a genome is rather impractical. It's not trivial to extract the DNA of a fruit fly just to look up *Moby Dick* in the Library of Congress, much less to figure out whether its words have mutated along the way.

There's a much less messy way to exploit genetic proliferation. Researchers have experimented with digital equivalents of such fast-breeding organisms, called genetic algorithms. And they have gone further by setting the parameters by which such virtual creatures evolve. Such "fitness functions" vary depending on which traits the researcher wants to encourage. Might it be possible to design such a fitness function to encourage the perserverance of digital culture?

Fitness functions

As in so many radical approaches to preservation, artists were there at the outset. To create his *Evolved Virtual Creatures* [FN], artist Karl Sims used a random number generator to create mutations in a series of boxlike shapes whose movements and articulations were also determined by their genetic makeup. Sims then ran these creatures through a series of tests, each corresponding to a different fitness function: Which creature could swim the fastest? Which could win a hockey game?

By breeding successful mechanisms together, Sims stacked the deck so that the winners in each category were more likely to pass on their genes to the next generation of creatures. To be more specific, as each creature was represented by a simple computer algorithm, Sims interspliced the formulas for these algorithms to produce new formulas that are in a genetic sense the offspring of the older algorithms. As a result after a hundred generations [FN: http://www.karlsims.com/papers/siggraph94.pdf], Sims' bizarre creatures could perform their tasks with recognizable competence—even though Sims never designed them to do anything except evolve according to a particular fitness function.

Of course, as intriguing as Sim's system is, it's less a means of preserving forms we already have than a means of inventing new forms—a sort of eugenics program for art. Fortunately, even if you don't want your artwork evolved by organic processes, they may still help generate the software necessary to preserve it.

Danny Hillis and others have experimented with similar processes to evolve useful software, such as word processors. [FN] What if such an evolutionary system were trained not to create a faster or more efficient word processor, but to create a more stable one, that could work in a wider variety of documents and operating systems? This strategy would shift focus away from preserving individual artifacts and toward setting up the rules necessary for evolving an ecosystem capable of withstanding unpredictable changes in technology. If the word processor is the figure, its technological context is the ground, and they must complement each other if the ecosystem is to endure.

We know how to write the figure—a word processor—with code. But how do you model the ground—those unpredictable changes in technology? We can turn to a helpful metaphor from evolutionary biology that explains how individual species and fitness functions interrelate: the Epigenetic Landscape. [FN:17]

Wind and rain

Biologists invoke the Epigenetic Landscape to depict the way the development of an organism can be subject to genetic and environmental forces at the same time. Imagine a stretch of land in which dramatic peaks and valleys have been formed by powerful seismic forces; different populations live in the various valleys of this landscape, out of touch with each other due to the intimidating ridges that separate them. In this visualization, seismic forces represent genetic influences, which tend to segregate species into incompatible gene pools; hence birds and reptiles can no longer mate, even though they evolved from a common ancestor. Nevertheless, the behavior of the population is not determined solely by this seismic topography, for rain and wind can erode previously impassable peaks down into humble hills more easily traversed by the landscape's inhabitants. In this metaphor, the wind and rain represent environmental influences, which tend to encourage the evolution of new species through dramatic climatic change. (Paleontologists hypothesize such a cataclysm to explain the sudden extinction of dinosaurs and diversification of mammals 65 million years ago.)

How might this abstract model be applied to evolve a more adaptable word processor? The organisms on the landscape—variations on word processors—might be interbred to produce new variations, and those judged best able to display various documents would pass their code onto the next generation of word processors. Meanwhile, in addition to a predefined set of technical conditions—from, say, a Wordstar file in Windows 3.11 to a NeoOffice file in Mac OS X—researchers might expand the test by adding some wind and rain—random samples from an algorithmically generated set of documents and algorithms. In this way, the resilience of display software could be tested against technical contexts that don't yet exist. [FN: Lanier]

The ethics of genetic preservation

This vision of self-evolving, future-proof artifacts is heady. But it's also hazardous, because it plays into our society's increasing reliance on genetic modification for innovative solutions without regard for the long-term effects. While pharmaceutical research has produced blight-resistant crops and new tests for cancer, it has also produced suicide seeds and antibiotic-resistant germs. Genetic modification has had a similarly mixed effect on preservation. Scientists by 2009 had created a living clone of an extinct species by transferring cell nuclei from the preserved skin of an extinct Pyrenean ibex into the eggs of a contemporary goat. In the same year, however, the US Food and Drug Association approved the sale of the pharmaceutical protein antithrombin produced in the milk of genetically engineered goats—in effect, engineering a new species of mammal for the sole purpose of delivering cheaper drugs, a practice known as "pharming." Given the limited resources on planet Earth, the fact that genetically modified creatures can often outcompete their natural cousins [FN: Wikipedia on Genetic Engineering] suggests that tampering with biological systems could reduce their diversity rather than amplify it. It may be that biotechnology does not support the **both/and** logic of digital proliferation but reverts to the **either/or** logic of analog space.

To harness the enormous parallel processing capability of a virus or cell is to play with fire; the same potential for explosive and unpredictable growth that makes genetic processes attractive as a preservation strategy also makes them a potential danger to existing creatures and their ecosystems. Critics such as Jeremy Rifkin question whether humanity is mature enough to wield the power of genetic processes responsibly, given their unpredictability and proliferative potential. Even technologists such as Bill Joy have expressed concern over the "gray goo" scenario, a doomsday endgame in which one species wins the zero-sum game of a planet with limited resources. In this hypothetical future, researchers accidentally unleash a self-reproducing, evolving machine or organism that overwhelms the natural (and possibly the built) environment, covering the planet with a kind of gray goo that obliterates the rest of the animal and vegetable kingdoms.

And what of the preservation of genetic artworks such as Eduardo Kac's glow-in-the-dark bunny or Davis's runish bacteria? Allowing them to breed uncontrollably in the wild may be the best way to promote their perseverance, but it accords these artists with a power far beyond what artists are accustomed to, even in the age of the Internet. Although the biotech industry would prefer we didn't notice, genetic materials are among the most powerful "weapons of mass destruction" available today. So how could archivists exploit nature's proliferative powers without endangering nature herself?

As important as the task of preserving human culture may be, we have already seen the effects of its being **too** preservable: landfills piling up with plastic toys and rusting automobiles, pharmaceuticals showing up in breastmilk, and space junk crashing down from orbit. In our experiments with organic forms of preservation, we should make sure that our zeal to leave behind a permanent footprint doesn't end up squashing nature in the process. Sure, it might be possible to encode the works of Shakespeare into every schoolchild's DNA for their future reference—but what unintended consequences might this have for our evolution and our planet? Even a self-evolving word processor, while it sounds innocuous, could mutate into a virus that overran every desktop on the Internet.

Emulating ecosystems

One safeguard that might be worth exploring is built into Tom Ray's *Tierra* project, a self-proclaimed "wildlife sanctuary for computer viruses" that simulates evolutionary processes in software. By creating a virtual petri dish in which snippets of code can mutate and reproduce, Ray harnesses a similar power as artists like Davis or Kac, as he cannot predict the outcome of the microscopic orgy committed by his computer programs. For example, to explore their behavior across a range of silicon ecosystems, Ray built a system that allowed his viruses to email themselves from server to server across the dispersed harddrives of his collaborators. Once set loose in this closed network, Ray's critters decided to circumnavigate the globe. Remarkably, they became a nocturnal species, always seeking the dark side of the planet where they could take advantage of CPU cycles left unused by a computer's sleeping user.

When challenged that he might be endangering everyone else's computer network if one of his viruses ever escaped captivity, Ray replied that the emails [FN: Synthetic Ethics] bouncing around between servers did not contain any code that was executable on its own, but only within the specialized runtime environment of the *Tierra* software architecture. To employ a term from contemporary preservation, Ray's critters live in an **emulated** world. Programs running in emulation don't have direct access to real hard drives; they just think they do. If I download a virus into a Windows emulator, it can eat up my emulated resources, but won't have access to my real resources if I don't want it to.

So it may be that combining the security of emulated environments with the power of genetic replication could provide a safe and powerful future for cultural preservation. Transgenic Canola plants engineered to outcompete their feral cousins have extinguished their competitors in the field [FN: Wikipedia ibid], but a genetically evolved word processor on one hard drive needn't automatically erase an older word processor on another hard drive.

Nature: from culprit to collaborator

It is hard to imagine nature playing a positive role from the standpoint of today's archives, with their banks of manila folders and solander boxes arrayed against nature's will to entropy. Yet in the long term it may be that archivists will no longer be able to resist letting natural processes in the door—maybe even the wind and the rain—either because of their amazing powers of perseverance, or because the artifacts under their care are increasingly created with such natural processes. At that point perhaps the archive may aspire, like so many of our current institutions, to find a way to cooperate with nature instead of working against it.

[This paper is based on material from the forthcoming book *New Media and Social Memory* by Richard Rinehart and Jon Ippolito (MIT Press).]

References and Notes:

[Original source mentions: "To come"]