Improvisation and Interaction, Canons and Rules, Emergence and Play.

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Abstract
Over the last two decades, availability of real-time computational technologies (hardware, software and peripherals) have permitted the development of categorically new kinds of cultural practices in which the machine system is constituted as a quasi-organism which responds to changes or perturbations in its 'umwelt', according to behavioral rules (most often) contrived by the artist/author. Such systems are found in 'new media' forms such as online interactive worlds, augmented and mixed reality work, locative media and fully physically embodied interactive installation and performance - in single and multiple participant, discrete and distributed modalities. They conform to, or derive from musical, literary, theatrical and plastic arts genres, but the fundamental creative/technical practices of designing behaviors and implementing machine perception is largely without precedent in such arts traditions. This paper proposes that a source for relevant aesthetic theory might be found in the improvisational forms which often exist as essential but informal dimensions of traditional arts practices and their knowledge bases. Within computational discourses and practices around the formal capabilities of computational systems there is a long and relevant history of discussion of questions of creativity, novelty and emergence. Computer based interactive art practices and traditions of improvisation thus provide as heterogenous an interdisciplinary polyglot as one could wish for. This paper explores that territory.

If we knew what it was we were doing, it would not be called research, would it?
Albert Einstein

Introduction

As a maker of digital interactive cultural artifacts coming from a fine arts background, it is bountifully evident that the aesthetic theory of conventional representation-based practices in the arts offer little guidance in the creation of artworks which behave. In the face of this theoretical vacuum, where might we find informed guidance for designing computational artifacts that have behavior? The main thesis of this paper is that traditions of improvisation might offer useful input. There is a structural isomorphism between computer-based interaction and improvisatory practices in the fine and performing arts, as well as other points of relatedness. This isomorphism is due to the fact that a truly interactive cultural artifact reacts in an aesthetically intelligent way to changes in its environment, in a way which is similar to what a human improviser does. This paper explores this isomorphism and points to way in which such practices might provide

aesthetic models and theoretical insights which can inform the design of more aesthetically rich interactive cultural artifacts. Recognition of this isomorphism leads us into an interdisciplinary conversation which draws us into deeper questions concerning emergence and creativity in computational systems. The arguments herein therefore triangulate the trajectories of several traditions – improvisation, interactive art and artificial life discourses.

The advent of interactive cultural practices and the emergence of their design as a field of aesthetic decision-making presents practitioners with a theory-vacuum, because most of the areas of pre-computational cultural practices which inform such new forms are static or temporally locked. That is, none of those forms involve artifacts which possess behavior, 'make decisions' and 'take actions' based on changes in its context in real time. There is therefore a lack of relevant aesthetic theory regarding the interactive dimension of such practices. Computer based interactive cultural practices offer the user(s)/player(s) a 'constrained freedom' – the opportunity of free action within a constrained gamut of possibilities defined by code, interface design and input modalities. Improvisation in cultural practices likewise permits a freedom of action within a frame – in musical improvisation for instance, behavior is constrained by key, rhythm, mode, ´sruti, ragam, tãlam, etc. Karlheinz Stockhausen was clear on this matter: "One always connects improvisation with the presentation of underlying schemata, formulae and stylistic elements." [1] It is worthy of note that a utopian rhetoric of 'freedom' has characterized (naïve) views of both improvisation and computer interaction.

This idea of 'constrained freedom' is central in what follows as it is a major part of the proposed isomorphism between improvisation and interaction. This conversation is undergirded by theoretical questions regarding emergence, novelty and the nature of creativity itself, in human, biological, evolutionary and computational contexts. This paper glosses some of those issues in order to provide a richer ground upon which to pursue the conversation. The following discussion will thus engage systems theory, distributed and enactive cognition discourse, theory of self-organising and emergent systems, improvisation and performance studies and other discourses, in the pursuit of a more developed theorisation of the interactive cultural artifact.

There has been a wide range of projects, academic and artistic, which have aimed at the generation of novelty - or the impression of novelty - in computational systems. At one extreme is the history of 'choose your own adventure' interactive literature, which while often aesthetically novel, has generally relied on simplistic selection processes – simple selection rules in lookup tables and quasi-random selection over databases etc. This kind of system leads to a Pavlovian point-and-click mode of interaction now typical of computer games and worldwide web interaction. There are clearly degrees in this continuum that runs from button or menu style 'user selection' to procedures which permit novel user-generated possibilities.

At the other end of the scale are systems whose designers have a stake in theoretical questions of novelty in computational systems. Some such works which variously deploy AI techniques, genetic algorithms, neural nets and other sophisticated techniques are

discussed. A key variable in such works is whether they also engage the question of interaction. Many projects in Artificial Life Art traditions take the form of synthetic ecologies which are observed as one might observe the goings on in an aquarium. Others provide the opportunity for the custom construction of synthetic life-forms which are then let loose in such a virtual ecology (see below: Technosphere, Avolve). Another genre focuses specifically on the dynamics of embodied human engagement (work in the tradition of Myron Kreuger, David Rokeby et al). These systems permit the user substantial gestural autonomy, but assume greater effort and skill on the user's part. The range from 'end user' to skilled virtuoso is again a continuum. Whether such interaction in some way constitutes improvisation is a subject for discussion. Nonetheless, various projects have focused centrally on the territory of realtime improvisatory machines in musical performance, notably Pasks's Musicolour and Lewis's Voyager.

In discussions regarding interactive systems, a common and basic disconnect regarding the term of discussion must be elucidated and clarified at the outset. Interaction can be viewed from the perspective of machine design – in which the 'user' is simply presumed to behave in a range of ways which are predictable, allowable and designed-in. In this way, interactivity 'constructs a user'.[2] Alternatively, interaction is viewed from the point of view of the interacting subject and the dynamics of the machine system are all but ignored. Such an opposition smacks a little of the 'science wars'. [3] The user/machine binary is a case of the conventionally humanist axiomatic subject/object dichotomy, a dichotomy which itself may be an impediment to understanding the phenomena in question, as Karen Barad has argued.[4] My goal is to move beyond this binarism, and towards a performative ontology in which the behavior of the system as a whole can be usefully discussed. Such an approach, I believe, offers the potential for both theory and practice to move beyond the cognitivist log-jam. Central to my argument here is the idea that capacity for interactivity is dependent on a more fundamental capacity for (agent-like) behavior, and the construction and design of sophisticated behavior must precede the design of interaction.

Technical history of interactive art

While Digital Interactive Art has some notable precursors, the field really got off the ground with the advent of the desktop computer slightly less than 25 years ago. Historically, much interactive practice has sprung from the context of the plastic and visual arts. The reasons for this were largely technologically determined. The historical trajectory of the evolution of computational systems begins with mathematical calculation. Processing of textual material followed. After basic numerical and textual representation, domestic and 'prosumer' computer systems incorporated some capacity to digitize, generate, store and manage static images and sounds. This was followed by increasing capabilities of input and output (scanners, printers, sound cards). The ability to combine such elements as 'multimedia' and 'desktop publishing' was facilitated by the fact that in computational context these elements had already been translated into compatible, computable, elements and structures. Capacity to handle sound also developed incrementally. [5] But handling of sound or image as digital representation was only half the problem. As I have discussed previously, the institutional and bureaucratic

origins of business and consumer computing culture meant that 'input and output peripherals' for image and sound work were slow in developing. [6] Even with the advent of the internet, movement of 'media' files was tricky until well into the early years of the world wide web in the later 90's. Through the first two decades of desktop computing, one constantly worked around i/o bottlenecks and data storage limitations. For instance, for a certain period, while it might have been possible to generate imagery, static or time based, there was no tractable way to record it save pointing an analog video camera at the screen. Likewise, while it may have been possible to generate synthetic audio, it was more difficult to input recorded audio. For two decades, so-called analog to digital and digital to analog conversion hardware remained in the form of cumbersome external peripherals. It is only with technological convergence in the form of digital audio and image/video formats and technologies that these processes have become relatively facile. While the built-in camera is now ubiquitous, we should be mindful that this is a recent development.

The ramping up of interactive capability followed a similar trajectory. As formats and processing capabilities advanced, so real-time interaction came to incorporate increasingly rich media forms, from text, to text and monochrome line drawings, to the integration of animation, sound and video. Increased capability for handling of media types was paralleled by increasingly sophisticated data management and decision-making systems, and a wider diversity of higher performance sensors and input devices.

Machines and creativity

Machines, as normally construed, do not improvise. When they do something that is unexpected they are broken. The screw-cutting lathe that creates a thread of varying pitch must be fixed. The blender that contributes shards of metal to the smoothy is bound for the recycle bin. The desktop computer is framed around such instrumental functionality. The last thing I want topsdbns
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….exactly. We want our word processor to be predictable and ready-to-hand. This is not something we expect from an artwork. In discussing computer-based interaction and specifically interactive art and cultural practices vis-à-vis improvisation, we recognize that an interactive system designed for cultural purposes is expected to behave in an inventive or mildly surprising way with respect to user behavior. The interaction dynamics of the word processor are designed precisely to predictable. Being uninteresting is a virtue in this context. On the other hand, system responses that correspond to variables the user is not cognizant of, create an experience which is indistinguishable from random behavior, and is therefore confusing or simply tedious. Between these two lies a zone of 'interaction poetics'. Christopher Dobrian elucidates a distinction between interactivity and reactivity in terms sympathetic to my approach: " Interactivity is a term too often employed to describe any use of a computer in live performance or installation. A computer might act independently, or might react to human actions (responding slavishly to triggers, or tracking continuous input), but this is not *inter*activity. The prefix *inter-* implies that both human and computer can act independently

and react responsively to the actions of the other. Thus, true interactivity must involve mutual influence, and cannot be all deterministically programmed." [7]

What then constitutes an interesting response from a machine to a human action? One might propose something like a Turing test - it would be similar to the kind of response one might get in a rewarding conversation with an intelligent, informed and motivated partner – relevant yet provocative, propelling the exchange 'forward'. A response which surprises yet tacitly acknowledges the current frame.[8]

Such response are always constrained by the already given structure of the machine system, whose output must be codified in terms of the output modalities it is provided with, usually constrained to two channel audio and presentation of colored pixels on a medium sized flat surface. The system will never juggle, no matter what the context or internal computation. Output is always (already) constrained. You can have any color, as long as it is in the gamut, you can have any note, within the range of the audio output system. (Such constraint on variety is discussed further below.) All computers perform predefined procedures (algorithms) upon a stream of already structured data. Their operations are rule-based and like any engineering pursuit, such rules allow no room for interpretation. An instruction like 'make a jazz noise here' does not compute.

The (poor) legacy of the Fine and Performing Arts

Interactive art practice – that is, arts practices which deploy real-time computing to generate responsive behaviors - is a novel pursuit at the intersection of two historically disparate domains - Engineering and the Fine Arts. One might go as far as to say that these domains have been constituted by their mutual opposition on continua of (ir)rationality and objectivism/subjectivism. Lurking in this pursuit are all the possible pitfalls of any radically interdisciplinary endeavor - and any number of unsuspecting practitioners have fallen into those pits, myself included. Some, regrettably, seem unaware that their domain of practice is in one or other such pits (such a pit might be for instance the implementation of a technical method which at some deep level is opposed to the larger aesthetic politics of the project). The constraints and pressures imposed on practices by the incorporation of computer systems is discussed in more detail below. Here I draw attention to the paucity of useful support for the practice from the domain of the arts.

As systems increased in computational power, and database systems became more tractable, the capability of real-time action over larger numbers of larger files became possible, first in the domain of production then increasingly in the domain of user interaction. This opened up possibilities for the production of dynamical cultural artifacts: artworks that could change their behavior as a result of changes in their environment, as detected by whatever sensor systems they were equipped with. But traditional practices of the fine arts were and had been concerned with the faithful and reliable production of artifacts, images, and sounds, and as such questions of autonomous and interactive behavior and their design and management never arose. Practitioners of interactive

practices therefore were left in something of a theoretical void. Nothing in the theoretical corpus of the fine arts prepares one for the task of designing an artifact which behaves.

Looking further afield in the arts, one finds little more in terms of support. Film and video are as interactive as a freight train. Nothing will perturb the movie from its headlong hurtling down its predetermined track, save outright derailment. Music, dance and theatre likewise, according to convention, are mainly concerned with the reproduction, or interpretation of, symbolic records - the script and the score. In biosemiotics, such a process is called symbolically-directed construction: the symbols, to a greater or lesser degree, dictate the performance, with the composer, playwright, or author dictating the symbols.

Improvisation and Interactivity both occupy marginal positions with respect to conventional arts practices. According to the logic of this paper, these two practices are also linked in the sense that interactivity can be thought of as automated improvisation. Thus it is in these evanescent areas of performative practice, where invention can take place in the moment of practice, that we might look for experience and strategies useful in the construction of interactive art. In what follows, I will discuss improvisation with respect to several areas of technological discourse, including artificial intelligence and artificial life, and will relate improvisation to generativity, emergence, dynamical and self-organising systems, as well as to concepts of responsiveness, creativity, invention, novelty, surprise and play.

Representationalism, performativity and code

The terms representation, representational and representationalism are inflected variously in different theoretical writing. My usage arises from the confluence of AI and cognitive science and their (phenomenological) critiques. Fundamental to a cognitivist view of the world is the idea that human (and other) intelligence operates on symbolic representations of the world. That is, that intellect is not performed upon the world itself in an embedded and ongoing way, but upon abstracted representations of it in a logical space. This is the basic commitment of Newell and Simon's Physical Symbol System Hypothesis, the root document of AI. Such a position is clearly a technical implementation dependent upon the great Cartesian bifurcation between the res cogitans and the res extensa. The most astonishing thing one must observe about this idea, which has influenced Western culture so profoundly, is that it is a fiction without a shred of scientific evidence to support it. This makes its influence in the so-called 'scientific period' all the more inexplicable. One of the ways in which this idea has permeated Western culture is the epistemological commitment to alphanumeric representation not just as a mode of knowledge but as the definitive evidence of the existence or possibility of (that particular) knowledge.

The assumption of such mental representationalism reinforces the authority of extrapolated symbolically encoded physical documents (equations, texts, scores and programs.) Michael Polanyi's dictum that 'we know more than we can say' points in the direction of other sorts of knowledge, and we might extend this dictum to assert that we can say more than we can encapsulate in alphanumeric codifications. Many kinds of arts

and cultural practices, and especially improvisatory practices, inhabit these realms of 'tacit knowledge'.[9] This difference is key to the ontological gap between such practices and academic cultures of (instrumental) text and number.

Andrew Pickering developed an analysis of scientific practice which distinguished between representational and performative idioms. My argument here is that many cultural forms subscribe to this representational idiom, and their practices involve, centrally, translation into and out of the representational, in the form of scores and scripts. Around the edges of these representational idioms persist performative practices which by their nature resist the codification upon which the conventional aspects of the discipline have built their institutional edifices – documents and libraries, publishing enterprises, intellectual property, copyright and licensing fees.

Improvisatory cultural practices have been regarded as – and have perceived themselves as - standing in opposition to master discourse(s). This has to do, I would argue, at least partly with a commitment to the emergent possibilities of an embodied present and a resulting unwillingness to commit to the ossification of the representational. As such, improvisational practices stand as exemplary of a performative ontology. Characteristic of the politics of such practices is a resistance to the process of validation of materially engaged and temporally embodied practice via translation into regimes of symbolic representation – that is, a resistance to the procedures of a representationalist epistemology.

This performative quality is also definitive of (much) interactive art. Whereas in interactivity of an instrumental variety – working with a word processor or navigating the web – interactive actions are designed to be, as much as possible, transparent and automatic, in interactive art, the active commitment by the user to actions, and the experience of effecting such actions and perceiving their results is constitutive of the work itself. Nor would it be useful here to adopt a strict representational/performative dichotomy. There is much representationalism within performance and the performative, and coding is a representationalist pursuit par excellence. Code is a paradoxical object – it is a text and it is a machine. As such it is both representational and performative. It behaves, and it can be generative, but can the behaviors of such code be said to be improvisatory? Or should we say that it is the machine performs the code? In which case code would retain its simple representational status, according to the reified Cartesian binary. But if we cast the hardware as performing rather than simply executing instructions, we disrupt the hierarchy of the dualism.

Another way of looking at the question which is sympathetic to the themes being developed here is that if a machine is solipsistically number crunching, executing code to perform some mathematical calculation (such as pi to a million places) the code/machine complex is utterly deterministic – not unlike a pianola playing a piano-roll. But if the machine has sensors which monitor some aspect of the world through time, then the code/machine/sensor system ceases to be so simplistically deterministic. In fact it comes to have the characteristics we are ascribing to improvisatory practice in the sense that the system will act in accordance with the constraints and directives of the code, but its

behavior will nonetheless be unpredictable to the extent that the data derived from the sensors will be unpredictable.

Improvisation in living

In modern music, dance, theatre - practices which are formalized with systems of textual codification – improvisation is unusual, and where it does happen, it takes the form of a more or less constrained freedom of action within the defined practices of a canon or genre. [10] Further afield from such high cultural pursuits – practices such as martial arts, football (of various sorts), dancing tango, etc - have defined structures, but improvisation is the rule rather than the exception. Improvisation is an integral part of the activity, which involve free action within a set of constraining conventions. In mundane life – gardening, doing the dishes – it's improvisation all the way down. Improvisation, as an informal way of living, characterises much of what people do most of the time, just as most of what people do most of the time is largely routine. It may seem paradoxical to propose that life is characteristically both improvisational and routine. Yet cybernetically and phenomenologically, this seems irrefutable (Maturana,Varela, Dreyfus, Agre). Routines, as part of tacit knowledge, are in some sense inexplicit rules, so the general model of constrained freedom within structured practices persists. Living is adaptation, and adaptation is the application of known and relevant routines to novel contexts. If the idea seems strange, it may be due to the prevalence of a particular notion of intelligence.

An axiomatic assertion in cognitivist psychology is that problem solving is fundamental to human intelligence. Working from ideas presented by Paul Edwards, Les Levidow[11], Philip Agre, Hubert Dreyfus, I propose that this axiomatic assumption, like most, bears examination. Paul Edwards has described in detail the parallel evolution of the cold war mentality and Artificial Intelligence as a (fundable) field of research. More recently Les Levidow has described such a militarized mentality as 'paranoid rationality'. While, as has been discussed above, a commitment to intelligence as logical operations on symbols owes much to Descartes, and to Plato, a notion of intelligence which valorizes logical rule following, planning and 'problem-solving' is evidently related to this diabolical combination of paranoid militarism and artificial intelligence. Dreyfus offered a Heideggerian critique of theories of learning based on cognitivist models. Subsequently Agre proposed an approach to AI rooted not in the assumption that the world is a dangerous place which demands constant cognitive vigilance, but rather in a conception of life as largely routine. The world is not (normally) a site of dangerous 'problems' to be solved, as per the cold war cognitivist construction of intelligence. Contrarily, the world is generally routine and benign, and when novel situations occur, we tend to deal with them by deploying already known problem-solving strategies. That is not to say that we, or other creatures do not solve problems, nor that problem solving is not an indication of intelligence. But contra the cold war anxiety, the world is (blessedly) tedious and novelty is rare. People find situations which are constantly dangerous in novel ways stressful and fatiguing. This is probably why we enjoy opportunities to gently surprise ourselves, though some surprises, like the notice of immanent shut off of the gas or being rear-ended in the car, are unwelcome. And indeed, much of which we take to be pleasurable in play is structured around problem solving.

The flexible adaptation of learned behavioral components to varying mildly novel situations is, one might suggest, a key aspect of the exercise of human intelligence in the world. The groceries will always be bagged, but the packages are never quite the same in size, shape and number. Likewise, the dancer makes a new combination of movements in relation to a novel context, but the component actions are already known as sensorimotor routines and seldom exceed that range of capability, otherwise injury can be expected. Moreover, limbs do not suddenly change shape and new limbs do not sprout.

The improvisatory Umwelt

Pioneer ethologist Jakob von Uexküll gave the term umwelt (life-world) to the experiential world of a creature. He proposed that the richness and dimensionality of the world of each creature is given by its temporal and physical scale and its perceptual and sensori-motor capabilities. Various creatures can inhabit the same 'place' (we may postulate an objective 'place' but its full extent is experientially unknowable to its inhabitants – due to their limited suite of sensors. These umwelts may intersect, in which case that can identify the same things. Some animals construct their umwelts via senses others do not have- the infrared sense of some snakes, the echolocation of bats. However, creature may also cohabit the same 'place' and be unaware of each other because their umwelts do not intersect. Dogs and people can identify the smell of a barbecue but the question of whether that odor 'means' the same thing for dogs and people takes us into the territory of Gibsonian affordances. Our olfactory umwelt is a subset of that of dogs. We recognize that the olfactory worlds of dogs are far richer than our own but we have no way to enter those worlds. [12]

Our perception of improvisation is thus constrained by our biologically determined perceptual capabilities and timescales. Dogs may have a highly developed olfactory art-form. A tree might fairly be said to be improvising when it sprouts leaves according to the seasons, the movement of the sun and adjacent areas of shadow cast by other (similarly improvising) trees. Likewise, slime molds and communities of bacteria perform delicate improvisational dances in relation to changing bio-physical contexts. But the performances of the bacteria, the slime molds and the trees are out of our perceptual range in terms of temporal and physical scale. One might make similar observations about the growth of cities and towns. What of the activities of the painter? Can we say that a painter is engaged in a slow solo improvisation as she paints? [13] One might ask why I am pursuing such seemingly absurd questions. It is to forge a link between improvisation and notion of adaptation and emergence in biology and artificial life. While cultural pursuits such as Carnatic improvisation involve sophisticated mentation, we might usefully drop our anthropocentrist guard for a moment or two to consider creative invention amongst other species. Such connections will then provide a nicely triangulated context for discussing the behavior of (computational) machines which produce behaviors capable of emulating or resembling improvisatory behavior.

Rules, Logical Frames, Surprise and Play.

Improvisation in the sense we have been discussing is performance in which the performers - vis-à-vis preset scores, scripts, rules, cultural and artistic conventions - have a freedom or action which is itself constrained. One improvises within a defined domain. Infinite improvisation looks like chaos, or the world. One may play strange notes, but it is inadmissible to pour glacial nitric acid into the horn of your partners' saxophone. You may play soccer but it is unacceptable to shoot the ball with a bullet from a gun. I may improvise with the materials from which I build my house, but only from within the frame of viable materials - soap bubbles and birthday cake are out.

Improvisation is a structured opportunity for constrained surprise, a game of exploration and experimentation. Any realm of improvisation implies a frame, a domain. Canons and genres are quasi-logical domains – contexts with axioms, frames and rules. A domain has a language which is operational only within that domain. A more encompassing language is required to move outside the domain in question, into a domain in which the domain in question is then a subset.

Creative practices are of two types with respect to such domains – the manipulation of formal variables within the frame, or the breaking of the frame. All manner of watercolor paintings are possible, but an attempt to make watercolor painting three dimensional would go beyond the conventional frame. We might call the former a combinatoric kind of invention. The latter - an intentional pushing at the genre envelope - has been the modus operandi of avant gardism throughout the twentieth century. In some case this has been an almost algebraic process of inversion of a single term in an equation – contesting representational ism in painting or contesting the 'fourth wall' in theatre.

Artificial Intelligence and machine creativity

Questions of machine creativity arose at lest as early as the postwar cybernetic period (i.e. von Neumann's self reproducing automata). In the AI community, this debate was the basis of a division between the so-called 'neats' and scruffies'. The work of Roger Schank in natural language understanding and story generation is emblematic of the 'scruffy' heuristic approach, while the work of John McCarthy is representative of the 'neat' school. While this division is crucial within the AI community it is seldom made explicit outside the field. In general the neats were concerned with the automation of purely logical reasoning, while the scruffies were preoccupied with the emulation of human capabilities (heuristics).

More recent perspectives cast doubt upon the possibility of truly creative actions in a machine whose operations are limited to the manipulation of pre-defined symbolic tokens on the basis of Boolean logical rules. Around the late 80s, significant cracks were appearing in the edifice of 'good old fashioned' AI, as indicated by the 'symbol grounding problem' (Harnad) and the 'frame problem' (McCarthy and Hayes) which are related questions of implicit knowledge and 'common-sense'. Hubert Dreyfus and others offered related critiques. In recognition of the stymied hopes for generating computer-based creativity via Artificial Intelligence methods, a central concern in the new field of Artificial Life (AL) was the development of mechanisms for generating novelty by simulating biological processes. This return to biological models – often covertly –

reintroduced ideas from cybernetics back into circulation – ideas of adaptation, emergence and self-organising systems.

The notion of creativity has affinity with emergent order and emergent novelty, and more generally with 'self-organizing system' terminology that immediately links the idea with pre-digital cybernetic/systems-theoretic thinking. Loosely speaking, a self-organising system is one which manifests new organisation de-novo. Roughly contemporary with the heyday of AI, cybernetics took a philosophical turn in what is usually referred to as 'second order cybernetics', which took up the implications of the observing subject as a key concern. This concern is memorably captured in the maxim of Heinz von Foerster "Objectivity is a subject's delusion that observing can be done without him", a postulation closely paralleled by Humberto Maturana's remark that "Anything said is said by an observer." [14]

Artificial Life, Emergence and Surprise

Artificial Life confronted the question of 'creativity' in synthetic systems in quite a different way from the way AI previously had. The question 'can a computer be creative?' was not in this case reduced to inference procedures but was connected to the emulation of duplication of emergence and specifically emergent complex behavior and self-organisation in digital environments. Improvisation, surprise, emergence, generativity, creativity, novelty are all explicit or implicit in Artificial Life literature. In the discourse of complexity, self-organising and dynamical systems, 'surprise' is conceived of as 'emergent' – an arising of (meta)properties which were not previously present in a system. The key quality of 'emergence' is that it is fundamentally non-reductive. Emergent phenomena arise out of and are constituted by underlying processes, but the behaviors and categories of phenomena manifested therein are autonomous from the underlying processes, and irreducible to them. Oft cited examples include the complex collaborative behaviors of colonial organisms such as sponges and slime molds; the architecture of termite mounds and the arising of consciousness from neural structure.

Artficial Life was a heterogenous field which included several research areas pertinent to this discussion. We might identify these as: evolutionary dynamics; reactive robotics; social organisms; connectionism and neural networks. [15]Artificial Life claimed to create, simulate or be modeled upon 'life'. Chris Langton, an early spokesman spoke of 'not life as it is but life as it could be'. Within the community, 'hard' and 'soft' positions referred to whether one deemed such phenomena to be actually alive or simply life-like. The question of the scale and the range of possible variety available within the 'computational' vis a vis the biological thus required some attention. So much AL research was concerned with computational simulation of 'life', and so computational processes which were life-like, such as cellular automata, were of great interest. On the other hand, the Wet Alifers were concerned with doing things to/with living organisms - the new field of synthetic biology is an offshoot of this subfield.

Self-evidently, evolutionary dynamics are engines of variety generation, and the techniques of genetic algorithms and evolutionary computing were developed to simulate

some of the aspects of development through biological evolution. The work of John Holland and Tom Ray brought previous work in computational modeling of genetics to a larger AL audience. [16] Like any simulation, situations were idealized, simplified, abstracted, analogised. Such systems often implemented a process of mutation and selection over many generations. They do, however, generate unpredictable novelty, which is a source of continuing fascination. But 'evolution' occurred in a teleological sense, towards a (predefined) goal state, defined by 'fitness criteria'. Each generation would be culled to a few individuals who came closest to the fitness criteria.

A focus on the behavior of simple animals and insects led to the reactive robotics of Rodney Brooks et al. As Brooks observed, it was bald-faced hubris to imagine we could build a human-like machine intelligence if we could not build a machine with the capabilities of a cockroach. Likewise a variety of biological systems (social organisms) and non-biological systems which demonstrate 'emergent complex behavior' came to have special importance in AL circles. A fourth area of (renewed) interest was connectionism and techniques such as simulated neural networks. In general the AL fields of inquiry focused upon mechanisms for generating novelty, including phenomena such as consciousness and 'intelligence' that might be understood as more associationist than deductive.

In all this work, deeper questions of what constitutes 'novelty' or 'emergence' begged clarification. The term 'emergence' is often applied loosely, and one man's emergence is another man's predictable if complex system. [17] If Artificial Life is about surprise, then the question of what constitutes surprise had to be asked. Over several decades, Peter Cariani has provided some analytic precision by deploying systems-theoretic approaches to analyse various categories of 'emergence' in the context of robotics and artificial life. Cariani (2011) makes the primary distinction between what he terms 'combinatoric' and 'creative' emergence. [18] These categories correspond to the notions discussed above of operating within a framework of set constraints vs. creating new frameworks. Combinatoric emergence consists in the recombination of existing symbol primitives, which brings us back again to Gödel. This is the kind of emergence which can be pursued in software systems. Although this space can be large it is countable and not infinite. Creative emergence requires the generation of new primitives – in the computer world this would correspond to the development of, if not new hardware then new procedures.

The limits proposed by Cariani - consistent with phenomenological critiques of AI, the frame problem and the symbol grounding problem (Harnad) - concerned the given-ness in ALife of the silicon 'hardware substrate' and the flexibility (via evolution) of the 'hardware substrate' in biology. [19] Cariani develops the notion of the ability to evolve new sensors as generally exceeding AI and AL techniques, although evolvable hardware has been pursued with some limited success.[20] The idea of evolvable hardware comes close to von Neumanns' grail of the self-reproducing robot/automaton. The conception of combinatoric emergence suggests an isomorphic fit between improvisational procedures and computational procedures. Cariani's 'creative' category can then be identified with the community of new instrument makers (acoustic, electronic and digital) who have followed in the path of Harry Partch – new hardware substrates for new behaviors.

Clearly all existing (all possible?) software-based generative and interactive systems depend on combinatoric emergence. One might ask – Is this sufficient? To focus the question in the context of our current concerns we might also ask – do improvisatory practices broach the combinatoric/creative barrier or do they fit into the category of combinatorial emergence within a general taxonomy of emergence? In general, improvisatory practices remain genre-bound and thus in the realm of the combinatoric. In certain cases, improvisatory practices have generated entirely new genres – the case of the Living Theatre comes to mind, as well as some live-video based improvisatory practices of the 70s (Wegman, Acconci, Campus).

But such genre-busting events are rare and sporadic, like successful mutations. (An analogy with Gouldian punctuated equilibrium seems apt). When these breakthroughs do occur, they are found to be disturbing and disorienting, at least until new worldviews can be grown around them. The growth of new worldviews – like the stabilisation of an ecology around a new or introduced species – is roughly comparable to a second key idea in Cariani's analysis, which is itself rooted in the second order cybernetics of von Foerster et al (Cariani also cites von Glasserfeld). This idea is 'emergence relative to a model', the notion being that the occurrence of creative emergence is only palpable when the behavior of the system becomes inexplicable according to the descriptive or explanatory model deployed by the observer. This model is an externally imposed reference and must be known and shared for the behavior to be perceived to be improvisatory. The point relevant to the current context is the necessity of a preexisting (and shared) model, representation or frame of reference for improvisation to 'make sense'. The response 'it doesn't make sense', 'it's just noise' implies the lack of a shared model between actor and observer.
The problem with a machine which possessed 'creative emergence' then would be that it would constantly exceed our capability to conceptualise its frame of reference – it would be confusing and as such would likely exceed the psychological comfort zone of any particular viewer/users and the experience would be perceived as unpleasant [21] – not unlike the experience (for many) of Survival Research Laboratories (SRL) or the Catalan performance group La Fura Dels Baus.[22]

The generative and the improvisatory.
What is a generative system? A novel with two possible endings can hardly be regarded as generative, nor can a 'choose your own adventure' book. The range of possibilities are firmly encoded in ink on paper, any 'surprise' quotient is minimal and predefined. The surprise is written on the page, its just waiting for you to read it. Card games, (poker, bridge or 500) are generative, but only within the combinatoric range of the existing cards and the established rules -you'll never get an eleven of diamonds. A computer poker game is generative only in the most trivial sense: if a normally large computing device happened to have stored all possible outcomes, how could we tell? A random number generator (or a pseudo-random number generator – who can tell the difference?) is generative, but its hardly interesting – at least to creatures like us. So what constitutes interest? Some kind of pattern and some kind of development? That is, meta-patterning: establishing a pattern, then breaking it, only to develop a larger pattern of which the prior

smaller pattern and its breakage can be seen to be a part. This sounds like a compositional strategy - a language is established, its rules are broken, producing a phase of incomprehensibility, then a new rule set is established which includes the rules of the first pattern and the 'rules' of the breakage.

Improvising agents improvising interaction

As suggested above, sophisticated behavior is a necessary precursor of interesting interaction. But that is not to say that to be interesting, an interactive artifact must have sophisticated interaction dynamics. The interest maybe elsewhere, ie: in the 'content', in the aesthetic qualities of visual and acoustic effects, etc. The least theoretico-aesthetically sophisticated improvisatory/interactive systems depend simply upon queriable databases as sources of output. The paradigm that has become dominant in computer gaming is not much more sophisticated: the pursuit of a higher score or a speedy transition to the next level in some domineering architectonic virtuality. Certain (more interesting) kinds of interactive system are conceived as active and provocative participants and some systems construct the human participant as actively inventive. With the foregoing as background, the following roughly chronological survey identifies a range of what we might call behaving aesthetico-technical systems or autonomous cultural agents. The list is by no means exhaustive but these works exemplify concerns discussed above, particularly in the way they elaborate modalities of improvisatory action or interaction.

Some of the works here manifest complex behavior but are not 'interactive'. Improvisation in the human domain can be a solitary pursuit, or it can involve two or more performers simultaneously. The idea of time-displaced improvisation seems to make little sense – something in the past cannot respond, and real-time response seems fundamental. Given the issues touched upon above regarding the status of code as both representional text and performative machine, there is a set of curiously deep questions regarding how we cast the machine – as an improviser-performer, as a time-displaced representation or avatar of the composer/programmer, or as a spatially displaced avatar - or performer, in the case of telematic performance. Some of these questions are clarified in the following examples.

The Musicolour of British cybernetician Gordon Pask (and collaborator Robin McKinnon-Wood) was the first machine system for which real improvisatory capability was claimed. Musicolour was substantially developed between 1948 and 1952. Consistent with Pask's general theory of interaction, this improvisatory behavior, which was constituted by light patterns, was conceived as acting in both a responsive and creative manner in engagement with a similarly inventive human musician. Because no actual record survives, what the Musicolour actually did is not known with precision, but one can assume certain kinds of behaviors based on the vintage of the technology, the standard electronic techniques of the time and the known behaviors of related machines – such as Ashby's Homeostat and Walter's Turtles.[23] Musicolour's behavior was likely a combination of coarse band filtration of the audio signal, analogous tracking of dynamics, time delay and, as Pask states, a capacity to become 'bored' – which probably amounted to a behavior change based on an accumulating charge on a capacitor. There is

tantalizingly brief mention of a 'sequence of operations' and an 'adaptive threshold device' which suggests something more complex. There is reference to 'symbols' but not to 'programs'. 1948 was the year the Manchester 'baby' ran its first program, so while Pask may have been familiar with the thinking behind early stored program computers, Musicolour appears to have been substantially analog. Behaviors were likely hardwired analog circuits with electromechanical elements (relays and servo-motors). The method by which new 'behaviors' were selected was probably some semi-random switching akin to the mechanisms of Ashby's Homeostat.

Von Neumann called Ashby's Homeostat a 'machine to think with', and we can surely say the same of the Musicolour in the realm of the automation of aesthetic invention. It would be hubris to imagine that such systems were necessarily primitive in their behavior just because the technology appears primitive to us. In recent years, many far more trivial automated amusements have been made with digital technologies which are orders of magnitude more complex. In any case, Musicolour seems to have been a fairly richly endowed autonomous aesthetic agent which shared the stage as it were as equals with a human performer. There is little here of the more common paradigms of the information vending machine or the automated accompanist. Musicolour was, as far as we can tell, not simply a pioneering work of interactive art but an improvising machine.

An early example of digitally implemented embodied improvisatory art is David Rokeby's Very Nervous System (1988). While Musicolour generated light in response to music, VNS generated music in response to light – primitive video of a user's gestural movements. VNS used simple machine vision (camera tracking) to create real-time acoustic accompaniment (assembled from stored samples). The system cannot be said to have possessed significant generative behavior (it did not compose melodies), but the behavior of users was collaborative, exploratory and improvisatory as they attuned their movements to the sensitivities of VNS. As in the case of many interactive installations, the rapid adaptivity and inventive play of users quickly becomes the most interesting aspect of the work. While much interactive art hews to scopophilic conceptions of spectacle, there is a class of interactive art which has the interesting effect of turning the users' attention and the attention of onlookers toward their own behavior.

Contemporary with VNS is George Lewis's Voyager (1986-88) – a software-based interactive computer music system explicitly conceived in the spirit of "a nonhierarchical, improvisational, subject-subject model of discourse" [24]. Informed by the multi-instrumentalist improvisatory practices of the AACM,[25] Voyager generates its own musical output in the absence of a human performer, and therefore provides a human improvising partner with provocative interventions. Lewis is emphatic that "with no built-in hierarchy of human leader/computer follower—no "veto" buttons, footpedals or physical cues—all communication between the system and the improvisor takes place sonically".[26] Voyager is a case of a virtuosic system designed for use by virtuosos. Much interactive art is designed with the assumption of an unskilled or untrained 'public' as opposed to highly skilled users who may well be the author of the system as well. This changes the relationship between human and machine dramatically.

Avolve (1994-95) by Christa Sommerer and Laurent Mignonneau [27] was one of several notable interactive 3D computer graphic works directly inspired by Artificial Life. In Avolve, users create a rudimentary simulated aquatic organism in a graphical editor interfaced by a touchscreen. The created creature is then released into a pond to swim and compete with other occupants. One looks down on the pond, which is a horizontal projection surface covered with a few inches of water.

Technosphere (1995) - Jane Prophet, Gordon Selley et al.[28] Technosphere was a richly elaborated internet-based virtual wilderness park. Works like Technosphere brought together developments of the previous decade in evolutionary computing and genetic algorithms, real-time 3D graphics, procedural and fractal based modeling along with nascent web-based technologies. As with Avolve, users could build creatures and release them into the world, then could track and visit them. Technosphere was a visually rich realization of the kind of net-based digital wilderness park which Tom Ray had called for just a few years before. But while Technosphere was a visually rich simulated natural terrestrial world – with a real world physics (gravity etc), Ray's proposal was for a 'digitally natural' environment in which the relevant physics involved memory allocation, processors cycles and baud rates, and the expressed goal was to create a space where potentially useful algorithms could evolve – to be later harvested. Rays proposal thus had more in common with the malevolent kinds of digital vermin we often have to deal with: viruses, worms and trojan horses. Karls Sim's Evolved Virtual Creatures (1994) which competed to achieve goals occupy similar territory. [29]

It is appropriate here to mention Sympathetic Sentience, a work by Simon Penny and Jamison Schulte (1996). [30] While inspired by discussions of emergent complexity, Sympathetic Sentience aimed at creating a hardware electronic environment which exhibited emergent behavior. Indeed, there was a desire to contrive the most minimal physically instantiated system capable of manifesting such behavior. The twelve units in Sympathetic Sentience communicated in a one-way serial loop, like a game of Chinese whispers (also known as telephone). Alone, each unit could only generate a single chirp at regular but semi random intervals, but in collaboration, this community of simple electronic organisms manifested emergent behavior. While the serial loop persisted, the system, and each unit, demonstrated unpredictable, constantly changing but melodic and rhythmic behavior. After an initial startup period, the ongoing sound sequence maintained about 50% saturation, that is: over any time period, the total duration of silence was always roughly equal to the total duration of sound. This quasi-stability was a surprisingly complex (emergent?) consequence of the presence of XOR gates at every node.

Façade by Mateas and Stern (2005) is a project which engages an untrained user in an ongoing improvisatory verbal/textual exchange. Façade is an interactive story, a drama for three characters, one of whom is the user – the other two are software agents. The scene is always the same, Grace and Trip are having relationship difficulties, and the user plays the role of an old friend who visits, unaware of the state of their relationship. The drama plays out in different ways but the action always conforms to a dramatic arc. Façade is a successor to the projects of Joe Bate's Oz group at Carnegie Mellon in the

90s. The Oz group was concerned with the development of interactive drama and believable agents, constructed with sophisticated AI techniques. Façade is designed to conform to a conventional and wellknown structure like any episode of a soap opera. Within this constrained context, the user can make interventions and the (software) characters respond and interact with the user and with each other, but there are rules of exclusion and 'illegal' responses in Façade.

Silent Barrage is a cyborgian organism with a sculptural and robotic physical body connected via internet to its remote brain which is an electronically interfaced array of cultured rat neurones. [31] As such Silent Barrage clearly reifies a Cartesian brain-body separation, though the brain is clearly material and biological. The brain - cultured by Dr. Steve Potter at the Laboratory for Neuroengineering at Georgia Tech, in Atlanta - receives information extracted from video regarding the movement of visitors among the grid of poles which constitute the body of the cyborg, and sends back data which is inscribed upon the poles as a record of behavior in the space. Begun in 2006, the main collaborators in the project were Philip Gamblen, Guy Ben-Ary, Peter Gee, Dr. Nathan Scott & Brett Murray, all affiliated with the Australian Bioart lab SymbioticA.

Jon McCormack is an artists and computer scientist with a long history of Artificial Life projects dating back to the early 1990s. His current work in the area of autonomous social behaving systems is exemplified by Eden (2004) : [32] "Eden is an interactive, self-generating, artificial ecosystem. A cellular world is populated by collections of evolving virtual creatures. Creatures move about the environment, making and listening to sounds, foraging for food, encountering predators and possibly mating with each other. Over time, creatures evolve to fit their landscape."[33]

The generation of poetic or narrative text has a venerable place in the history of computer programming. [34] One of the first working computer programs wrote love letters. 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.[35] Its computational strategies were simple, and computational poetry generation has taken many forms since, notably radical among them is the hypertext poetry of Jim Rosenberg.[36] As an aside it is curious to note that over the same period the Oulipo group of authors (including Calvino, Queneau, Perec et al) pursued algorithmically constrained literary techniques, but the two communities do not seem to have converged till later. It is important to note that this sort of text generation gave rise to the first interactive software agent or 'bot' - Weizenbaum's Eliza. Eliza is the 'Eve' of all chatbots. More recently, the Griot system (2005) built by Fox Harrell, in association with Joseph Goguen, is a performative poetry generator based in the 'concept blending' of cognitive linguists Fauconnier and Turner.[37] Concept blending theory proposes a process for the generation of new concepts via 'blends' of existing concepts, the standard example being the generation of variants 'boat-house' and 'houseboat' from 'boat' and 'house'. This idea links back to questions of improvisation and emergence as neurologically improvisation and fluent speech occur in the same parts of the brain. The phenomenon of concept blending is clearly combinatoric in the Carianian sense.

Another work which utilizes quite different technologies to generate text is David Rokeby's Giver of Names (1998-). [38] Give of Names utilizes an associationist network with machine-vision front end. The system first extracts qualities of observed objects, then these qualities are "'radiated' through a metaphorically-linked associative database of known objects, ideas, sensations, etc."[39] The musings which are generated can sound absurd, psychotic or philosophical.

Conclusion – It's all about agency

My larger purpose has been not to recap a history of improvisatory machines, but to help to enrich discourses around computer-based interaction by considering what designers of digital interactive systems can learn from existing improvisatory practices. If improvisational practices open a space for skilled play and real time response to changing scenarios, then a lesson can which be learned in interaction design is that enhancing the users sense of agency is always a good thing, but the sense of agency is not constituted by undirected liberty, but by having a purpose and a sense of knowing the right thing to do, the right kind of thing to do, or the best choice of possible actions is a given situation and the autonomy/freedom to choose a particular direction (or action).

Well into the final draft of this essay, I obtained a copy of a paper "The Secret Love between Interactivity and Improvisation" by George Lewis, of which I was previously unaware. In its conclusion he says – "If we allow interactivity and improvisation to finally consummate their relationship through an interdisciplinary study of how meaning is exchanged in real time interaction, combining the insights of artists, cultural theorists and technologists, we could witness the development of far more powerful new user interfaces engaging new forms of art and more sophisticated interactive computer applications."[40] It is in precisely that spirit that this essay has been written.

Simon Penny, July 2011.

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Endnotes

[1] Lewis, George E. "The Secret Love between Interactivity and Improvisation, or Missing in Interaction: A Prehistory of Computer Interactivity". In Fähndrich, Walter, ed. *Improvisation V: 14 Beiträge*. Winterthur: Amadeus (2003), p195

[2] in much the same way that 'you are the product of television' as the famous reflexive video art work 'television delivers people' by Richard Serra and Carlotta Fay Schoolman put it. http://www.youtube.com/watch?v=nbvzbj4Nhtk

[3] The 'science wars' was the name given to the acrimonious debates of the mid 90's between some in the sciences and some in poststructuralist theory, which centered on whether scientific knowledge was absolute and objective or culturally constructed.

[4] "On my agential realist elaboration, phenomena do not merely mark the epistemological inseparability of "observer" and "observed"; rather, phenomena are the ontological inseparability of agentially intra-acting "components." That is, phenomena are ontologically primitive relations—relations without preexisting relata." Barad, Karen. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter". *Signs: Journal of Women in Culture and Society*. vol. 28, no. 3. The University of Chicago, 2003 .p15

[5] In higher end systems, research into computer based sound and music predates computer graphics.

[6] Penny, Simon. "Experience and Abstraction: The Arts and the Logic of Machines". *Fibreculture* 11, 2008. http://eleven.fibreculturejournal.org/fcj-072-experience-and-abstraction-the-arts-and-the-logic-of-machines/
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[7] He goes on to say: "In a truly interactive instrument, the computer will have the capability to act independently and to react indeterminately to input. These characteristics are inherently contrary to an attempt to produce a fully controlled, determinate, predictable work of music. One can program an instrument that responds in a known manner to all likely input data, but that is just reactive, not interactive." Dobrian, Christopher. "Aesthetic Considerations in the Use of 'Virtual' Music Instruments".

[8] Penny, Simon. "Towards a performative aesthetics of interactivity". (forthcoming, Fiberculture, 2011 ed Ulrik Ekman)

[9] Polyani, Michael. *The Tacit Dimension*. London, Routledge. 1966.

[10] That is not to say that there is not a fractality of micro-improvisation on the level of nuance, gesture, emphasis, tone.

[11] Levidow comments: “Marcuse extended Marx's concept of ideology to technological rationality. He attacked Max Weber for idealizing instrumental rationality as a value-free, calculable efficiency: such an ideology legitimates a specialized administration which dominates nature and humanity by reducing relations to quantifiable things. Everything is reduced to the administration of things: 'a reification of reason, reification as reason' (Marcuse, 1978, pp. 205, 217).” Levidow, Les. “The paranoid rationality of the gulf massacre”
http://90.146.8.18/en/archives/festival_archive/festival_catalogs/festival_artikel.asp?iProjectID=8615

[12] Philosophical dimensions of this were taken up by Nagel. The focus of sensori-motor specificity is key to modern neuroethology and also to phenomenologically inflected schools of embodied cognitive science.

[13] * the **Alan Resnais** film of Picasso painting

[14] Or as I more recently quipped – ‘objectivity is in the eye of the beholder’.

[15] I refer to Artificial Life in the past tense as the field has dissipated and diversified.

[16] Key figures in this work were Alex Fraser , Lawrence J. Fogel, Ingo Rechenberg and Hans-Paul Schwefel.

[17] Cariani, Peter. “Design Strategies for Open Ended Evolution”. *Proceedings of the Eleventh International Conference on the Simulation and Synthesis of Living Systems* Eds Seth Bullock, Jason Noble, Richard A. Watson and Mark A. Bedau. MIT Press. 2010, 94-104.
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[18] Cariani, Peter. “Creating new informational primitives in minds and machines”. *Computers and Creativity*, eds. Jon McCormack and Mark D'Inverno. Springer Verlag (forthcoming 2011)

[19] The very existence of the hardware/software dual is of course, an axiomatic construction which is quite as dubious as its Cartesian model (see my ‘Towards a performative ontology’).

[20] ie by Adrian Thompson: http://www.cogs.susx.ac.uk/users/adrianth/ade.html

[21] Wundt curve

[22] http://www.srl.org/ , http://www.lafura.com/web/index.html,

[23] As far as I know, little persists except some black and white photographs and Pasks’ own reports. There are first hand third party reports, no recordings, and the machines have not survived.

[24] Lewis, George E. “Too Many Notes: Complexity and Culture in Voyager” *Leonardo Music Journal*, Volume 10 (2000) MIT Press p34.

[25] Association for the Advancement of Creative Musicians

[26] Ibid p36

[27] http://www.interface.ufg.ac.at/christa-laurent/WORKS/FRAMES/FrameSet.html

[28] http://en.wikipedia.org/wiki/TechnoSphere

[29] http://www.karlsims.com/evolved-virtual-creatures.html

[30] http://www.simonpenny.net/works/sympathetic.html, http://www.simonpenny.net/works/sympatheticII.html

[31] http://www.silentbarrage.com/

[32] http://diotima.infotech.monash.edu.au/~jonmc/sa/artworks/eden/

[33] http://www.csse.monash.edu.au/~jonmc/projects/eden/eden.html

[34] McHale, Brian "Poetry as Prosthesis" *Poetics Today* - Volume 21, Number 1, Spring 2000, Duke University Press. 1-32

[35] "loveletters" wrote appalling love letters such as the following:

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. – see http://www.alpha60.de/research/muc/

[36] http://www.well.com/user/jer/

[37] http://cseweb.ucsd.edu/~goguen/projs/griot.html

[38] http://homepage.mac.com/davidrokeby/gon.html

[39] http://homepage.mac.com/davidrokeby/gon.html

[40] Lewis, The Secret Love between Interactivity and Improvisation, p203