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ABSTRACT

It was not until the late 1980s that the term 'Artificial Life' arose as a descriptor of a range of (mostly) computer based research practices which sought alternatives to conventional Artificial Intelligence methods as a source of (quasi-) intelligent behavior in technological systems and artifacts. These practices included reactive and bottom-up robotics, computational systems which simulated evolutionary and genetic processes, and are range of other activities informed by biology and complexity theory. A general desire was to capture, harness or simulate the generative and 'emergent' qualities of 'nature' - of evolution, co-evolution and adaptation. 'Emergence' was a keyword in the discourse. Two decades later, the discourses of Artificial Life continues to have intellectual force, mystique and generative quality within the 'computers and art' community. This essay is an attempt to contextualise Artificial Life Art by providing an historical overview, and by providing background in the ideas which helped to form the Artificial Life movement in the late 1980s and early 1990s. This essay is prompted by the exhibition Emergence –Art and Artificial Life (Beall Center for Art and Technology, UCI, December 2009) which is a testament to the enduring and inspirational intellectual significance of ideas associated with Artificial Life.

Keywords

Artificial Life, Artificial Life Art, Emergence, self-organisation, Art and Technology, Alife, Cybernetics, Chaos, non-linear dynamics, fractals, genetic algorithms, Interactivity, believable agents, autonomous agents, chatbots, reactive robotics.

1. INTRODUCTION

It was not until the late 1980s that the term 'Artificial Life' arose as a descriptor of a range of (mostly) computer based research practices which sought alternatives to conventional Artificial Intelligence methods as a source of (quasi-) intelligent behavior in technological systems and artifacts. These practices included reactive and bottom-up robotics, computational systems which simulated evolutionary and genetic processes, and are range of other activities informed by biology and complexity theory. A general desire was to capture, harness or simulate the generative and 'emergent' qualities of 'nature' - of evolution, co-evolution and adaptation. 'Emergence' was a keyword in the discourse. Two decades later, the discourses of Artificial Life continues to have intellectual force, mystique and generative quality within the 'computers and art' community. This essay is an attempt to contextualise Artificial Life Art by providing an historical overview, and by providing background in the ideas which helped to form the Artificial Life movement in the late 1980s and early 1990s. This essay is prompted by the exhibition Emergence –Art and Artificial Life (Beall Center for Art and Technology, UCI, December 2009) which is a testament to the enduring and inspirational intellectual significance of ideas associated with Artificial Life.

Artificial Life could not have emerged as a persuasive paradigm without the easy availability of computation. This is not simply to proclaim, as did Christopher Langton, that Artificial Life was an exploration of life on a non-carbon substrate, but that Artificial Life is 'native' to computing in the sense that large scale iterative process is crucial to the procedures which generate (most) artificial life phenomena. The notion that Artificial Life *is* life created an ethico-philosophical firestorm concerning intelligence, creativity and generativity in evolving and adaptive non-carbon-based life-forms. Unfortunately but inescapably, such debate was often muddied by Extropian rhetoric asserting that in computers and robotics, humans were building the machine successors to biological (human) life.

Artificial Life burst onto a cultural context in the early 90's when artists and theorist were struggling with the practical and theoretical implications of computing – that is, it was contemporaneous with virtual reality, bottom-up robotics, autonomous agents, real-time computer graphics, the emergence of the internet and the web and a general interest in interactivity and human-computer interaction. In part due to the interdisciplinarity of the moment, it was a time also when paradigms accepted within the scientific and technical communities were under interrogation – dualism, reductivism, cognitivism, and AI rooted in the 'physical symbol system hypothesis' among them. There were inklings of a Kuhnian paradigm shift in the wind.

Amongst the (small) community of interdisciplinary computer artists, a smaller subsection were highly attentive to the emergence and activities of the Artificial Life community because in these techniques was promise of a kind of autonomously behaving art which could make its own decisions, based on its own interpretations of the (its) world. That is, the methods of Artificial Life promised the possibility of the holy grail of machine creativity. The artist would become a gardener, a meta-designer, imposing constraints upon the environments of his creatures, which would then respond in potentially surprising ways. In some cases this activity was clad in obvious religious terms of 'playing god'. One of the enduring fascinations of Alife is that simulated evolutionary systems did and do produce increasingly well adapted, efficient forms, which solved their problems in surprising ways, and in many cases, are structurally incomprehensible to programmers, that is, are resistant to reverse engineering. Before discussing such artwork, it is necessary to recap some of the technical and philosophical pre-history of Artificial Life.

Digital Arts and Culture, December 12–15, 2009, Irvine, California, USA.

2. BIOLOGY, COMPUTING, AND ARTIFICIAL LIFE.

2.1 Vitalism, Emergence and Self-Organisation

The question of what it is that distinguishes the living from the non-living has been a constant theme in philosophy and science. Henri Bergson posited the idea of an ‘élan vital’ or life force. This idea which was subsequently received with ridicule by mechanist scientists, characterising Elan Vital as the phlogiston of the life sciences. The spirit of vitalism has recurred in various discourses around emergence and self organization, ideas which have been central in cybernetics and artificial life. G H Lewes used the term emergence in its current context as early as 1875, indicating the philosophical context for Bergson’s élan vital. J.S. Mill embraced such ideas. In A System of Logic (1843) he gave the term “heteropathic causation” to situations where an effect is the result of the combined multiple causes. In his writings of the 1920s Samuel Alexander proposed a general theory of emergence which purported to explain the transition from non-living to living and from non-conscious to conscious. Such ideas were influential in fields as diverse as sociology and embryology. Hans Driesch, one of the founders of experimental embryology subscribed to a notion of entelechy, a form of emergence. The mechanist/vitalist tension persisted throughout the twentieth century, and is easily detected in Artificial Life discourse .[9]

2.2 Cybernetics and Biology

Biological and ecological metaphors were the stock-in-trade of cybernetics, as it was preoccupied with the integration of an entity within a context, and with the study of such systems of entities. In 1937, biologist Ludwig Bertalanffy first presented his General Systems Theory, [2] and this became central to the emerging field of cybernetics during the formative Macy Conferences of 1946-53. Ross Ashby coined the term ‘self organising system’ in 1947, it was taken up by Norbert Weiner among others. [21] The term self-organization refers to processes where global patterns arise from multiple or iterated interactions in lower-levels of the system. Canonical examples are the organisation of social insects and the emergence of mind from neural processes. Other cybernetic luminaries such as Stafford Beer, Heinz von Foerster and others were preoccupied with self-organisation, and idea grouped in the early cybernetic literature with ‘adaptive’, ‘purposive’ and even ‘teleological’ systems. As a meta-discipline, cybernetics wielded significant influence in the ‘60s, in biology (systems ecology), sociology (Luhmann), business management (Beer) and the Arts (Burnham).

2.3 Systems, Information, Software

As I have discussed elsewhere, two qualities of computing paradigms and emerging discourse made cybernetic approaches increasingly incomprehensible. First, an increasing commitment to the concept of intelligence-as-reasoning (the physical symbol system hypothesis of Newell and Simon), as opposed to intelligence-as-adaptation. Second, an increasing commitment to the hardware/software dualism which made the idea of the integration of intelligence within (biological) matter itself problematic. The clear distinction between information and matter was not part of the cybernetic paradigm.

In 1948, Claude Shannon published his "A Mathematical Theory of Communication" in which he formalized his ‘information theory’. [18] Earlier, he had done fundamental work applying Boolean logic to electrical engineering, and had written his PhD thesis developing an algebra for genetics (!) and had worked with Alan Turing during the second world war. In the context of this discussion, it is important therefore to note that the very concept of ‘information’ was in the process of being technically formalized at the time (the post-war years). Arguably, the most significant was the formulation of the notion of ‘software’ as a (portable) information artifact without material existence which became axiomatic to the construction of computer science. The ramifications of this reification were slow to occur. The idea of ‘code’ (a computer program) as something other than custom and handcrafted was also slow in developing, as was the notion of ‘platform independence’. Software as a ‘stand-alone’ information artifact was not reified as a commodity until well into the 80s. [1]

The influence of Cybernetics waned in later decades, in part due to the ascendancy of approaches related to the development of digital computing. Cybernetics went undercover, so to speak, as systems theory and as control theory. Ideas of self-organization and emergent order percolated through the more systems-oriented parts of the Alife community. Many of the ideas central to cybernetics reappear under slightly different terminology in artificial life discourse. Central to cybernetic thinking were questions of self organization and purposive behavior, the relationship of an entity to its (changing) environment, its real time response and adaptabilty - interactions characterised as ‘feedback’. In artificial life, these ideas are clad in terms of autonomous agents, reactive insect like robots, simulated evolution in fitness landscapes, emergence and self-organizing criticality. And indeed, theorists like Peter Cariani [6] and others explicitly bring systems theory and cybernetic theory to bear on Artificial Life.

2.4 Biotech and Alife.

In 1953, Watson and Crick first announced the structure of DNA, building on work of Linus Pauling, Rosalind Franklin and others. Analogies from both cryptography and computer programming are everywhere in genetics language, and seem to have been from the outset. (Note that a Univac, the first ‘mass produced’ computer, was installed in the US Census bureau in 1951.) Watson and Crick made explicit analogies between computer code and genetic code, with DNA codons being conceived as words in DNA codescript. They explicitly described DNA in computer terms as the genetic ‘code’, comparing the egg cell to a computer tape. The human Genome project began in1990, and was headed by none other than James Watson.

Like any structuring metaphor, computer analogies doubtless had significant influence on the way DNA and genetics is thought, particularly by laying the fallacious hardware/software binary back onto biological matter - constructing DNA as ‘information’ as opposed to the presumably information-free cellular matter. What is seldom noted is that the conception of computer code and

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[1] For instance : WordPerfect was first marketed in 1980, its first PC version was available 1982. The first PC version of Wordstar was available the same year. Demo versions of Microsoft Word were distributed on disk (5 ¼” floppy) in PC World in late 1983.

computer programming in 1950 was radically different from what it became 50 years later. The analogy of DNA to machine code has some validity. The analogy of bio-genetic operations to contemporary high-level programming environments is rather more complex and tenuous, and certainly demands critical interrogation. The treatment of DNA as computer code laid the conceptual groundwork for mixings of genetics and computing, such as genetic algorithms and biological computing – deploying genetic and biological processes as components in Boolean and similar computational processes. This unremarked historical drift of denotation has also permitted not-always-entirely-principled mixings of biology and computing, such as the construction of the possibility of living computer code (ie artificial life).

2.5 DNA, matter and information

Cybernetics and digital computing deployed differing metaphors from biology, and as we have seen, the conception of genetic information owed much to the conception of the computer program. The conception of the genetic program as deployed by Watson and Crick did not specifically dissociate the genetic 'information' from its materiality, but by the late 80s, it was possible for Artificial Life adherents to speak in these terms. A basic premise of Artificial Life, in the words of one of its major proponents, Christopher Langton, is the possibility of separation of the 'informational content' of life from its 'material substrate'. Contrarily, embryological research indicates that the self organising behavior of large molecules provides (at least) a structural armature upon which the DNA can do its work. That is: some of the 'information' necessary for reproduction and evolution is not in the DNA but elsewhere, integrated into the 'material substrate'. Alvaro Moreno argues for a 'deeply entangled' relationship between explicit genetic information and the implicit self organising capacity of organisms. [15]

2.6 Hard and Soft Artificial Life

Chris Langton, an outspoken spokesman for Artificial Life, referred to it as "a biology of the possible", and was wont to make proclamations such as : "We would like to build models that are so lifelike that they would cease to be models of life and becomes [sic] examples of life themselves". [12] In what may have been a rhetorical push-start to the Artificial Life movement, the community purported to divide itself into hard and soft factions. The Hard Alifers maintained that silicon based 'life' was indeed alive by any reasonable definition. They argued that biology must include the study of digital life, and must arrive at some universal laws concerning "wet life" and digital life. A major case example for these discussions was Tom Ray's Tierra system, created around 1990. Tierra executes in a 'virtual computer' within the host computer, small programs compete for cpu cycles and memory space. Tierra generated a simulated ecosystem in which species of digital entities breed, hybridise and compete for resources. Tierra would be set to run, overnight, and inspected for new forms. While Tierra was framed in ecological and biological language, it does not employ Genetic Algorithms per se, its code was in fact based on the early and esoteric computer game Core War. The major significance of Tierra was that not only did forms evolve to compete better, but various kinds of biological survival strategies emerged, such as host/parasite relations, and cycles of new aggressive behaviors and new defensive behaviors.

Some years later, Ray made a proposal to promote "digital biodiversity" : a distributed digital wildlife preserve on the internet in which digital organisms might evolve, circumnavigating diurnally to available CPUs. He noted that "Evolution just naturally comes up with useful things" [2] and argued that these creatures would evolve unusual and unpredictable abilities (such as good net navigation and CPU sensing abilities) and these organisms could then be captured and domesticated. [17]

3. MATHEMATICAL AND COMPUTATIONAL PRECURSORS OF ARTIFICIAL LIFE

3.1 Fractals

The desire to describe 'nature' mathematically has a long history, one of its major landmarks being the magnum opus On Growth and Form, by D'Arcy Wentworth Thompson (1917). [20] In 1977, Benoit Mandelbrot published his highly acclaimed 'the fractal geometry of nature'.[3] Fractals became a celebrated form of computer graphics, and popular poster art. Fractals were quickly applied in computer graphics to generate more realistic clouds, mountain ranges, vegetation and coastlines. The rhetoric around Fractals supported a generalized techno-mysticism as they seemed to affirm that computers would unlock the secrets of nature. Indeed, the design logic of multiply iterative procedures does capture some formal aspects of biological process. But we must note that the basic mathematics of fractals, of symmetry across scale, was over 100 years old (Cantor) at the time, and the notion was well known in the early C20th, exemplified by mathematical oddities such has the Koch snowflake, the Sierpinski triangle and the Menger sponge, but the visual elaboration of extended iteration only became viable with automated calculation. In a famous paper, Mandelbrot proved that the coastline of Britain is of infinite length. [14] This seemingly absurd result is based on a fractal understanding of scale. If, say, I measure the coastline of Britain with a yardstick, I will get a certain distance, but if I measure it with a foot-rule, the total length will be longer. If I measured around the wetted surface of every grain of sand, at a scale of, say, 0.1mm, the number would be astronomical in comparison.

3.2 Chaos theory and non-linear dynamics

On the heels of fractal hysteria came a more embracing result of iterative computation: non-linear dynamics and complexity theory. Again, the mathematics behind 'chaos' was a century old (Poincaré). It was a meteorologist, Edward Lorenz, who in1961 found that rounding his figures to three decimal places gave results which were unpredictably different from using the same numbers to six places. [13] That is, the measurement of, say, windspeed as 17.587 km/h, could give a radically different result than if it was rounded to 17.58. Such results were counter-intuitive to say the least. This phenomenon came to be known as 'sensitive dependence on initial conditions' or more colloquially as 'The butterfly effect', the notion being that the flap of a butterfly's wing in the Amazon could instigate a chain of events which could result in a tornado in Louisiana.

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[2] (Artificial Life IV conference, MIT 1994, personal notes)

[3] In 1977, Benoit Mandelbrot published his highly acclaimed 'the fractal geometry of nature'.

Through the 1970's the significance of nonlinear mathematics was recognized, the work of Robert May, for instance, built lasting influence in biology and ecology. These kinds of studies led to a related set of fields and themes called dynamical systems, non-linear dynamics, complexity theory, emergent complexity, and self organising criticality and self-organising systems. A later but influential and widely cited paper, 'Chaos' (Crutchfield, Farmer, Packard, and Shaw) contributed to increasing popular understanding of these phenomena. [8] It should be noted that the 'chaotic regime', contrary to its spectacular name, does not refer to sheer disorder, but to the ragged edges of determinism, referred to as 'deterministic chaos' where behaviors, while not predictable, were susceptible to statistical analysis.

Symmetry across scale (in fractal mathematics), and sensitive dependence on initial conditions (in complexity theory), had a resounding effect on 'normal science'. These developments on the one hand offered a purchase on previously intractable problems in fluid mechanics and on the other, posed, on a philosophical level, an in-principle challenge to reductivism. This resulted in a growing realisation that the clean lines of Newtonian physics and Euclidean geometry occupied a world of Platonic abstraction whose correspondence to the world of phenomena was tenuous. Mathematical and computational modeling depends for tractability on reduction of data volume via approximation, The challenge posed by this new math was that such approximation and generalization is fundamentally unreliable. In broad strokes, these realities imply that any mathematical model of any phenomenon is inherently unreliable. Clearly we still manage to get bridges and airplanes to stay up (most of the time) but that is largely because the materials and technologies have been engineered to conform to mathematical models. We do not have that option with 'nature'. The infinitesimal detail of biological systems is in principle resistant to the classical generalisations of Newton and Euclid. Nonlinear dynamical math transpires not to be an odd corner of the mathematical world inhabited by monsters, but contrarily, the general rule. On a more theoretical level, the assumption that complex phenomena may be reduced to simple multiple simpler phenomena which then 'sum' as an adequate explanation of the original complex phenomenon is rendered dubious. This brings the method of reductivism, axiomatic to scientific practice, into question.

3.3 Neural Networks

The idea of an electronic simulation of (a certain understanding of) the behavior of a network of biological neurons was first proposed in 1943 by Warren McCulloch and Walter Pitts. McCulloch and Pitts pursued technical research and development on the topic in ensuing years. Such networks were found capable of learning and could be trained, yet were resistant to reductive analysis. That is, while a network might display a behavior, half the network would not display half the behavior, and one neuron alone would not display one part of the total behavior. The idea of neural nets was a central theme in cybernetic research and rhetoric, characterised as it was by feedback, referred to as reinforcement. Consistent with cybernetic thought, it was felt that the emulation or biological brain mechanisms could result in simulated intelligence.

As serial digital computing became increasingly viable through the 60s and 70s and came to support cognitivist AI, neural network research was increasingly seen as a backwater. Indeed Seymour Papert and Marvin Minsky argued that a neural network could not learn an XOR function. (In 1972 /73, Grossberg demonstrated that neural networks could learn XOR). The Minsky/Papert critique reveals, rather tellingly, the power structure of computational discourses at the time: it was incumbent upon neural networks to be able to emulate procedures of 'physical symbol system' AI, but Physical Symbol system techniques were, it appears, not required to be able to emulate the special behaviors of neural networks.

At root was a clash of paradigms, a biologically based paradigm of growth and adaptation, and a mathematico-logically based system of propositional reasoning on explicit representations. The question of representation was central to discussions at the nexus of AI and AL (Artificial Life). It also arose with respect to genetic programming and with respect to Rodney Brook's subsumption architecture, which some argued was representation free. These qualities of Neural Networks: freedom from explicit representation, semi-autonomous growth and adaptation were sympathetic with, and informed, the emerging Artificial Life paradigm.

3.4 Genetic Algorithms and synthetic evolution

In 1975, John Holland published Adaptation in Natural and Artificial Systems, in which he outlined the notion of a Genetic Algorithm as a method of problem analysis based on Darwinian natural selection. [10] In such a system, an initial population with randomly generated characteristics are evaluated by some method (called 'fitness criteria') to establish the most successful. The most 'successful' are mutated and crossbred to produce a new population which are then tested against the same criteria. The process is repeated numerous time in a way which resembles evolution, and increasingly 'fit' products are generated. A curiosity of the technique is it can arrive at novel and mysterious solutions, algorithms that are not structured like human-written algorithms and are resistant to reverse-engineering- that is, they work but we don't know why. Genetic algorithms have been deployed in a host of application domains to design or evolve: machine vision systems, diesel engines, stock market prediction systems and coffee tables, as well as artworks and robots. Karl Sim's spectacular evolved virtual creatures were a poster child for this technique.[4]

3.5 Cellular Automata

The ur-example of artificial life dynamics is an iterative mathematical game called 'Life', developed by John Conway in 1970, originally without the use of computers. Life is a class of mathematical phenomena called cellular automata, originally devised by John von Neumann a part of his discussion of the possibility of self-replicating machines. Played out on a simple square grid, cellular automata like Conways life demonstrate the emergence of variety and complex behaviors from a few simple rules. As such they quickly became emblematic of the notion of emergent complexity. By the late 80's it was clear that highly

[4] see video archived at http://www.archive.org/details/sims_evolved_virtual_creatures_1994

iterative computational processes held the paradoxical potential to simulate processes which seemed to defy the ordered predictability of Boolean logic. Research into fractals, non-linear dynamics, cellular automata, genetic programming and related practices generated a context in which Artificial life might develop. Stuart Kauffman's expansive 'The Origins of Order – self organisation and selection in evolution' (1993) quickly became one of the primary texts of the movement, as belatedly, did Steven Wolfram's A New Kind of Science (2002). [11]

3.6 Procedural Modelling

In the1980s, digital 3D animation was a young field, and attempts were being made to automate the movement of entities through such virtual, animated spaces. It was in this context that Craig Reynolds developed a set of 'steering behaviors' which, applied to entities in groups, resulted in remarkably persuasive simulation of flocking and schooling behaviors of virtual entities he called 'boids'. [5] The larger theoretical implication of the work was that simple autonomous behaviors by numerous simple agents could produce the appearance of large scale organized behavior. Reynold's 'boids' thus were taken as a exemplar of Emergence, one of the key themes of Artificial Life discourse. Reynolds was invited to present this research at the first Artificial Life workshop in 1987, thus the 'boids' became an icon in Artificial Life.

3.7 Reactive robotics

By the late 1980s, a level of frustration had developed within the robotics community as the application of conventional AI techniques to the robotic applications had met with limited success. It was in this context that various researchers, including Rodney Brooks and Luc Steels pursued approaches to robotics based in the idea that most of the creature which demonstrably survive and thrive in the world have very small brains, are unlikely to reason and very unlikely to build internal representations of their worlds upon which to reason. As Brooks famously asserted, reflecting on the fallibility of models in general and especially models built on-the-fly by robots, 'the world is its own best model'. On the basis of such ideas, researchers developed a range of small robots with very limited computational abilities which demonstrated remarkable success at various mobile tasks. Such results fed the idea in artificial life that biological analogies held promise as technological models. In combination with ideas such as flocking and emergence, conceptions of 'multi-agent' and 'swarm' robotics were developed which linked robotics with the study of social insects such as bees, ants an termites.

4. ARTIFICIAL LIFE ART: HARMONY PARALLEL TO NATURE

4.1 An Aesthetics of Behavior

With the access to computing, some artists recognized that here was a technology which permitted the modeling of behavior. Behavior - action in and with respect to the world - was a quality which was now amenable to design and aesthetic decision-making. Artificial Life presented the titillating possibility of computer based behavior which went beyond simple tit-for-tat interaction, beyond hyper-links and look-up tables of pre-programmed responses to possible inputs, even beyond AI based inference – to quasi-biological conceptions of machines, or groups of machines that adapted to each other and to changes in their environment in potentially unexpected, emergent and 'creative' ways.

Rhetoric around fractals, complexity theory, cellular automata an related pursuits was replete with suggestions that a deeper order of dynamics of nature had been revealed. This notion of a quasi-biological autonomy intersected in quirky ways with themes in the arts – pastoralist landscape painting – the depiction of 'nature', and in some places, an enduring romanticism which found some hope for the reconciliation of technology and nature in paradigms of emergence. If art, as Paul Cezanne proposed (in opposition to the academic representationalism of Ingres, et al) is harmony parallel to nature, then an art of artificial life could render a 'harmony parallel to nature' dynamically. Cezanne's practice was constrained by the representational idiom in which he practiced. But active computational works could not simply be images of, static depictions of the visual signature of, but be, in an ongoing way, dynamical performances of para-biologies.

The first Artificial Life artworks predate Artificial Life as a recognize movement by decades. The first self proclaimed cybernetic artwork was Gordon Pasks' Musicolor, of 1953. Pask himself was a cybernetician, and around the same time, two of his colleagues made groundbreaking projects. [6]Among these were Grey Walter's Machina Specualtrix Tortoises Elmer and Elsie, and Ross Ashby's Homeostat. Ashby, a clinical psychiatrist, built his homeostat, an adaptive machine which had the capability to recover from perturbances out of war surplus parts in 1948. In the same year, Grey Walter, a neurologist who had built his own EEG machine, built two simple autonomous robots, Elmer and Elsie, which he collectively named Machina Speculatrix. These robots demonstrated simple automonous behaviors such as phototaxis (light tracking). In 1986 Valentino Braitenberg published 'Vehicles: Experiments in Synthetic Psychology'. [3] These vehicles were celebrated amongst roboticists of the early 90s, but neither they nor Braitenberg himself (although he was a director of the Max Planck Institute of Biological Cybernetics) seems to have been aware that several of his thought experiments had been physically built and demonstrated 40 years earlier by Grey Walter.

In the 60's cybernetic thinking influenced numerous artists to develop behaving artworks according to biological analogies, or to look at systems as artworks and artworks as systems. For instance, at the time, Hans Haacke's aspirations for his condensation sculptures were to "make something which experiences, reacts to its environment, changes, is non-stable…make something that lives in time…" [4] Haake went on to look at socio-economic systems as artworks, notably in his scandalous 'Shapolsky et al. Manhattan Real Estate Holdings, Real-Time Social System' (1971).[7] While the anarchic machines

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[5] http://www.red3d.com/cwr/boids/

[6] http://www.isss.org/projects/gordon_pask

http://www.pangaro.com/published/Pask-as-Dramaturg.html

[7] Gregory Sholette aptly summarises the work " Shapolsky et al. consisted of maps, written descriptions and 142 photographs of New York City real estate holdings owned by landlords Harry Shapolsky and his family. Haacke's mock-scientific approach offered viewers the facts about something the artist described [at the time] as a "real-time social system," one that was invisible

of Jean Tinguely are better known in the art world, other artists such as Nicholas Schoffer and Edward Ihnatowicz occupied a more intellectually and technically rich cybernetic 'high ground'. Ihnatowicz' great work Senster presaged agendas of robotics, HCI and artificial life by a quarter of century.

It is not unusual for speculative technological invention to occur in contexts of interdisciplinary arts a generation before they occur in academic and corporate research contexts, but more often than not, such work is forgotten or more likely simply unknown, and goes unrecognized in the latter contexts. (If there was ever an argument for radical interdisciplinarity, this is one). [16] Like the Videoplace works of Myron Kreuger in the realm of machine-vision based interaction, the work of these artists and researchers was roundly misunderstood at the time : understood neither as artworks nor as works of artificial life, as such descriptors were probably literally unthinkable at the time. Indeed, it is only now that the conception of an artist who is also a technical researcher, for whom aesthetico-theoretical and theoreto-technical research go hand in hand, is somewhat recognized in some quarters by the designator 'research-creation'.[8]

4.2 Mimesis, Art and Artificial Life

One of the major preoccupations of western art has been mimesis, the desire to create persuasive likeness. Although the modern period saw a move away from this idea in the fine arts toward various notions of abstraction, mimesis is the preoccupation of popular media culture: cinema, television, computer games. "Abstract" television is a rare thing indeed! For the fine arts, the prototypical mimetic moment is the story of Parrhasius and Zeuxis: "[Parrhasius] entered into a competition with Zeuxis. Zeuxis produced a picture of grapes so dexterously represented that birds began to fly down to eat from the painted vine. Whereupon Parrhasius designed so life-like a picture of a curtain that Zeuxis, proud of the verdict of the birds, requested that the curtain should now be drawn back and the picture displayed. When he realized his mistake, with a modesty that did him honour, he yielded up the palm, saying that whereas he had managed to deceive only birds, Parrhasius had deceived an artist." [1]

Although we regard classical Greek sculpture as a high point of mimesis, I contend that at the time, the static nature of sculpture was not regarded as an esthetic requirement, it was purely a technical constraint. The Greeks stuccoed and painted their sculptures in a highly lifelike manner. [9] My guess is that if the greeks could have made soft fleshy sculpture, they would have. Hero of Alexandria was renowned for his pneumatic automata which combined static sculptural mimesis with human-like (if repetitive) movement. The famous clockwork automata of the C17th were capable of much more complex behavior than the Heros' pneumatic automata. The "scribe" by Jacquet Drosz could dip its pen and write lines of elegant script. Vaucansons famous Duck is said to have been able to flap its wings, eat, and with a characteristically duck-like wag of the tail, excrete foul smelling waste matter!

It is of note, not simply that these clockworks were contemporary with the first programmable device, the Jacquard weaving loom, but also that their behavior was constructed from mechanical "logic" much like that which Babbage used for his difference engine. We should further note that these automata were not regarded as fine art but simply as amusements. The industrial era equipped the automaton with reliable structure and mechanism and the possibility the autonomy of untethered power sources, first steam, then electric. The image of the mechanical man became a cultural fixture. Literature was populated with a veritable army of mechanical men (and women). from pathetic representations like the tin man in the Wizard of Oz, to the mechanical girlfriend of Thomas Edison in Tommorow's Eve by de L'isle-adam, and the distopic portrayals of Mary Shelley's Frankenstein, Fritz Lang's Metropolis and Karel Capek's RUR (Rossum's Universal Robots), the dramatic work in which the term "robot" originated.

It was the move into the electronic that began to offer first the simulation of reflexes, then a modicum of intelligence. In the context of this historical trajectory, we must consider Artificial Intelligence as a continuation of this broad cultural anthropomorphic and mimetic trajectory. Indeed, Alan Turing defined the entire project as anthropomorphic with his test for artificial intelligence, now referred to as the "Turing Test". Simply put, this test says that if you can't tell it's not a person, then it has human intelligence.

4.3 Interactivity, Novelty and machine creativity

In the arts, the drive to mimesis has most recently flourished in the field of interactive art. Since the availability of the desktop computer, a small community of artists has been exploring the possibility of a quite new artform, in which the esthetically manipulated quality was "behavior". Computer-based Interactivity held the promise of an openness and variability in artworks. Many practitioners, more preoccupied with content than form perhaps, focused on hypertextual models (of the kind which led to hyperlinked systems such has the worldwide web), using tools such as the venerable Hypercard, or purpose-built tools such as Storyspace for electronic literature. As has been well documented elsewhere, the strategy of hyperlinking has its roots in the topology of early text-based gaming - Dungeons and Dragons:

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yet entirely accessible through public records. The artist's accumulated evidence presented a pattern of social neglect typical of New York's invidious real estate market. Shapolsky et al. also resembled, if not in fact parodied, the conceptual or information art being made in the early 1970s by artists such as Mel Bochner, Adrian Piper or Joseph Kosuth. After canceling Haacke's exhibition just prior to the opening Thomas Messer, the museum's director, summed up his opposition to Shapolsky et al. by stating, "*To the degree to which an artist deliberately pursues aims that lie beyond art, his very concentration upon ulterior ends stands in conflict with the intrinsic nature of the work as an end in itself.*" Defining what did lie beyond the art's "intrinsic nature" was to become the central question for a new generation of activist artists." Submitted 18 Feb2006 at http://www.neme.org/main/354/news-from-nowhere

[8] Such as the Canada Social Sciences and Humanities Research Council. www.sshrc-crsh.gc.ca

[9] Although this fact is well known in art historical circles, curiously there has been no attempt to re-polychrome the friezes of the Parthenon or the sculptures of Praxiteles.

passages, junctions and doors. While much rhetoric of freedom was associated with 'hyperlink' interactivity freedom of interactivity such freedom is a very consumerist freedom - freedom to shop - freedom of choice among pre-given options. The problematics of such interactivity devolve to the problematics of multiple choice.

Artificial Life techniques offer a new type of interactivity in which there is the potential for systems to respond in ways that have not been so explicitly defined. Unlike previous mimetic art practices, in this work the dynamics of biological systems are modeled more than their appearance. These works exhibit a new order of mimesis in which "nature" as a generative system, not an appearance, is being represented. Numerous new artworks employ biological growth algorithms, simulated ecosystems or communities, genetic algorithms, neural networks in the structure of the systems. Genetic techniques were seen as a salvation from the 'multiple choice' limitation: the system would generate variety, it would demonstrate 'emergent' behavior.

As Mitchell Whitelaw and others have also observed, in Alife in general and in Alife Art, there is a desire for novelty, for the machine to do the unpredictable, which is of course, a contradiction in terms. The spectre of such boundless freedom is illusory. The mechanism of simulated evolution having been developed, boundary conditions are established by logico-theoretic enframing. Given the tools of watercolor painting, all possible watercolor paintings are theoretically possible, but marzipan is not. This Goedelian limit is also true of mathematical systems, a limitation that biological evolution appears to be somewhat freer from. In genetic programming, the measure of success of new mutants is defined by pre-decided 'fitness functions' or a 'fitness landscape'. (It is a quirk of genetic programming that 'rugged' fitness landscapes with multiple peaks and valleys have the effect of leaving species stranded at the pinnacle of 'local fitness peaks', with no way to descend to climb other/higher peaks). In the case of some examples of Artificial Life Art, human choice injects variety or direction into the fitness criteria, such as Karl Sims' Genetic Images installations of 1993.[10] While in this case, the decision making devolves again to multiple choice, Sim's goals were not interactivity per se, user input simply provides a new crop of criteria for the perturbation of the system.

An early example are the Reaction Diffusion Texture Buttons of Andrew Witkin and Michael Kass, 1991. These computer graphic textures were generated by reaction diffusion nonlinear partial differential equations.[11] This work is historically interesting in this context not simply because it represented significant progress in computer graphic research at the time, but because it deployed the mathematics of nonlinear dynamics but because the reaction diffusion referred to is itself a simulation of the canonical example of self organization in chemistry, the Belousov-Zhabotinsky reaction.

One of the uses of genetic techniques has been the automatic generation of variations. But it is important to recognise that the capacity to generate such variations predates genetic techniques, and is in fact a quintessential quality of computation. The capability to iteratively perform the same function upon a specific set of data, and to apply an algorithm sequentially to a list of data items, are basic capabilities of the Turing machine. Early abstract graphics were generated in this fashion, as were many other kinds of output. In the late 80's Russel and Joan Kirsch, Ray Lauzanna and others, used LISP shape grammars to encode formal canons. In Lauzanna's case, he generated passable Kandinsky line drawings, the Kirschs generated new works in Miro's 'constellation' series.

4.4 Problematics of the "evolved aesthetic object"

In genetic or evolving projects, the tyranny of reductive paradigm is again at work. Algorithm is again separate from data. In the physics of the virtual, the force of the algorithm works upon the mass of the data. In the genetic paradigm, the evolved code establishes an intermediary step, but it is the design of the breeding system which generates the code which becomes the designed or (meta-) creative act. Even if one were to propose the breeding of the breeding systems themselves, or to propose that the 'fitness landscapes' were configured so as to evolve responsive to the pressures of the populations evolving within them, the design function simply moves one more step into the background, or to put it otherwise, the system is jacked up another level off the ground. But at root, the system always grounds out in the Boolean logical operations, finally, fixed in hardware.

So where does this leave attractive arguments of emergence, in particular of arguments of the emergence of consciousness? Peter Cariani has argued that computational emergence is always devolvable to exclusive logical operations, and is thus not emergent at all. [5, 7] Cariani argues, consistent with the 'second order cybernetics' of von Foerster, that such system are only 'emergent' relative to the observational frame of an observer. Put simply, if its a surprise, its emergent, and if its not, its not. Cariani identifies true emergence with adaptation (a cybernetic keyword), and reserves it for systems which are integrated into and open to the physical world and can evolve their own sensors. In his terms, 'Syntactically adaptive' systems can evolve their response to sensor data and 'semantically adaptive' devices alter the relation between environmental state and internal representation by the evolution, for example, of new sensors. Such ideas are cogent in the world of physical, biological phenomena, but become murky in the digital world, and here is the root of a certain disingenuousness in the rhetoric of the Hard Alifers. The fact is that in the digital realm, everything is potentially definitive and knowable, there is no need for interpretation or determination of salience (of sensor data) as there is in the physical world. This is the sense in which Michael Mateas can assert that 'software is a perfect material'.[12] What of the notion common in programming of 'virtual sensors' which pick up particular data from a stream of digital data? Should they not be more correctly called filters? The conception of a 'virtual sensor' - some piece of code which watches for other significant code events, be it in a digitised video data stream or a mail agent sorting email - is metaphoric at best.

The conundrum of the sensor/processor dual for biological systems is at root a fallacy of computationalist rhetoric. In digital systems, conversion from 'analog' sensor signal to digital 'data' is

[10] http://www.karlsims.com/genetic-images.html

[11] http://www.cs.cmu.edu/~aw/gallery.html

[12] Personal communication

axiomatic, but in biological systems it is non-existent or occurs in multiple, finely graduated steps. In the flies eye, some computation occurs ‘in hardware’ in the physical layout of the light-receptive cells. The enforcement of an A/D discontinuity on biological systems is obfuscating computationalist dogma. Such a mechanistic reduction does not transfer to biology without some confusion.

5. SPECIES OF ARTIFICIAL LIFE ART

Like most such interdisciplinary communities, practitioners entered the house of Artificial Life through different doorways, so to speak. But unlike more ‘user-friendly’ areas, Artificial life was fairly technically demanding, so practitioners tended to come from technical backgrounds, or to be bona-fide interdisciplinarians. This did mean the field had a fairly high nerd quotient, and the dividing line between nerdy demo and artwork was often blurry. The phenomenon of long standing collaborative partnerships involving an ‘artist’ and a ‘technician’ were comparatively common, and these partnerships tended to produce good work. On the other hand, cases where relatively non-technical artists were paired with technical ‘guns for hire’ tended to produce less successful work.

5.1 Evolved painting, evolved sculpture, evolved animation

In 1992, Andrew Witkin and Michael Kass won the Ars Electronica Golden Nica for computer graphics for RD Texture buttons, a system which generate plausibly ‘natural’ patterns and textures based on a simulation of reaction-diffusion dynamics.[13] In the same period, combining the bio-mathematical research of D’Arcy Thompson with aspects of fractal math, and deploying simulated evolution, William Latham was evolving an array of biomorphic forms, mostly existing as virtual sculptural objects. [14] Over the next decade, Karl Sims played a leading role in developing technologies and works (an early example being the animation ‘Panspermia’) as well as discourses in the field. [19] In Turbulence (1994/5) John McCormack took another approach, presenting digital animation of an array of evolved and synthetic lifeforms in an installation context. User interaction was restricted to navigation of the database of such clips. In this context, mention must also be made of the weirdly hallucinogenic biomorphic and zoomorphic animations of Yoichiro Kawaguchi. [15]

5.2 Virtual ecologies

One of the early and celebrated Artificial Life experiments was built by a biologist and discursively constructed as an ecological scenario. This was Tom Ray’s Tierra, discussed above. As an idea Tierra was exciting, but like much scientifico-technical research, it was essentially invisible. As with other contexts in which artists are motivated by science, the challenge to the art community was how to open such phenomena to direct sensory experience. Given such a world of creatures, one might reasonably want to watch them, follow them, construct them and constrain them. This entailed visualization and interaction/interface design. A whole community of ‘art-breeders’ arose in the early ‘90s, who explored the generation of aesthetic artifacts via various Alife and genetic procedures, including Karl Sims, John McCormack, Scott Draves, Jeffrey Ventrella,[16] and Bernd Lintermann[17]. Digital creatures and communities of behaving and often interactive digital lifeforms became common. Numerous projects inhered biological and ecological analogies in different ways, as well as developing various underlying evolutionary and ecological architectures. TechnoSphere by Jane Prophet and Gordon Selley (1995) involved a web accessible computer generated landscape/environment in which users could ‘set free’ creatures they had built from components available in the application.[18] Creatures would then interact with and compete with each other, by fighting and attempted mating, etc. Along with the modeling of an artificial ecology, Technosphere engaged other contemporary challenges in digital media arts such as the creation of navigable virtual landscapes, strategies for real time interaction and utilizing the web as a presentation environment.

Interactive Plant Growing by Christa Sommerer and Laurent Mignonneau involved a novel interface to a virtual world and presents a clear illustration of this desire to model biological phenomena. Five potted plants are monitored for changes in their galvanic condition. As visitors approach and fondle these plants, these galvanic changes are utilised as variables in the program which grows virtual plants in on the screen, in response to the visitors fondling. The recently released game Spore in this sense represents the commodified afterlife of Artificial Life Art.

5.3 Eliza’s children, MUC’s grandchildren – text based agents and chatbots

Joseph Weizenbaum created something of a scandal when in 1966, he invited several psychology grad students at MIT to interact with a famous Rogerian therapist via teletype. Consternation arose when he revealed that they had in fact been interacting with a computer program, and further consternation erupted when he revealed that the program. Eliza, ran on only 16 rules. [19] Eliza may have been the first interactive chatbot, but it appears that an Alife artwork of sorts was among the first written programs, period. In 1951, Christopher Strachey. developed a program for the game of draughts, for the Pilot ACE, a computer designed in part by Alan Turing. Later that year, he rewrote the program for the Manchester Mark 1. He wrote the "Loveletters" program in 1952, which wrote appalling love letters.

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[13]http://90.146.8.18/en/archives/prix_archive/prix_projekt.asp?iProjectID=2465

[14] http://doc.gold.ac.uk/~mas01whl/index.html

[15] http://www.iii.u-tokyo.ac.jp/~yoichiro/profile/profie.html

[16] http://www.ventrella.com/Darwin/darwin.html

http://www.ventrella.com/index.html

http://www.Swimbots.com/

[17] http://www.bernd-lintermann.de/

[18] http://www.janeprophet.com/technoweb.html (previously shown at the Beall Center UCI, in the Control Space exhibition of computer games curated by Robert Nideffer and Antoinete LaFarge.)

[19] http://nlp-addiction.com/eliza/

DARLING JEWEL

YOU ARE MY DEAR PASSION: MY BEAUTIFUL FERVOUR. MY CURIOUS ENCHANTMENT FONDLY PANTS FOR YOUR EAGERNESS. MY WISH HUNGERS FOR YOUR FANCY. YOU ARE MY SWEET ENTHUSIASM.

YOURS AVIDLY

M. U. C.

(MUC stands for Manchester University Computer). Strachey also wrote a music program which performed In the Mood, God Save the Queen, and Baa Baa Black Sheep, so he deserves due credit for pioneering work in computer music, computer gaming and computer literature. Eliza was followed by Parry (1972), a paranoid schizophrenic. There was an historic meeting between Eliza and Parry. Reportedly, the exchange quickly descended into drivel. A book called The Policeman's Beard Is Half Constructed (1984) [20] was billed ‘the first book ever written by computer’ specifically by an AI program called Racter, by Bill Chamberlain and Thomas Etter, has echoes of MUC. From 1982, the Loebner prize marks progress on chatbots, under Turing Test criteria. Through the 90’s a plethora of netbased chatbots have emerged. Marc Boehlen’s Universal Whistling Machine, while neither a chatbot nor a real time music composer or improvisor, is clearly related to both trajectories of computer cultural practice.

5.4 Believable Agents, believable crowds.

Through the 90’s, the Oz group at CMU was one of several initiatives which took a hybrid approach to the development of more literary forms, interactive drama based in interacting communities of so-called ‘believable agents’. The techniques of the OZ group were rooted in AI but pointed at interactions of semi-autonomous software agents. [21] Façade (Mateas and Stern) is a more recent and successful example of the approach.[22] Andrew Stern, with Adam Frank and others, had previously produced the commercially successful virtual pets called Petz (1995). A more recent contribution in this field is Sniff, by Karolina Sobecka and James George, which is notable for deploying a game engine (Unity) as its animation environment. Sniff is a virtual puppy, with sophisticated behaviors triggered by machine vision analysis of the user-space. Such projects evidence the interaction of Artificial Life Art communities with commercial gaming communities, a trend that has continued in games such as Myst and Spore, and has had direct effect on the formulation and elaboration of online virtual communities such as Second Life, and Massively Multi-User RPGs such as World of Warcraft. In the movie industry, the rendering of synthetic characters and synthetic crowds has become an entire sub-industry leveraging research in procedural modeling, autonomous agents, genetic algorithms and related Alife fields.[23]

5.5 Physically instantiated Alife systems

Most of the work cited above existed in virtual realms. Another important aspects of Artificial Life Art was physically instantiated Alife systems, including mobile robots, robotic sculpture and internactive environments. This trajectory which begins with Grey Walter’s tortoises and Gordon Pask’s Musicolor, includes such landmark works as Edward Ihantowicz’s Senster, the Theatre of Hybrid Automata by Woody Vasulka, my own Petit Mal [24] and Sympathetic Sentience [25], works by Ulrike Gabreil, Ken Rinaldo and many others. The Flock (1992) by Ken Rinaldo and Mark Grossman is an installation of, originally, three robotic sculptures suspended from the ceiling. Flock is a community of devices which sense and move towards visitors and speak to each other using audible telephone dial tones. It uses ‘flocking behavior’ to coordinate the activities of the three ‘arms’.

More recent examples of this trajectory include Propagaciones by Leo Nuñez, and Performative Ecologies by Ruairi Glynn. Propagaciones is a sculptural realisation of one of the icons of artificial life, the cellular automaton, which in its construction is reminiscent of Jean Tinguely. In Propagaciones, separate electro-mechanical sculptural ‘cells’ stimulate each other into mutual action, creating propagating patterns across the field. Performative Ecologies, by Ruairi Glynn consists of a trio of ‘dancing fools’ – devices that seek to demonstrate the most pleasing dance they can devise. The devices use gaze tracking with infra-red camera to determine how attentive their audience is while performing each dance. In downtime, they breed new dances using genetic algorithms on dances determine to be most attractive, producing new dances to be tried out on the audience and shared with their fellows.

6. ARTIFICIAL LIFE AT 21

Roughly speaking, Artificial Life and Artificial Life Art has existed for two decades. Over that period, the computational capability of consumer computer technology has advanced profoundly, as has our acculturation to it. Daily, we casually do things on our phones (and complain about them) that were out of reach of million dollar supercomputers two decades ago. We must bear this changing reality in mind when viewing early Artificial Life Art. The ongoing lively interest in this interdisciplinary field is testified by the fact that the VIDA Art and Artificial Life Award is now in its 13th year. [26] As is the case with much research in computational techniques, much of the basic Artificial Life Art research has now found its way into, or influenced larger scale and commodity products. As mentioned above, the computer game Spore (Will Wright/Maxis) is a clear descendent of numerous similar art projects. But less obvious is the fact that the

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[20] http://www.ubu.com/historical/racter/index.html, (ISBN 0-446-38051-2),

[21] http://www.cs.cmu.edu/afs/cs.cmu.edu/project/oz/web/worlds.html#woggles

[22] http://www.interactivestory.net/

[23] a recently celebrated example being crowd and battle scenes in Lord of the Rings.

[24] http://ace.uci.edu/penny/works/petitmal.html

[25] http://ace.uci.edu/penny/works/sympathetic.html

[26] http://www.fundacion.telefonica.com/arteytecnologia/certamen_vida/en/index.htm

vast array of techniques for generating synthetic but natural looking landscapes, weather patterns, vegetation and plants, animals and synthetic character and crowds (and their autonomous and group behaviors); which we see in movies, computer games and virtual environments: all these have some connection to the Artificial Life research of the 1990s.

The foregoing is but a cursory introduction to the history and theory of Artificial Life Art. I hope that it creates interest and provides a context for further research.

Simon Penny August-November 2009

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