Bridging Two Cultures : Towards an Interdisciplinary History of the Artist-Inventor and the Machine-Artwork.

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This paper is dedicated to Jack Burnham, whose work Beyond Modern Sculpture presciently engaged many of the issues discussed here.

"You need a mellow, elegant, South Kensington period in developing any cybernetic art form" Gordon Pask.ⁱ

The goal of this paper is to assert the historical validity of a consistent tradition of practice which exploits emerging electronic and mechanical technologies for cultural purposes. Due to its inherently interdisciplinary nature, this tradition can be fully understood *neither* within the terms of conventional art historical discourse nor within the terms of discourses of technological research and development. ⁱⁱ

It is interdisciplinary because it pursues technical research which exceeds the constraints of the objectivist-positivist pursuit of knowledge per se and likewise exceeds the base constraints of production of technological commodities for market, because it is motivated by and integrated into larger socio-cultural flows.^{III}

In truth, many of the innovations in science and technology, arose from a passionate commitment to specific causes or ideas. The drive to invent and the drive to create are, at root, almost indistinguishable. But scientists are taught to discount motivations which exceed the positivist quest for knowledge, while artists have no such constraint, and in many cases, will shun facticity as didactic.

As a way of loosely marking out this history I will discuss some significant works and makers. My goal is not to dwell in depth on these, but to take them as reference points in order to explore some of the challenging questions this tradition raises. I want to

emphasise the historiographic nature of my intervention. In my opinion, it is not sufficient to discuss these practices in the discursive terms of traditional art history, nor is it generally possible to recuperate it into a traditional representational aesthetics of the plastic arts or of film studies.^{iv} Nor has such work and such an interdisciplinary perspective on technological research for cultural ends ever been part of conventional histories of science and technology. Thus, such histories, like the practices themselves, have fallen between the cracks, and have largely disappeared. These practices cross-fertilise artistic and technological methodologies and agendas in a way which demands the formulation of an historical and theoretical approach which is adequate to the task and thus require a rigorous transdisciplinary approach to this history.

I have made the argument that such practitioners - meta-engineers and techno-artists - with respect to the size of the population, and their access to resources, have made contributions to technological discovery which in both their quality and quantity, are extraordinary.^v I maintain this position, and will cite some examples here, but I do not want it to be understood that I take this as the ultimate validation for the practice. This would fall into line with what I have previously identified as the Media Lab apologia: the recognition that artists can be both smart and useful (who knew?) because they "think out of the box". This is a simplistic analysis of the value of art methodologies, but is also reduces the value of their work to an instrumental commodity-capitalist rationale. Such cultural practice therefore cannot be assessed purely as technological R+D without doing violence to the phenomenon, nor can it be assessed in terms of the traditions of production of aesthetic artifacts without the same consequence.

Many of the characters in stories of technological origination appear as rugged individualists, irascible outsiders. Outsider status is inevitable if one is to aspire to goal not shared by a larger professional community or social group. Certainly Tesla, Goodyear and many others are characterised this way, while others, such as Daguerre, Bell, Morse and Edison, seem to have escaped such characterization. (Alliances with the wealthy and powerful has more than a little to do with the narratives which are deployed).

The emergence of any technological cultural form, be it photography, television or networked gaming, always involves a highly skilled and motivated community of toolmakers. In their contemporary context, such technical heroes sometimes enjoy transitory fame. But when technologically and commercially consolidated, their particular contributions and motivations are seldom noted, except in specialized studies^{vi}.

Individualism and Collaboration

The conventional portrayal of the modernist artist, alone in his garret, belies a commitment to the exploration of 'individual' inventiveness. In its excesses, it leads to cults of genius and originality, and even to the celebration of the value of certain tortured psyches over others. The positive influence of these ideas leads the works of my chosen subjects to have, for all their failings, a conceptual and structural coherence which is the necessary outcome of an integrated holistic process. Such practitioners tend to regard the particular technologies they work with as their medium, and thus have or aspire to a deep familiarity which leads to fluency. The desire to avoid outsourcing technical components or tasks, as usual among collaborative groups of specialists typical of technical and scientific research, or more broadly as in the commercial world, grants the artist the capacity to hold macroscopic and microscopic views of the project concurrently. This works against the modularity of black-boxing, and reliably results in a more aesthetically coherent totality.

Beyond the ghetto of visual arts, cultural and technological practice is more often pursued by collaborative groups of practitioners. Most scientific research occurs this way, as does theatre, filmmaking and architecture. Increasingly, it is seen as a necessity in techno-cultural production. In contemporary practice, the ethos of Open Source has introduced a third, viably anarchic way, which offers an alternate ethos to both the cult of individuality in the arts, and the hierarchical corporate mode. This is the zone where such art-practice intersects with techno-activism and tactical media in highly productive and provocative ways, exemplified by the anonymous collective Institute for Applied Autonomy (IAA).

It may also be argued that collaboration has been necessitated by the unwieldy prototypical nature of the technologies cobbled together to achieve goals in the first decades of digital arts production. As the landscape of techno-cultural production settles, increasingly conventionalised practices, such as web design and 3D animation, avail themselves of increasingly well-attuned tools. Yet there will always be a community whose aspirations are located at the edges and interstices of technological capability, and these people will necessarily not have access to refined, purpose built tools. The artist-engineer partnerships of EAT are early exemplars of such a condition.

The gradual development of finely attuned tools leads inevitably to another state which has its own constraint, that of the "end-user". In media art increasingly, the majority of practitioners are inclined to accept a pre-constructed 'tool' as an environment, and to explore the richness of creative possibilities therein – the software package creates a genre - 'flash animation' or 'jitter video'. The class of practitioner I want to focus on is a different one. While the 'user' asks: "what can I do with this technology", such a practitioner ask: "what constellation of technologies, existing or imaginable, will suffice to achieve my goals". Such a process implies the rigorous engagement of technological R+D, but severed from its usual instrumental motivations. This approach should not be regarded as eccentric. Contrarily, the current condition of the media arts should be regarded as bizarre. For hundreds of years, artists and artisans have refined their tools and media in constant back and forth play between physical properties and aesthetic goals. Oil paint, that cutting edge visualization technology of a bygone era, was developed by the people who knew their requirements best: painters. We now accept an odd situation where we review tools developed by a technical community, in order to ascertain how we might exploit them.

In light of this introductory framing, I suggest that the following assertions about the history of these practices can fairly be made:

- There is a consistent history of culturally motivated technical research dating back centuries. Indeed, in the time of Francis Bacon, science and art were seen as complementary and not oppositional. It is only at the early stages of the industrial revolution when 'cultural' and 'technical' practices became separated, as 'technics' became largely identified with emerging industrial capitalism.
- Because disciplinary borders bisect and dissect this practice, a range of practices and practitioners fall into the chasm and thus a useful history remains to be written.
- Technocultural artifacts developed by this community consistently precede the cultural and technical imagination of their society, and of academic/industrial research by a decade to a generation. An example is Google Earth

(<u>http://earth.google.com/</u>), almost precisely the same project as *Terra Vision* by German media art/design group Art+Com in the early 1990s. *Senster*, discussed below, is another -notable case.

- 4. Many of these breakthrough inventions become fundamental to new industries or new social practices (paradigmatically, photography). When they are commercially deployed, however, it is usually in utterly different socio-cultural milleu, such as broadcast television or commodity electronics. This has the effect of breaking a chain of attribution to the originator, and usually separates the technical performance from the aesthetic function. Much of the (largely 1970's) development of novel video synthesis by Woody Vasulka, Ed Emschwiller, Nam Jun Paik and others has this quality.
- 5. It is not unusual that an artist-inventor will assert the inherent correlation between a technology and an aesthetic manifestation, a spiritual or political position. The fact that this perceived connection is so easily sundered is in itself an interesting phenomenon. It also provides perspective in the discussion of the (technical) paradigm of the *general-purpose machine* paradigm in the context of cultural practices (discussed further below).

Inventors and Engineers

Prototypes of major technologies seldom arise from within the professional communities of engineers. Historically, Engineering has adopted and perfected these prototypes and made them safe, reliable and cheap, and amenable to industrial mass production, but the fundamental creative-inventive act often occurred outside the institution. More often, as discussed above, they were developed by outsiders who are sometimes renegades or eccentrics. As institutions often write their own histories, such histories tend to celebrate institutionlised identities and claims the inventions of outsiders for the discipline, often without attribution: willfully or in ignorance, the chain of attribution is broken.

Technological breakthroughs must necessarily occur before their 'field' exists. Stephenson, Goodyear, Bell Telsa, Edison, Hargrave, the Wright brothers and any number of other are claimed by the tradition of Engineering, but were not Engineers in the institutional or academic sense. Some 'Art and technology' practitioners, media artists, and most recently, 'computer artists' are

part of the a larger grouping of technology originators which has remained invisible in its own constituency and has not been acknowledged by the institutionalized discipline of Engineering ^{vii}, nor by commercial interests. Visionary technologies are, by definition, ahead of the technological-industrial curve. Thus, when they appear, they appear as prototypes, as mock-ups, proofs-in-principle, strange kluges of available technologies. This has been the case with so many of the visionary technologies (the Wright Flyer or Vannevar Bush's Memex) and tends to be true of the machine artworks I am discussing.

Louis Daguerre, often cited as the founder of photography, was neither a chemist nor an optical engineer. He was a realist painter and a set painter at the Opera. He used a camera obscura as an aid to painting in perspective. Inflamed with a passion to 'freeze the image' he applied the fortune he had amassed through his development of his Dioramas to realize this dream. A M. Dumas related the following anecdote: In 1825 he was lecturing in the Theatre of Sorbonne, on chemistry. At the close of his lecture a lady came up to him and said: "Monsieur Dumas, as a man of science I have a question of no small moment to me to ask you. I am the wife of Daguerre, the painter. For some time he has let the idea seize upon him that he can fix the image of the camera. Do you think it possible? He is always at the thought; he can't sleep at night for it. I am afraid he is out of his mind. Do you, as a man of science, think it can ever be done, or is he mad?" "In the present state of knowledge". Dumas generously responded "it cannot be done; but I cannot say it will always remain impossible, nor set the man down as mad who seeks to do it."" viii In 1826 Daguerre learned of the work of Nicephore Niépce, and worked with him from 1829 until he died in 1833. By 1837 Daguerre was able to fix images, in a process he called a Daguerreotype.

A little later, in lesser known case, in 1859, the first 3D optical scanner was developed by a french sculptor Francois Willeme. The 'photosculpture' system involved 24 cameras arrayed at 15 degree increments around the subject. Silhouettes extracted from the images functioned as profiles for the semi-automated construction of sculptures. This system predates machine vision, 3D scanners and stereolithography by a full century.^{ix} If one examines the histories of standard or once-standard technologies and systems of technologies in photography, in cinema, in acoustic, electronic and digital sound and music, in video, computer graphics, immersive technologies, robotic and interactive technologies, and most recently in (internet based) distributed and/or networked practices, including virtual communities and multi-user gaming, one finds very often that they were the work of an artist-inventor, or that an uncelebrated precedent occurred a decade or ten years earlier among this hybrid artist-inventor class. This explains to some extent why these originators have been ignored by the established disciplines. In the case of engineering, as I have witnessed personally, the ethos of freely shared Intellectual Property among the art community (which predates the similar ethos in the 'open source' community) and the relative disempowerment of individual artists with respect to the legal departments of large corporations makes 'borrowing' the ideas of artists (without credit or remuneration) for commercial development unproblematic. ^x

Instrument makers

Outside specialized disciplinary courses, we tend not to valorise those who contribute to the construction of media forms which may (or may not) become a ubiquitous cultural vehicle - neither the Lumiere brothers, nor anyone else could foresee the development of the vast and complex film industry. Such developers are engaged in a process of historically contingent formation and formulation of a technologically specified genre. Through the late C19th and early C20th, sound and music technologies developed along three related lines, technologies of production (instruments), technologies of reproduction, and technologies of distribution. The development of the electromagnetic 'loudspeaker' and related technologies represents a significant transition. Previously, reproduction of the sound of a specific instrument was achieved by the augmentation of that instrument to function as a playback device– the pianola or player piano is a case example (the Synclavier a more recent equivalent). The loudspeaker is a general purpose acoustic reproducer. The wax rolls, punched spring steel plates, paper rolls and later phonograph discs all provide models of 'general' data storage. The central metaphor of Alan Turings foundational work on the Universal or Turing machine was a (recordable, playable and erasable) tape. These artifacts are clear conceptual precursors of the computational idea of *generality* and the 'general purpose machine'. As David Mindell masterfully documents, computing culture arose in the context of electrical

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engineering, particularly electro-acoustic engineering, radio, telephony, and the signal processing problems which arose in those contexts. ^{xi}

From the late 1960s through the 70s, in the heady days of video art, a substantial community of hardware hacker artists developed diverse kinds of video technologies, including feedback and treatment devices, synthesizers and frame buffers. These were often technically related to music synthesizer technology and also often focused on synaesthesic relations between video and audio signal, a relation which in a technological sense was given, as both were encoded as analog electronic signals. ^{xii} Woody and Steina Vasulka were key developers in this genre. Another active developer was Dan Sandin who later developed, for video installation purposes, the prototype of what became the 'cadillac' of Virtual Reality technologies, the CAVE.

These examples, however innovative, hew to the *instrument* paradigm. An instrument is the means to achieve the cultural experience. I submit that the instrument mode is different from one in which the technological invention is the artifact itself, lets call it a machine-artwork. With respect to the instrument maker (in music but also in the visual and plastic arts), an instrument is a device which is employed to generate an aesthetic artifact. The artists here discussed conceive of an aesthetic artifact which is simultaneously a novel technological artifact. I want to dwell on this delicate distinction further while considering some examples, in the realm of music machines, image machines and among automata and robotics.

In the machine-artwork, which is the focus of this paper, I maintain that the embodied affective experience is integrally related to and cannot be separated from the material manifestation of the artifact.^{xiii}

Two concepts closely related to *instrument* in this discussion are the (new) *venue* and the (new) *medium*. Daguerre's Diorama is an example of the former, a novel combination of new and older technologies in a novel spatial arrangement which resulted in a new class of cultural experience. The cinema, as a venue, is without doubt the most successful and persistent of these novel venues to emerge from the C19th. If there had only been one film ever made, would the cinema be a machine-artwork? Does

a machine artwork become a medium or venue when the integration of the informational and the material is sundered, when *form* and *content* can be separated? Does the artifact thus becomes an instrument when more than one volume of 'content' can be, and is, *poured in*?

Is it possible to predict which machine-artworks will become vehicles? One might posit that it is likely if the hardware is amenable to mass production and the content is as material-light as possible, i.e. celluloid frames on a reel rather than a truck load of oil paintings: reduction of the material component and propensity to mass production. Amenability to industrial production is historically contingent. Babbages' Analytic Engine was hugely technologically challenging precisely because Babbage had a vision which exceeded that capability of the current technology. A mere twenty five years later, precision machining had advanced so much that the project was entirely feasible: it might have become commercially viable. ^{xiv}

Regarding the need for standardization: I proposed above that the separation of form and content evident in the C19th technological media such as photography and wax-roll sound recording are the origin of, or at least precedents and models for, the hardware/software dual. We should note that in order for the cinema to be a 'general purpose machine', its content must conform very tightly to a set of technological specifications. It is not truly 'general purpose' but imposes an (arbitrary) standardization, a process integral to technical monopolization. The narrow constraints for input and format are simply accepted as a genre, a technologically specified genre, like modern file formats.

Duchamp, Tinguely, Ihnatowicz – evolving relations to technology

Marcel Duchamp, lauded in modernist art history, offers a conflicted and ultimately negative example for my purposes. As Jack Burnham reminds us (in his in his 'Beyond Modern Sculpture, a landmark work which sought to theorise and historicise Art+Technology), when Duchamp employed the bicycle wheel in a readymade, it was not a nostalgic gesture, but state of the art technology: "From a practical standpoint, the Readymade bicycle wheel was an apt choice. Only a few years before Duchamp's appropriation it had been mechanically perfected. The ball bearing mounted axle and tension wire spokes made the bicycle wheel one of the lightest and most elegant devices then in common use...The lightweight wheel, the chain drive, the tubular frame construction made the bicycle, along with the automobile, revolutionary forms of personal transportation." ^{xv} The very concept of the readymade originates in industrial mass production and is hence a commentary upon the transition from an artisanal culture to a commodity culture. The significance of the Fountain, the Bottle Rack, the Snow Shovel and the bicycle wheel is not as dadaist absurdity or surreal juxtaposition. Their later celebration in these terms is more a reflection on the anachronistic and isolated nature of mid century art historical discourse than on the significance of the works themselves. In my opinion, these works interrogate the notion of the artisanry in the context of the rise of mass production and the consumer commodity.

Mass production and mechanization are 'joined at the hip', so to speak. Burnham notes: "More than any artist previously, Duchamp confronted the psychic and practical difficulties of realizing a viable motorized art. A Kinetic art, somehow, presented a contradiction in terms. As a sculptural totem, the machine was unassailable. Yet to function in actuality, and artistically, it had to be injected with imprecision and irrationality. Then, perhaps, it could begin to live, in doubt and indecision, as human beings do..." xvi Here, Burnham, for all his radicalism, can't help reiterating certain themes of modernist art history which perpetuate a notion of art as anti-technological. . Hence also the lionizing of Jean Tinguely, whose self-mocking machines reassured a community whose world view was destabilized by the machinic, over Takis, whose work elegantly celebrated physical and technological verities. Duchamp, to developed his rotoreliefs (rotary optical technologies) and showed them at an inventors fair. Burnham opines: "No longer dealing with the gentle illusionism of painting, nor even the leverage of Dada's tools, (irony, fallibility, and repetition), Duchamp realized that he had placed himself on the brink of raw technology. Such a situation demanded that one either draw back or plunge into a rational world of impersonally controlled effects. He chose to do the former." xvii Tellingly, years later, when the Experiments in Art and Technology group approached Marcel Duchamp and asked if he would be the mentor of the group, he remarked to the effect that they must be insecure if they needed mentor, and is reported to have asserted : technology will either sink or drown art.

It is Edward Ihnatowicz who stands, in stark contrast to Duchamp and Tinguely, as paradigmatic of the kind of practitioner I want to foreground in this paper. He (among

others xviii) applied cybernetic thinking to kinetic sculpture and in so doing made the crucial step of endowing automata with automated reasoning. The Senster (-1971) (IMAGE) presages by a quarter century a wide range of technical research agendas including artificial life, reactive robotics, bio-robotics, and more specialised research areas such as sensor fusion and sensor-effector integration or active sensing, though those researchers remain oblivious of its existence. Senster was an embodied autonomous agent, employing a quasi-biological paradigm of robot as organism and utilizing digital computing to coordinate an array of sensors including radar with sophisticated and custom hydraulic servo control. Senster was designed and built by Ihnatowicz, utilizing war surplus radar technology and custom servo-hydraulic actuators, with a jointed structure modeled on that of a lobster claw. It is paradigmatic of the practices I am addressing as the artist maintained a detailed hands-on involvement in all aspects of the project while holding a complete overview, thus maintaining a deep confluence between the motivating concepts and the elaborations of the technology. This holism resists black-box methodological orthodoxy and it is this, I believe, which lends the Senster its experiential integrity.

Around the same time, Myron Krueger, in his *Videoplace*, developed the paradigmatic video camera based interactive cultural artifact. His relation to the machine vision research of a later generation is comparable to that of Ihnatowicz' with respect to later robotics. With his *Very Nervous System*, David Rokeby in the early 1980s, developed a machine vision based interactive paradigm which was as economical as it was sensitive. Both his and Kruegers work also presage more contemporary research in vision-based and embodied human-computer interaction. (HCI)

Posthumous attribution of artness

Having framed this tradition of culturally motivated technology development, I will now discuss a set of interesting counter-examples. These are artifacts which, allowing for their historical anachronism, would be regarded as art objects if they were made now. They were not regarded as art objects by makers, critics or the public when they were made, because a category or context to accommodate them did not yet exist. They provoke in this context the question of whether we are entitled to assign the identity 'art' a-posteriori to an artifact which was not originally regarded as 'art' in the sense we now

understand it. Must the makers identify as artists or cultural producers in order for us to consider them as part of this hybrid identity? ^{xix}

This is in fact the modus operandi of Art History. The role 'artist' in the modernist sense of an independent individual originator of non-utilitarian aesthetic artifacts, did not exist in many cultures prior to contact with the west. Yet the artifacts of those cultures are now routinely grouped as art. Nor do other cultures understand their cultural practices and artifacts in terms compatible with our concept of art. If the idea of art is an historical construction and not a god given verity, thus we are perfectly justified to confer upon artifacts of technological invention the status of art, though likely, no-one would be more surprised than the maker. If we were to accept that such an a-posteriori move is appropriate in the case of the following artifacts then this adds force to my contention that a purely art-historical assessment of this tradition is not adequate.

The Ferranti Mark 1, a commercial version of the Manchester Baby Mk1 (1948) was released in February 1951, qualifying it as the first commercially produced stored program computer, predating both UNIVAC and LEO (the commercial version of EDSAC) by several months. One of the early programs written for the Ferranti Mark1 constructed love letters (they weren't very good):

Darling Sweetheart,

You are my avid fellow-feeling. My affection curiously clings to your passionate wish. My liking yearns to your heart. You are my wistful sympathy: my tender liking. Yours beautifully,

M.U.C. ^{*xx*}

Thus one of the first computer programs might justifiably be assigned the status of a work of culture.

Claude Shannon actively engaged in making things we must now class as machineartworks. He built a device he called his Ultimate Machine which is described by Arthur C. Clarke in Voice Across the Sea: ``Nothing could be simpler. It is merely a small wooden casket, the size and shape of a cigar box, with a single switch on one face. When you throw the switch, there is an angry, purposeful buzzing. The lid slowly rises, and from beneath it emerges a hand. The hand reaches down, turns the switch off and retreats into the box. With the finality of a closing coffin, the lid snaps shut, the buzzing ceases and peace reigns once more. The psychological effect, if you do not know what to expect, is devastating. There is something unspeakably sinister about a machine that does nothing -- absolutely nothing -- except switch itself off."^{xxi}

Clearly, as Clarke reports it, the device had a poetico-aesthetic power which extended somewhat beyond the more common kind of technological pun object. As a self-curtailing automata, it has an ironic relation to von Neumanns' 'self-reproducing automata' and to Ashby's Homeostat. These were cocktail party conversation topics in the cybernetic circles of the day. What status did Shannon's artifact have in its day? It appears to have been little more than a mantelpiece curiosity. It was not presented as an artwork, nor did Shannon claim artistic identity, yet in its performance of nihilism, it is kin to Tinguely's Homage to New York. ^{xxii} Shannon's machine succinctly condenses in a provocative artifact, a range of conversations about decision-making, free will and intelligence among machines. It is thus an exemplary artwork.

Grey Walter, in the late 1940s, built two autonomous cybernetic devices he called Turtles which, with a minimum of analog electronics, behaved in seeming life like ways. ^{xxiii} (**image**) These devices are pioneering autonomous robots which implemented in hardware the behaviors merely described much later by Valentino Braitenberg, in his "Vehicles", a volume much lauded in 90's robotics circles.^{xxiv} In fact, Walter's Turtles foreshadow the entire bottom up or reactive robotics school of the 1990's. Later generations of reactive robotic artworks develop on their reactive behavior schemes.^{xxv} (**image** PM)

In 1966, Joseph Weizenbaum scandalized the psychology department of MIT by producing a computer program which fooled sixteen graduate students in psychology that there was a world famous Rogerian therapist inputting to the teletype. These students were chagrined to discover that *Eliza* was constructed of only sixteen rules and were further chagrined that they could not deduce those rules. *Eliza* is the grandmother of all chatbots and must be regarded as the pioneering work of procedural dramaturgy.

Beyond the box

If the version of history summarized here is accepted as valid, then the questions necessarily arises: why is it that this typology has been so inventive; why has its vision so often preceded that of institutionalized researchers ? Consistent with my arguments regarding visionary technological invention and interdisciplinarity, the key is what is

simplistically referred to in technological communities as: "thinking out of the box". It takes some 'thinking out of the box' to ask what the box is. The box is the value system and criteria of disciplines.

•Professional validation constrains pursuit of idea. Given the exigencies of research funding and accreditation, in conventional institutionalised technical research, research is required to be validated at each successive phase, for safety, reliability, etc. The field of possibility is thereby substantially reduced.

 The exigencies of commodity capitalism construct related constraints. In industry, research is seldom supported unless a path to a successful market is foreseen. Clearly, the vast majority of technological invention could not have occurred under such constraints.

Contrarily, without such constraints the field of exploration is much wider. Some of the characteristics of invention in this expanded field include:

• 'Under Engineering', the mode of the prototype Technical invention outside the institution is often characterized by a hybrid and unorthodox combination of techniques, tinkerings and 'kluges'. As discussed, the necessity for such kluges is sometimes explained by the fact that the appropriate technology does not yet exist, that such work is in fact a mock-up for a new technology – a prototype. Such prototypes are clearly not destined for production and public use and so many orf the constraints of normal engineering development are relaxed. In some cases it is simply a case of machine-art-povera, utilizing whatever is available. In other cases, it is a matter of familiarity, a motor mechanic is likely to adopt automotive technologies in his development of say, an airconditioning system. This may or may not result in innovative and useful results.

Consistent with Billy Kluver's remark that all the Experiments in Art and Technology (EAT) projects were "ridiculous from an engineers point of view" machine-artwork research is often guided by motivations which appear absurd by instrumental criteria. Such eccentric motivations are a generator of variety.^{xxvi} This freedom to pursue eccentrically motivated research is an accepted aspect of arts cultures.^{xxvii}
Connection to popular culture and engagement with social movements and political issues has been a dimension of contemporary arts since dada and Russian constructivism. Such connection to meaningful social flows is often discouraged by the ivory tower and the corporate campus.

• The fundamental Cartesianism of the academy imparts insidious prejudice that brainwork and hand-work are incompatible. This notion is of course utterly denied in any discipline which involves bodily practice – especially the arts. The more academicised disciplines valorise a 'hands-off' approach, rewarding the more purely theoretic and assigning craft or artisanal functions to technicians. Contrarily, artists are taught to integrate the artisanal and the conceptual which as per the Ihnatowicz example, tends to result in an integrated, holistic product. ^{xxviii}

Overall, this context of invention can be analogized to evolutionary development by mutation and sexual reproduction. Some novel hybrids, like the tree climbing bicycle (**image**) are destined to almost immediate extinction. Others, like the stereopticon, have their day in a specific techno-social niche. Truly novel and advantageous hybrids, such as cinema, arise through such anarchic cross -fertilisation.

Interdisciplinarity and the Arts

In The 1960's and early 70's radical new genres, forms and practices emerged which challenged conventional forms and conventional venues. The inherent interdisciplinarity of that 60's moment was captured by Australian art historian Donald Brook when, in the early1970s,he defined avant-garde art, rather scientistically, as: "non-specific experimental modeling". His definition captures the idea of a quasi-scientism practiced in an anarchic open field, or to use more contemporary parlance, a multi-dimensional state-space of ideas. 'Non-specific' captures precisely the sense of both technical and ontological license that was claimed for art practice.

In the visual arts, a notion of 'intermedia' emerged, which argued for the abandonment of distinctions between media forms and traditional media based practices. I contend that this trend created a context in which artists felt licensed to engage any available media and technology. ('Intermedia' also marks an implemention of interdisciplinarity in the academy a generation ahead of the academic curve.)

It was in this very context that the Art+Technology movement emerged. Occurring at a time of both social and technological change, its practitioners were informed by the civil right movement, race politics, nascent feminist and environmental politics, by political activism, and by the culture of experimentation with chemically altered states of consciousness. Another key influence was the culture of second order Cybernetics, itself

a radically interdisciplinary culture, in which technical theories of control and communication became generalized to address diverse topics biological and social as well as technological.

The first generation of digital media artists, emerging from this context, largely enacted a creative agenda rooted in the ideas and values of this formative period. As such, so-called New Media Art, is, I would assert, one of the most radically interdisciplinary practices of the last half-century, combining as it does artistic traditions with traditions of science and engineering.

Implications for Scholarship

Inasmuch as the work discussed in this paper is guintessentially interdisciplinary, it follows that in order to discuss this work in a satisfactory way, historians and scholars must have a similar breadth of training and experience as the practitioners they study. The kind of art criticism typified by the connoisseurship model is inappropriate and inadequate here. It is not sufficient to address such works by passive assessment of them as static aesthetic artifacts, as has been the case with more conventional treatments of 'new media art'. Several new realities make this kind of critique close to irrelevant. Firstly, such works are seldom fit in the conventional cultural milieu of the museum/gallery/private collection, but are often immersed in a radically new kind of dispersed digital simultaneity – the net. The materials out of which such works are made are guite apart from the conventional artists media, and the techniques and methodologies required to manipulate them have more in common with the machine shop, the science lab or the computer lab than the conventional artists studio. Thirdly, the modalities of aesthetic experience usually involve ongoing temporal engagement with a device or system which semi-autonomously responds to changes in its world. As such, as I have argued in the past such work demands to development of a new branch of aesthetics: what I have called the aesthetics of behavior. xxix

In creating such cultural machines, artists have negotiated and extended the capabilities of specific technologies, submitting to hard limitations here, subverting or perverting functionality there. Without an understanding of the dynamics and constraints of the technologies, the achievements of the artists cannot be understood. Moreover, the artist, in developing and adapting technologies, must negotiate the intersection or collision of radically divergent worldviews.

A useful history of this field must thus involve a history of intellectual negotiation of powerful and historically significant ideas, manifested in complex artifacts as opposed to texts. A scholar must have an understanding of this intellectual context in the same way that a scholar of abstract expressionism must be familiar with existentialism.

I hope to have been persuasive in my contention that, not only is the work I have been discussing part of a coherent tradition, but the understanding of this tradition demands a new and interdisciplinary historical approach. It is insufficient for this work to be regarded as examples in the class of artifacts presented in art museums as it is simultaneously engaged in the flows of technoculture. These works are chess pieces in the tensions of the two cultures and must be discussed in such a context.

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ⁱ In 1953, Gordon Pask, the British cybernetician, presented the first of several incarnations of his Musicolor, a theatrical scale, microphone driven sound/light transducer. Of a later phase of the development of the Musicolor, Pask wittily opined that "You need a mellow, elegant, South Kensington period in developing any cybernetic art form" (Gordon Pask, in a comment, a case history and a plan. p86, Cybernetics, Art and Ideas, Jasia Reichardt Studio Vista UK, 1971) A sentiment which might be taken as a motto for the entire field of practice I am here discussing.

ⁱⁱ As readers who are familiar with my work will recognise, this type of practitioner is of particular significance to me, as I count myself in their number. I write this paper as an historian and theorist, but as one with long-term active engagement in the practice itself. This experience, I hope, adds a richness of direct experience to this text.

ⁱⁱⁱ I am speaking of a kind of hybrid practice which is now recognized in Canada under the official descriptor 'researchcreation'.

^{iv} As Andrew Pickering has proposed concerning the relation between the representationalism , and thus inherently epistemological mode of symbolic AI, with respect to the more performative and thus inherently ontological mode of cybernetics, I have repeatedly argued that the representational aesthetics of the plastic arts is inadequate to the reality of performative cultural technologies because the logic of their automated behavior, of the associated human behavior, and their ongoing interaction is inherently experiential , phenomenological and embedded in a contingent temporal flow. Cf Andrew Pickering, Cybernetics and the Mangle: Ashby, Beer and Pask. Social Studies of Science 32/3June 2002, 413-437

^v see for instance my Adequate pedagogy: the missing piece in Digital Culture, in: A Guide to Good Practice in Collaborative Working Methods and New Media Tools Creation (by and for artists and the cultural sector) eds. Lizbeth Goodman and Katherine Milton (fall, 2003) AHDS (Arts and Humanities Data Service)

^{vi}. The disappearance from history of these innovators is a phenomenon which bears study, across technological genre boundaries, but that is not the focus of the current study.

^{vii} Carolyn Marvin lucidly documents the process of institutionalisation of an engineering discipline, in this case Electrical Engineering, in the chapter 'Inventing the Expert – technological literacy as social currency'. In When Old Technologies Were New: Thinking About Electric Communication in the Late Nineteenth Century (Oxford University Press, 1988). In this spirit, I am here referring to the instituionalised discipline of Engineering, as a professional formation, with membership criteria (PhD degrees), professional organizations which mandate standards, such as IEEE

viii From The Illustrated News, New York, 16 July 1853, cited in http://www.rleggat.com/photohistory/history/daguer3.htm

^{ix} Improved by Pierre Cardin, Carlo Baese and Claudius Givandan, 1900-1930, 'Sculptographie', took 454 images, A similar machine was developed in 1934 in Japan.

^x A paradigmatic case is the recent and unfortunately successful attempt by a New York media exhibit company, Reactrix, to patent, both in the US and more recently in Europe, the entire concept of utilising real time analysis of video as input for interactive entertainment. As such, they have secured patent on the entire field of machine vision driven interactive art! Astonishingly, both the US and European patent offices have allowed this patent, while the applicants flagrantly ignore (or are ignorant of) the well documented work of Myron Kreuger, David Rokeby and several other practitioners of 'prior art' including myself.

xi Mindell, David. Between Human and Machine: Feedback, Control and Computing before Cybernetics. Johns Hopkins, 2002.

^{xii} One of the rare attempts to document this history was the extraordinary exhibition Eigenwelt der Apparate-welt curated by Woody Vasulka at Ars Electronica 1992. (Dunn, David / Vasulka, Steina / Vasulka, Woody (ed.): Eigenwelt der Apparate. Pioneers of electronic Art. Linz 1992)

xiii This is important because it asserts a limit to the 'general purpose machine' dogma of computer science, and brings into question the hierachical dualism of hardware-software, in the context of cultural practise.

xiv Babbage's technician, Joseph Whitworth, found it necessary in his work on the Difference Engine to standardise and specify screw thread geometries and drill sizes. The Whitworth (or BSW) threads were standard across the British Empire/Commonwealth, through the mid twentieth century.

xv Jack Burnham, 'Beyond Modern Sculpture' George Brazilier 1968, p227

xvi Jack Burnham. ibid p230

^{xvii} Jack Burnham. ibid p230

xviii Previously, in the mid 1950s, Nicholas Schoffer had the opportunity to work with engineers from Phillips to develop his CYSP series. These functioned as a complex analog display device for environmental monitoring. ^{xix} Cf. the essay by Katja Kwastek in this volume. ^{xx} Pears Cyclopaedia, 64th edition, pp 190-1. London 1955. Cf. David Link, There Must Be an Angel

On the Beginnings of the Arithmetics of Rays, in: Variantology 2. On Deep Time Relations of Arts, Sciences and Technologies, eds. Siegfried Zielinski, and David Link (Cologne: König, 2006): 15-42

xxi From http://www.research.att.com/~njas/doc/shannonbio.html. Thanks to Noah Wardrip-Fruin for the citation.

^{xxii} Nor was Shannon alone in producing artifacts which were emblematic of his research and which possessed a high quotient of poetry or play. In the last years of WW2, Alan Turing developed Delilah, a voice encryption system premised on the injection and removal of patterned noise by the playing of an identical phonograph record at either end of the process

xxiii Walter, Grey. An Imitation of Life. Grey Scientific American, May 1950, and

A machine that learns. Grey Walter. Scientific American 1951

^{xxiv} Braitenberg, Valentino, Vehicles: Experiments in Synthetic Psychology. MIT Press, 1986

The behaviors of such contemporary projects as Casey Reas' procedural drawing programs are themselves rooted in a (software) implementation of Braitenberg's work.

^{xxv} For instance the author's Petit Mal. See www.ace.uci.edu/Pennv

xxvi The Great Northeastern Power Failure, a short paper by Kluver, republished in Multimedia: From Wagner to Virtual Reality, Randall Packer, Ken Jordan (Editors), W W Norton and company, 2001

^{xxvii} This is a theme which is pursued in my Consumer Culture and the Technological Imperative: The Artist in Dataspace. Written in 1993 and published in Critical Issues in Electronic Media Edited by Simon Penny, Published by SUNY Press 1995

xxviii This idea is explorted at length in my paper Experience and Abstraction, presented at DAC2007, and published in Fibreculture, Jan08). I have previously pursued similar themes in my The Virtualisation of Artistic Practice: Body Knowledge and the Engineering World View. CAA Art Journal Fall97 Special Issue on Electronic Art, Ed: Johanna Drucker, and my Agents as artworks and agent design as artistic practice" in "Human Cognition and Social Agent Technology" Ed: Kerstin Dautenhahn, John Benjamins Publishing Company 1999

^{xxix} See for instance, my paper Aesthetics of Behavior, presented at ISEA2004.