Experience and Abstraction: the Arts and the Logic of Machines

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ABSTRACT

This paper is concerned with the nature of traditions of Arts practice with respect to computational practices and related value systems. At root, it concerns the relationship between the specificities of embodied materiality and aspirations to universality inherent in symbolic abstraction. This tension structures the contemporary academy, where embodied arts practices interface with traditions of logical, numerical and textual abstraction in the humanities and the sciences.

The hardware/software binarism itself, and all that it entails, is nothing if not an implementation of the Cartesian dual. Inasmuch as these technologies reify that worldview, these values permeate their very fabric. Social and cultural practices, modes of production and consumption, inasmuch as they are situated and embodied, proclaim validities of specificity, situation and embodiment contrary to this order. Due to the economic and rhetorical force of the computer, the academic and popular discourses related to it, are persuasive.

Where computational technologies are engaged by social and cultural practices, there exists an implicit but fundamental theoretical crisis. An artist, engaging such technologies in the realization of a work, invites the very real possibility that the technology, like the Trojan Horse, introduces values inimical to the basic qualities for which the artist strives. The very process of engaging the technology quite possibly undermines the qualities the work strives for. This situation demands the development of a 'critical technical practice' (Agre).

This paper seeks to elaborate on this basic thesis. It is written from the perspective, not of the antagonistic luddite, but from that of a dedicated practitioner with twenty five years experience in the design and development of custom electronic and digital artworks.

Note and Disclaimer: This paper, inevitably, focuses on issues which arise as a result of the peculiarities of western cultural and technical history, and reflects discourses conducted in the English language. As discussed, some of the forces influencing those historical flows relate to the traditions of western philosophy, itself strongly influenced by Christian doctrine. The question of what form automated computation might have taken if it had arisen in a culture with different religious and philosophical history is a fascinating one. Likewise, the way that such a culture might negotiate the relation between technology and culture might be very different from that which has occurred in the West, and might offer important and useful qualities.

Keywords

Generality, Abstraction, Instrumentality, Computer Science, Digital Cultural Practices. Media Art, Media Art Theory, Media Theory, Interdisciplinarity, Science and Technology Studies.

1. INTRODUCTION

"Art: no experience necessary".This slogan, seen on a T-shirt in Singapore evoked in me both amusement and a poignant sadness. While the intent may have been directed to the (questionable) notion that 'anyone can be an artist' - ie that being an artist requires no professional training or special acumen – it also, perhaps unwittingly - asserts the Cartesianism which has had such a withering effect on Arts discourses in the modern period, and more recently has been reinforced by the influence of computational discourses.

Much of my writing has grappled with issues which I find fundamental to the formation of art-practices which exploit the capabilities of emerging technologies (often but not always, involving real time digital computation). [1][2]. These theoretical inquiries arise out of pragmatic attempts to apply these technologies to artistic practice. I have been developing custom electronic and digital technologies for cultural practices for twenty-five years. Throughout that time, I have felt an abiding disquiet regarding implicit disjunctions between technological and cultural practices, at a fundamental level. This paper is an attempt to make explicit a set of issues which I feel are fundamental to the contemporary socio-technological context, and crucially relevant to questions interdisciplinarity, interdisciplinary digital arts practices, and to the question of the role of the arts on campuses and in the world at large [3].

The presence of arts practices on contemporary campuses is fraught with complexity. While contrasts are commonly drawn between the science and humanity 'sides' of campuses, these practices share a common commitment to abstraction, symbolic notation and some notion of the power of general applicability. The academy as a whole, is a culture of the symbolic notation, of the book and the text. The arts, at its core, bypasses this translation from worldly experience of materiality to symbolic representation as alphanumeric characters. The arts is largely concerned with the way objects, forms, materials, and bodily actions can *mean*. The arts focus on immediate sensorial experience, unmediated by alphanumeric translation. I make this generalization quite aware that it is full of holes, but I make it in order to set such practices in stark contrast to practices of alphanumeric abstraction, and specifically to the act of coding and the functioning of code as an alphanumeric machine.

I am at pains to emphasise that although I will identify problematic aspects of theoretical, technical and cultural practices, I am not antagonistic to any of these. Indeed, I am an active and longtime practitioner in them all, and in their combinations. My goal is to help to establish a rigorous interdisciplinary critical foundation from which well-informed digital cultural practices can proceed.

This inquiry maps out a project of radically interdisciplinary intellectual research and artistic/technical production concerning the relation of embodied practices to the current state of digital technologies and the underlying values reified in the technology. As such it entails:

1. a rigorously interdisciplinary agenda,
2. a tightly integrated relation between theory and practice, where practice initiates theorising and theory informs practice,
3. the recognition of the need for the development of a theory of practice and of the 'aesthetics of behavior'.

In my opinion, the full force of some of these realities is felt most clearly by the practitioner in the complex process of realisation of cultural artifacts employing these technologies. Contemporary digital arts practice is shaped, in large part, by the ramifications of the disjunctions discovered in a process where technological components formulated for instrumental ends are applied to goals which exceed these instrumental conceptions. Michael Mateas observed that 'you push against the materials and the materials push back'. But in the case of digital arts, one might well assert that it is the ideology pushing the materials back.

These concerns can be differentiated into sub-categories. The most superficial (but nonetheless challenging), have to do with the pragmatics of the technical capabilities of these devices and the development of a design and development process for cultural applications which incorporates them. Another layer of concern is about how employment of these devices changes the kind of art which is made. Basic to any theoretico-historical study of emerging digital art practices is the recognition that such practices are the confluence of two streams. These are the traditions of industrial automation rooted in rationalist science (and consumer commodity economics); and the traditions of artisanal arts practices and their related institutions and philosophical contexts.

Digital Cultural Practice is a heterogenous field, and distinctions can be drawn in along diverse axes. A fundamental distinction is between practices which are the emulation in digital technologies of pre-existing practices, as compared with those which are novel and 'native' to the new medium, for which one must struggle to find precedents in pre-digital practices. 2D image treatment rooted in photography, graphic design and painting, and digital video, are prime examples of the former. On the other hand are practices which are in some sense native to the context of computational technologies, and could not exist via backwards-emulation: 3D modeling and animation, hypertextual and sensor based interaction, interactive and multi-player networked gaming. (While this distinction is fundamental, it is not always clear, and as practices evolve, these distinctions tend to become aspects) [4]. Any practices that exhibit dynamic real time behavior, or responsiveness to their environment and require real time computation and/or networking fall into the class of practices for which, I believe, a wholly new branch of aesthetics is demanded: the aesthetics of behavior.

A deeper level of inquiry concerns the negotiation of the values of the professional culture which gave rise to the machine with respect to the values and traditions of the arts. What flows from this is a recognition of how the values of the discipline of engineering insinuate themselves into art practice and art consumption, changing the practice. At root, one is drawn into a deeply interdisciplinary consideration of the fundamental values and world-views of these two kinds of practice, these *two cultures*.[5]

What is called for then, is a simultaneous assessment of these values ands their implications to contexts outside their 'native' territory, and simultaneously, a reassessment with respect to these issues, of the core values, methodologies and sensibilities of the arts. We need then, to find new, relevant and compelling argument for the arts in the new techno-social context. This will necessarily lead, I believe, to a re-evaluation and re-valuing of aspects of the traditions of the arts which have been or are in the process of being occluded or lost, due to the authority of technological rhetorics perceivable on every campus, a certain kind of cowering in the face of such rhetorics, and an *articulation deficit* on the part of arts practitioners.

2. FRAMING THE ENFRAMING

Embodied in the machine there is an idea of what the mind is and how it works. The idea is there because scientists who purport to understand cognition and intelligence put it there. No other teaching tool has ever brought intellectual baggage of so consequential a kind to it. Theordore Roszak. [6]

"..most tools produce effects on a wider world of which they are only a part, the computer contains its own worlds in miniature…" Paul Edwards [7]

A computer…does not simply have an instrumental use in a given site of practice; the computer is frequently about *that site in its very design. In this sense computing has been constituted as a kind of imperialism; it aims to reinvent virtually every other site of practice in its own image.* Philip Agre [8]

Heidegger proposed that the essence of technology is a project of 'enframing'. We make the world amenable to manipulation and exploitation through instrumental science. We dominate nature through knowledge. The last few centuries can be characterised by an ever-growing assemblage of knowledge and power, science and technology, which enframes the world and ourselves within it. At issue is not whether instrumentality is a good thing, but whether the machinery, the hardware and software, is imbued with the ethos of instrumentality. And if, in applying this technology to human pursuits not previously embraced by such technology, these practice are thus perturbed in a way which might be deemed unfortunate.

Technologies do not pop into the world fully formed, they emerge from specific cultures with specific traditions. In order to understand what the computer, at root, is, we must look at its history, its precedents, the goals set for the research, the interests of the funders, and the intellectual traditions of the generating contexts. The question then becomes: can we assume that the computer is a neutral tool, or does it inhere specific notions about information, knowledge, and representation (etc)? This would not be a huge issue if the technology remained located in its original application zones. But the contemporary socio-technological situation is one in which this technology is constantly moving out across society and culture, engaging various sort of established practices for which the instrumental paradigm (and related values) has dubious relevance. This then is a call for an active critical engagement. The following questions must be asked:

1. Are fundamental philosophical values reified in the technology. If so how and where, and how are they expressed.
2. Are these values supportive or destructive of each of the new zone into which the technology moves.

3. These questions then imply an assessment of the core values of the practices which are effected.

~~4.~~ If the result of the inquiry reveal areas of serious concern, then one must ask: is the situation salvageable, ie can the tools and the practices be adapted together to produce a positive situation. If not, must the entire project of technological art be abandoned or is it possible to imagine a technology which would have such positive qualities.

~~5.~~ If so, we must discuss how to build technologies which are more supportive of the core values of these practices. An entire interdisciplinary technological research program is thus implied, one that moves towards technics from real human needs, rather than moving out from motivations of profit and manufacturing efficiencies, through advertising campaigns into the market.

The Cartesianism of the academy and its emphasis on abstraction; the construction of Generality as a virtue in computer science (which is itself entirely in sympathy with the logic of economy of scale in industrial production); and the emergence of the digital commodity and its associated culture: these three form an unholy alliance which demands interrogation in the interests of more critically sound digital cultural practice. The rationalism of the academy is characterized by the valorization of symbolic forms of representation: textuality, logico-mathematical symbol systems, and symbolic representation more generally. Computer code is entirely consistent with this environment. (The paradox of code is that it implements and reifies academic textuality as an operational machine). Philip Agre makes a similar argument when he observes that these fields ”concentrate on the aspects of representation that writing normally captures. As a result, theories will naturally tend to lean on distinctions that writing captures and not on the many distinctions that it doesn’t.” [9].

Cultural practices are traditionally often concerned with specificities of history, personality and context. They have not, in the past, been subject to evaluation on the basis of instrumental criteria such as efficiency, productivity, generality and optimality. With the emergence of computing as a commercial and a cultural force, these values have insinuated themselves, into areas of cultural practice. When the values of computer science piggyback on commercial technologies as they travel out of one socio-cultural niche into another, they can cause havoc. The computer is, in this sense, a Trojan Horse which carries these ideas, hidden, through the gates. Agre describes the application domains of computational systems as a frontier: “Each of these borderlands is a complicated place: everyone who resides in them is, at different times, both an object and an agent of technical representation, both a novice and an expert…every resident of them is a translator between languages and worldviews: the formalisms of computing and the craft culture of the “application domain””. [10]

We cannot dispute that computers and computation constitute the *paradigmatic technology* of our day. [11] As in Descartes’ day, when human physiology was described in terms of the cogs and springs, so today, even thought is susceptible to computational metaphors. It is reasonable to be deeply suspicious of any theorisation that adopts such metaphors unreflexively. Yet, by the same token it is easy understand why computational explanations are unreflexively adopted: they are the intellectual waters we swim, they are a constitutive part of our world view. As a result, many fundamental qualities of our culture evidence a drift as a result of the ubiquity of computation and computational metaphors.

Take for instance the astonishing changes in the notion of *play* over the last couple of decades. When stripped of its colorful monsters and futuristic weapons, game-play in the paradigmatic first person shooter is indistinguishable from the worst qualities of industrialized labor: constrained and highly repetitive tasks executed in social isolation, a tight harnessing of user and machine, rewards linked to high rates of production, to say nothing of the covert inculcation of military skills. In this way, pleasure has been instrumentalised and commodified. Any gaming-partisan can (and several have) taken me to task, saying ‘but game X is not like that’, or ‘such an analysis ignores aspects PQR which are culturally good’. It will also be asserted that such games are shaped by the market as well as by the makers who themselves are the product of a larger and older culture. I do not, in principle, dispute those objections, but the fact remains that, for better or worse, such game-play is colored and constrained by the history of industrial labor and the development of sciences of man-machine integration for military applications.

To reiterate: the purpose of this paper is to explore dimensions of the fundamental problematic encountered when machines for abstract mathematico-logical procedures are interfaced with cultural practices whose first commitment is to the engineering of persuasive perceptual immediacy and affect, employing sensibilities and modalities alien to the technology and possibly incompatible with its structuring precepts. I must necessarily paint in broad strokes, in order to broadly describe a class of issues. Inevitably exceptions can be found. My concern is not so much to persuade as to make explicit a set of issues which must be engaged if critically coherent practice is to occur in the field. This paper is thus a call to a Critical Technical Practice in Digital Cultural Practices. I want to draw a distinction between Agre's use of his term and my use here. He called for such practice as a corrective for the difficulties he recognized in a discipline (AI) with a substantial history behind it. I want to argue that in digital arts, we need a critical technical practice in order to build a critical/theoretical apparatus adequate and appropriate to an emerging range of practices.

This conversation, is, at root, concerned with the power of scientifico-technical rhetorics and their relevance to fields which have come to be on their margins, whether that is because of an imperializing on the parts of those discourses, or due to their attractive power to previously non- scientifico-technical fields in the current technophilic climate. (I do not mean to universalize regarding scientific practice, there are many 'sciences'. I refer to the power of the those discourses as presented in their oversimplified form for ideological or commercial purposes.) As Friedrich Kittler noted, following Nietchze, *"If the 19th century…was a victory of the scientific method over science, then our century will be one which saw the victory of scientific technology over science*." [12]

There could be little argument that the computer is the most complex appliance in common use at home and in the workplace, so any discussion of its use must be general, or must differentiate between diverse aspects: the interface, the operating system, various applications, the fundamental procedures which define the von Neumann machine, theoretical paradigms, the status of the device in contemporary cultures and in the past, the various modes of use, as research tool, as office tool, as pleasure tool, the integration of the machine into a global network and all the dimensions of networked computer use. To address all these aspects would exceed by far the time and space available here. Here I focus mainly on the history, cultural placement, computational fundamentals and the interface.

3. ACADEMIC CARTESIANISM AND ARTISANAL CRAFT

All the art projects I have worked on have at least one thing in common... From an engineers' point of view, they are ridiculous. Billy Klüver

There is, in the western academy and other aspects of western culture, a deep value which ascribes greater worth to more abstract and 'mental' work, and implicitly or explicitly denigrates work which involves manual labor and skill, and therefore devalues the people who do that work. This is a dangerous and foolish belief system. Manual work is not inherently stupid, an where it is, it has been made that way through the de-skilling of labor in industrial contexts, and prior to that in the proto-industrial context of slave labor driven Carribean sugar plantations. [13] It is necessary to distinguish between aggressively de-skilled industrial labor, and artisanal labor. Technical labor, crafts and trades, bodily training in sports, dance and martial arts, often require high intelligence (think of virtuoso musicianship). Intelligence and manual skills are not mutually opposed.

Computer science, as a technical discipline, reifies philosophical notions which, oddly, were already under interrogation in other disciplines prior to its formation. Among these are the Cartersian dualism, an implicit and unproblematised Objectivism and a simplistic notion of Intelligence, inflected by a paranoid militarism. The conception of intelligence in computational discourses is rooted in an early-mid C2Oth approach valorizing mathematico-symbolic problem solving – precisely the same functions that the first generation of AI researchers sought to simulate in their systems (famously Newell, Simon and Shaw's Logic Theorist). This monolithic conception of intelligence has been largely abandoned by the psychological community, replaced with an idea of intelligence as individually varying aptitudes in 20 or more aspects. It is surprising is that mathematical logic should be unilaterally hailed as the hallmark and epitome of intelligence in humans, and yet the process is utterly consistent with a logic of isomorphism (Maslow) ubiquitous in computer science. Boolean logical operations are implemented as a machine – then the machine demonstrates (via applications such as Logic Theorist) that human intelligence is logico-mathematical in nature. Here then is a prime example of the representational nature of computer science, in which an automated system is built to emulate a certain description of a human capacity, and this system and the rhetoric around it then goes on to form an entire school of thought about human thinking – computationalist cognitive science.

This issue is of great significance in the current discussion, as the kinds of intelligences which enable the arts and cultural practices are among those exclude from the mathematico-symbolic conception. Handwork can involve high intelligence and sensibility. But that kind of intelligence – embodied, kinesthetic and multi-modally sensorial intelligence, tends to be irreconcilable with textual, alphanumeric logico-symbolic forms of work. Contrarily, the process of translation from the abstract to the concrete is an exercise of high intelligence, and valuable knowledge and insight is drawn from actual manipulation of matter, as opposed to talking about it or using pre-constructed simulations.

Conventionally, artists are 'not very clever but they are good with their hands'. The implication is that artists are stupid, but it also reinforces the mode of bastardized Cartesianism which infects our campuses that asserts that manipulating matter and intelligent thought are mutually exclusive. [14] An artist must have a deep sensitivity their tools and their medium. There is a tension between the academicism required of the university, and the traditions of bodily training and kinesthetic and proprioceptive sensitivity development so crucial to virtuosity. As programmable technologies have become increasingly usable, coding as a practice has become increasingly pervasive and basic mechanical and electronic skills have seemed less relevant. In many fields, computer technology is causing a problematic drift away from embodied and material intelligences. [15]

To a generation naturalized to commodity digital technologies since childhood, three related assumptions seem to qualify their relation with that technology: an assumption that all possible digital commodities already exist; that they are value-neutral; and that all that is required in making a project is to plug them together and provide necessary software glue. None of these could be further from the truth. All commodity technologies come with constraints as well as affordances. These constraints are often only revealed in the process of working with them and attempting to make them do something they were not designed explicitly to do. Poor choice of high level components can make tasks more complex and more difficult than necessary. Such reality is consistent with the general principles of knowledge representation, indeed, such artifacts embody and reify certain modes of knowledge representation.

The notion of information having the possibility of existing in a disembodied form is, we must remind ourselves, axiomatic and rhetorical and without evidence. All information is materially instantiated, and the idea that information can be migrated from one material to another does not assert the independent immaterial existence of information as a thing. The entire computational dualism of immaterial information inhabiting a material substrate is nothing but a recapitulation of Descartes' peculiar and tenuous dualism, conjured up to resolve his own crisis concerning the relation between the immaterial soul and the material body. It is odd that computer science would take as so fundamentally formative an hypothesis that has not a shred of scientific evidence to support it.

Contrary to the idea from symbolic AI that 'intelligence' was the logical manipulation of symbolic tokens in an abstract reasoning space unconnected to the world, it is equally easily asserted that interaction with the physical and social world constitutes intelligence, and that historically, AI took its position because the necessary sensing and interpretation tasks were technically challenging, if not intractable. (see 'the matter with matter', below).

4. MAN-MACHINE INTERACTION AND TECHNOPHILE RHETORICS OF LIBERATION

"Our computers retain traces of earlier technologies, from telephones and mechanical analogs to directorscopes and tracking to radars." David Mindell [16]

As David Mindell reminds us, the physical conformation and functionality of the machine we use is determined by the history of technologies from which it arose. It is a skeuemorphic assemblage. The history is military, bureaucratic and commercial, to varying degrees (depending on who you read). Interactive multimedia, we must recall, is the child of Cold War computing research. The ur-HCI project was the SAGE system, which put soldiers with keyboards and lightpens in front of monitors, to accomplish the complex pattern recognition functions which the system could not autonomously manage. This constellation of technologies was the model for the keyboard-mouse-monitor paradigm. The fact that this harnessing of flesh to machine was later clad in the rhetoric of liberation in the heyday of interactive multimedia remains deeply ironic.

Why do I sit at a desk to use a computer? The unavoidably historical answer is that the device was developed as a replacement for a component of a preexisting organisational and architectural order, in this case the business office. The desktop computer is, or was, an enhanced typewriter and calculator with added filing-cabinet functionality. It follows then that it is particularly useful and relevant for activities which resemble office desk activities, and is decreasingly appropriate for activities whose social and architectural placement diverges from that scenario. Most cultural and artmaking activities do not resemble office work in their physical contexts, methodologies or goals.

While various pioneers in computer art have been and are being inserted into a retroactively compiled pre-history of the field, the fact remains that in the formulation of the fundamental aspects of the machine, hardware and software, and their relationship, serial processing and operating systems, networking and interface, artistic needs, goals and methods were never considered and no artist was ever consulted. It seems surprising from this perspective that any artist would imagine that computer art might be possible. (That, I suppose, is the genius of art.) By the same token, it is no surprise that in attempting to utilize the machines, artists have experienced repeated frustrations. (In the past I have likened the situation to sending a swat-team into battle with excellent hair-dryers and toaster-ovens.) And seldom does this frustration reach a level of analysis where a distinction can be made between a technical fault (a bug) and a limitation in principle.

There is no end to the accolades we hear offered for the triumphs of computer animation, or scientific visualization, or hypertext, or the web, or multiuser gaming- new cultural practices which are more or less compatible with the various constraints of conventional computing and computer use. It is much more difficult to ask – if the basic conformation of the device and its peripherals were different, what kinds of socio-cultural practices might be accommodated, assisted or afforded? This very acceptance of the hardware conformation of the machine constrains the kind of practices which can occur. Here then is a research agenda which begins from rigorous intellectual inquiry and offers the prospect of unimagined realms of technical and aesthetic development.

5. EMBODIED AND SITUATED PRACTICES AND THE DRIVE TO FORMAL ABSTRACTION

As a longtime practitioner of practices of embodied intelligence, I remain alarmed that we are prepared to accept as generally useful, a machine system which is only capable of interpreting as input, linear strings of alphanumeric characters. The machine knows nothing of the world, except that which a human predigests and feeds to the machine as alphanumeric strings. Such a system is excellent for doing arithmetic and accountancy, calculating tide and firing tables, storing and retrieving textual records (the kinds of practices which the technology was originally designed for) because these practices have already been abstracted into formal mathematico-logical representations and organizational and cataloging systems generations before the machine existed. (Implementation of algorithms for sorting by date an alphabetically clearly depend on the prior development of calendars and alphabets, and the construction of a more or less universal literacy with regard to them.) Indeed, the machine is well attuned to these practices because the formalisms upon which the machine is based, and the formalisation of those organizational practices arise from a common root.

Reflect on the larger historical arc, beginning, as AI practitioners like to do, with Descartes and the establishment of rationalism. Here, in broad terms, we see the success of attempts to categorise and organize the world according to mathematico-logical ordering systems. Subsequently, we see the development and increasing sophistication and elaboration of techniques for designing and building machines: engineering and the industrial revolution. This paradigm gains momentum as electricity, radio, telegraph and related technologies arise, and coalesce as electrical engineering and electronics, during a time when engineering itself is being reconfigured as an increasingly analytic and mathematical discipline [17]. From this technical base arises electronic computing. Now while many of the founders of AI were psychologists, the technology they employed had a different provenance. The implementation of Boolean logic as electronic machine was the foundation upon which programs like logic theorist ran. So it should be no surprise them that such technology was found to be highly amenable to the automation of mathematical logic, and by the same token, it explains why problems outside that realm have been found so intractable. Again, Philip Agre concurs : “a theory of cognition based on formal reason works best with objects of cognition whose attributes and relationships can be completely characterized in formal terms.” [18].

Our world is replete with complex cultural and social practices in which the calculation, storage and retrieval of data play a vanishingly small part, and in which spatial awareness, texture, gaze, gesture, tone of voice, perceptual integration, active sensing, kinesthetics and proprioception (all sensibilities outside the ken of the computer) play key roles. What this means, in effect, is that the technology to which we are encouraged to apply to these functions is incapable of sensing or measuring these qualities (I hesitate to even call them variables). In effect, the conventional PC is a filter which filters out all aspects of our complex embodied intelligence except that small part which can be encoded as strings of alphanumeric characters. Rhetorics of computing, both marketing rhetorics and the more complex and subtle charactisations of the computational in literature and film, commonly contain extropian and anti-corporeal sentiments which imply that human experiences which are not amenable to serial Boolean logical expression are somehow irrelevant. Surely this should be an issue of greatest concern to practitioners and theorists of embodied practices, yet there is an almost entire absence of informed critical assessment of the relevance of such a technological paradigm to activities like, for instance, choreography, painting, cooking, sailing, clinical diagnosis or physical therapy.

At root, this is the danger of the implicit acceptance of the von Neumann machine as the paradigmatic technology of our day as is the case in computationalist cognitive science. By taking the functioning of the serial processing Boolean computer as an acceptable analogy to the functioning of mind, we thereby afford the development of a specific range of ideas and research programs and close off the possibility of many others. There is thus, an underlying and seldom acknowledged conflict between the values reified in the hardware and software of computer technology, and the purposes to which these technologies are put. The simple fact is that media arts employ technologies designed for instrumental purposes – automation, accountancy, archiving. It cannot be asserted that artistic needs and purposes were ever considered in the design of the basic technologies. It follows then that existing computer technologies are unlikely to be optimally appropriate for such applications. This is unlike, for example, the evolution of the medium of oil paint, which was developed over generations specifically for the task of painting pictures.

A machine designed for manipulating strings of alphanumeric characters may simply not be relevant to certain human tasks – why should we assume it should be? Why should we be at such pains to deny the obvious fact that our intelligence and our embodiment are precisely attuned to each other, through childhood development as well as through evolutionary process? Our intelligence is expressed in all modes and all combinations of modes of our lived physical being. Yet we are increasingly naturalized to the idea that we should be ready to translate any sort of human notion or practice, into keystrokes, in order to make in acceptable to this cloth-eared device. Not only is it absurd that such an expectation be attached to such a purportedly marvelous technology, but it relegates any human quality not amenable to such processing to oblivion or irrelevance.

All too often, digital culture workers seem to think in terms of 'how can I (change my behavior in order to) exploit this (available, commodified) technology'. This assumes that the currently available range of commodified hardware products are adequate and sufficient. I find this preposterous. Vast new areas of research and practice will open up if we instead ask: 'what sort of technology would be an asset in the prosecution of my chosen task?'

We are conditioned to imagine that the output (and input) of an interactive system will be symbolic, textual and graphical, probably on a monitor: a technologically arbitrary arrangement determined only by historical factors. Even though the hegemony of the desktop appears to be fissuring, the new portable, locative and wearable technologies generally simply minaturise and otherwise replicate this paradigm, as was the case for many of the interfaces developed for immersive stereoscopic environments (VR) in the 90's: devices such as the 'wand' which absurdly ported the pointing device with buttons idea, originated to compensate for the lack of spatiality and tangibility of the desktop, into the realm of embodied interaction.

The machine which has *trickled down* to artists is a machine for the quasi-arithmetic manipulation of abstract alpha-numeric symbols. [19] It is very good at that. But if digital arts practices are to develop in a well theorized way, we must ask: is art practice, always, primarily or ever, about the logical manipulation of symbolic entities? Indeed, to ask this question would be to open a range of important inquiries. Occasionally, exploratory work in the media arts explores the range of possible practices less constrained by paradigms of data-entry and command-and-control. It is worth noting that while such practices were more common in mid twentieth century art+technology experimentation, they were less common in late twentieth century work, after the consolidation of the desktop computer paradigm. It may be that such projects are now more confounding to audiences due to the naturalization of that audience to the desktop and related paradigms.

6. ART AND AI

Art and AI are remarkable foils for each other. While AI saw logical problem solving as the defining pinnacle of intelligence, that capacity does not rank high in any conception of intelligence in the arts. Whereas AI came to grief in the complexity of everyday life, art would come to grief in attempting logical generalism. While CS takes generality as a virtue, one might propose that Art takes specificity as a virtue. While reductivism is part of the very fabric of CS, art is holistic. Artificial Intelligence found its initial successes in the automated solution of mathematico-logical problem solving activities, the logic theorist and GPS of Newell, Simon and Shaw, chess programs, toy and micro-worlds and the like. These were heralded as heights of intellectual achievement but they were consistent and constrained, local logical domains. AI stumbled on the realities Kurt Goedel articulated, as it attempted to extrapolate these successes to the real world, spoken language and the like: untidy, heterogenous and illogical domains in which artist are trained to operate.

The drive toward abstraction and generality came into computer science from the mathematical side. Abstraction is beguiling in its promise of transcendent clarity. Abstraction affords a certain kind of power, yet it also forgoes any power that specifity and the particular can bring. As Wendy Chun notes, "Programming languages inscribe the absence of both the programmer and the machine in its so-called writing." [20]. Indeed the march to ever 'higher level' languages creates increasing abstraction in which both hardware specifics and stored data are increasingly effaced. Instrumentality entered from another side, linked to digital technologies as they arose as a form of industrial production. Against these, as it were, are arrayed situated and embodied sensibilities native to the arts, and a commitment to material specificities.

In the histories of the plastic arts, in the modernist period, there was a notion that the appearance of an artifact should betray the nature of its materials and methods of manufacture. Hence the Bauhaus dicta of ‘form follows function’ and ‘truth to materials’. Computing, contrarily, hews to a postmodern aesthetic of surface and superficiality: the function of the interface is to obscure the true nature of the machine. To protect the machine from the user and/or vice versa is the motivation of HCI.

In terms of effective HCI, a tool or package is successful to the degree that it is intuitive. That is, that it recedes from conscious awareness, that it facilitates an illusion that there is no mediating technology between the user and the work object or process. Contrarily, that an artwork should contrive to obscure its own artifice is almost unconscionable in the modern and postmodern periods. Works often exist to bring to attention the artifice of the medium, the qualities of the technology or the way they perturb the situation or object of attention. Illusionism is constructed only to be broken, or intentionally problematised. In these terms, the relationship of (naïve) HCI and (critical) media art practice are entirely opposed. If HCI aspires to be ‘ready to hand’, media art aspires to be ‘present at hand’. *In my own work Fugitive, an illusion of immersion was facilitated, only to be abruptly disrupted, in an attempt to bring the user to an awareness of their own trajectory of embodiment (as opposed to their subject position as an actor of limited agency in a prestructured world) and their own willing suspension of disbelief.* The function of the project, then was intentionally reflexive and ‘meta’ . It was conceived, as most of my works are, as an intervention into a discourse, in the form of an artifactual system which is directly experienced rather than read.

A significant difference between computer science research and media arts practice lies in the ontological status of the artifact. As discussed above, for an artwork, the effectiveness of the immediate sensorial effect of the artifact is the primary criterion for success. It is engaging, it is communicative, it is taken to be coherent, or it is a failure. The criterion for success is performative. Most if not all effort is focused on the persuasiveness of the experience. Backstage may be a mess, a kluge. In computer science the situation is reversed. If the physical presentation is a little rough around the edges, or even missing entire pieces, this can be overlooked with a little handwaving, because the artifact functions as a ‘proof of concept’ which points to the real work, which is inherently abstract and theoretical.

7. INFORMATION, COMMUNICATION, MEANING

Fundamental to CS is the idea of information, and the idea that information exists, or can exist, in some abstract non-material realm, separate from and independent of, its material substrate. This is an (inherently Cartesian) assertion and not a self evident truth. As a structuring assumption it is ripe for critique. As such, it has permitted the sorts of advances compatible with the paradigm, but, equally, has excluded entire avenues of research.

Due to the elaboration of this paradigm, an ontological drift in the term ‘information’ has occurred over the past half-century under the influence of the development of techniques which utilize Boolean operations in a von Neumann architectures. Expressions such as Information Economy and new disciplines such as Informatics attest to this drift. The range of common contemporary uses of the term indicate, that, like many expressions in common language in which technical definitions and uses have been applied applied to them retroactively, the word possesses a hazy cloud of meanings. I suggest that the discipline is structured by an informal working definition which is not unproblematic because it confuses ‘information’ with ‘computability’. ‘Information’ has been formalized as quantifiable and logically manipulable (Shannon), and hence, *information* which is not quantifiable and logically manipulable is no longer information. Now it may be that it is not logically manipulable because there has been no compelling (commercial) reason to render it manipulable, or it may be that it is inherently not amenable to logic or quantification in that sense. We must therefore examine the value structure thus created: if logical manipulability is valorized, then vast realms of human practices are hence devalorised. [21].

As Ronald Day notes: “Within the context of information theory’s operational and statistical understanding of language and affect, all human actions are subject to statistical and predictive prediction and design. Needless to say, such prescriptions have dire consequences for any statistically marginal dialects, forms, genres, or identities that are not socially dominant, as well as for activities of language (such a poetry, art, and even, sometimes, critical theory) in which language's formal and social functions precede and ground their more, so called, "communicational" functions." The conduit metaphor " not so much plays the role of describing an empirical event, but rather, of transmitting and prescribing a certain model of language and society. That model is an utopian one of a formally closed communicational society, similar to that which is found in the "closed world" of the Cold War (see Edwards, 1996)." [22]

In effect, these operational and statistical understandings construct a hegemonistic order which changes a landscape of plurality and diversity into an oppressive order, marking certain practices as deviant and forcing them underground.

Interestingly, it is into this subterranean well that mainstream culture then dips for novelty. One way to understand the artistic avant-garde is as the provider of this mechanism to reintroduce (memetic?) variety from the cultural 'wilderness park' or 'biodiversity preserve' which is thereby constructed – a protected zone of (named and tolerated) deviant behavior which is simultaneously nurtured and marginalized. The mechanisms of the art world – small semi-commercial galleries and performance venues, small presses, low budget media production, and marginal public media (ie pacifica) provide the 'conduit' by which this diversity is sucked back into mainstream culture in metered doses to revivify it. [23]

8. OBJECTIVITY AND ENACTION

One of the large trends in western thought over the last century, felt equally in the sciences, in the humanities and the arts, has been the challenges to the presumed authority, validity or even possibility of objective knowledge or a detached objective viewpoint. This trend is perceived in the crisis Heisenberg and Schroedinger brought to modern physics as it is in the problematising of authorial status and the authority of texts (Barthes, Derrida etc). In the sixties and seventies, both second-order cybernetic theory and autopoietic theory addressed the condition of the observer directly. As Heinz von Foerster remarked "Objectivity is a subject's delusion that observing can be done without him." The culture around computer science, like any other academic discipline, has its inconsistencies and oddities. These include subscription to an unreconstructed Cartesianism and unreconstructed Objectivism, explicit in the 'gods eye view' often encountered in software and systems. [24]

Enactive and situated theories of cognition and phenomenological critique of AI (Dreyfus, Suchman, Varela, Lakoff and Johnson, et al) exposed a platonic and top down spirit in that enterprise and the school of cognitive science associated with it, and led to a recognition of the relevance of theories of situated and embodied cognition. This opened a way for more subjective and less autocratic modes of technical practice (Brooks, Maes, Agre, Horswill and Chapman et al). David Marr begins his well-known 1982 book on vision with the statement that "vision is the process of discovering from images what is present in the world, and where it is". [25] But in human and animal biology, the study of perception as a one way process, an of methods in which are clinically isolated from lived experience has given way to the conceptualization of *active sensing*, which asserts the importance of examining the kinesthetically engaged, temporal coupling of sensing and action.

In the plastic arts we see an ongoing challenge to the single, detached, privileged viewpoint reified in perspective, first in modernist image making (Cubism) in which the conventional perspectival view was perturbed and multiple viewpoints were combined, thereby problematising the unique and authoritative viewpoint of the observer. By the mid 60's, the authority/authoriality of the artist was actively under critique by artists themselves, as was the divide between critic and artist, and between text and the plastic arts (Conceptual art). This process generated a profusion of new genres in which the reliable stasis and formal relationship between viewer and work, as well as between artist and work, were broken down. In such cases the spatial and temporal subjectivity of experience was emphasized. Such works were thus often disorienting to their audiences.

As I have previously observed, the theoretical agendas of (at least the first generation of) media artists were established in this period. In hindsight, one can view the radical work of the 60s and 70s as prefiguring and modeling the challenges of digitally based art forms. (This would be consistent with the idea that one of the functions of art in our culture is as a cultural 'early warning system'.) With the availability of computational tools, the arts have engaged in the design of (automated) behavior and interaction. Recognition of this paradigm shift demands the abandonment of old aesthetics of passive contemplation and calls for the formation of an aesthetics of dynamic engagement by and with cultural artifacts [26]. This trend gives rise to modes of cultural practice in which the user takes some active and constructive role in the creation of her experience. This trend is clear in the transition from the authority of the cinematic eye/screen to the distributed contingencies of multi-user gaming in hybrid environments combining the agencies of remote players and semi-autonomous software agents or 'bots'.

As instrumentality is natural to the realm of machines, so autopoeisis and symbiotic relationships are natural to biological organisms and systems thereof. In biological (as well as social) systems, cybernetics notwithstanding, identification of discrete inputs and outputs depends on a tenuous and strained contrivance. A critically motivated practice might work towards technological projects in which organization is based on an autopoietic or ecological metaphor, where none of the entities or parts produce 'output' but, in the spirit of Actor Network Theory, all entities – humans, animals, instruments, networks and institutions are conceived as agents are linked in a hybrid, heterogenous and mutually enhancing circulation. New paradigms for understanding and making interactive cultural pursuits may be theoretically enhanced by reference to contemporary Cognitive Science, Neurophysiology, Ecology and Social Theory.

9. GENERALITY AND SPECIFICITY

A fundamental commitment of computer science is that of the *General Purpose Machine*. From the outset, generality was taken to be desirable, for reasons which are unassailable in formal terms. The principle of the 'general purpose machine', is an elaboration of Alan Turing's fundamental notion of the 'Universal Machine' (known latterly as the Turing Machine). The virtue of generality was reinforced with the GPS (General Problem Solver) of Newell, Simon and Shaw. It is basic to the concept of the digital computer, (this is textbook computer science history). The unquestioned axiomatic acceptance of the concept of generality as being a virtue in computational practice demands interrogation, especially when that axiomatic assumption is unquestioningly applied in realms where it may not be relevant. Indeed, the fact that the idea of the universal relevance and validity of the concept of generality is rarely asked; itself suggests fertile ground for interrogation. [27]

Historically one can identify a two-stage process of elision and reification, related to the economic principles of the computer industry and the rapid uptake of the computer in diverse socio-cultural contexts far from the original applications of the machine. The first stage was the transfer of the notion of 'general purpose' to the beige colored box and its big vacuum tube appendage. Quite possibly a result of the odd combination of ignorance, mendacity and pecuniary interest so particularly characteristic of the advertising (so-called) industry. The idea of generality, entirely substantiable in formal mathematical terms, became thus attached to a physical commodity. The notion of generality thus offered justification for highly profitable strategies of consumer commodity economics. The casualties of this capitalist sortie are seldom discussed. But if all uses for the computer could be contained by alpha-numeric desk-work, the other sorts of human practices which were not compatible with that particular work culture, or not identified as profitable enough sectors to justify the investment in software tool development; had to reshape themselves or suffer the stigma of remaining uncomputerised.

The world was thus divided into the computerized and non-computerised realms, and caché and advantages flowed to the computerized practices, in popular culture, which was itself increasingly defined by and located in digital practices; as in the academic and research worlds, where computerized/computerizable disciplines were able to access comparatively huge funds (much of which flowed directly back to the computer hardware and software industry). The result of this trend was that all sorts of human practices for which the computer, as formulated by the industry, was not ideally conformed, often then bent and reconfigured themselves to adapt, often at a significant cost to the integrity of the practice and its sensibilities and knowledge base.

This process is observable in diverse fields and disciplines over the last quarter of the C20th, from engineering to the arts, but it is in the arts that such trends are particularly stark. This is because, as argued, the arts the practices rest on such profoundly different foundations, both historically and theoretically. This then is the core of my argument. Artworks are made by individuals of particular physical conformations, with particular perceptual and physical skills, immersed in specific cultural and historical contexts.

10. EMBODIMENT, SITUATION AND TOOLS

Pataphysics will be, above all, the science of the particular, despite the common opinion that the only science is that of the general. Alfred Jarry, [28]

Tools are specific to functions. There is no such thing as a general purpose tool. Every craft has a range of specialised tools. The skilled craftsman is highly discerning about matching a task to a tool. The notion that generality is a virtue is opposed to a generally accepted notion that there is a tool for every job and a job for every tool. Contrarily, informed by the dual evil motivations of user-friendliness and generality – software tools seek to reduce the diversity and specificity of individual and cultural motivations and world-views: user friendly software tools make easy (generalisable) tasks easier and difficult (more specific) tasks more difficult.

In opposition to the ideology of generality, one might propose that art is naturally Pataphysical. An artwork is deemed to be excellent if it addresses a particular situation with persuasive precision. That is, by a subtle combination of the signifying potential of spatial organisation, materials, sounds, images and user dynamics; a coherent experience is generated which leads the audience/user into a particular realm of interpretation. An artwork is successful to the extent that it is specific. Generality is not a virtue in the Arts. Generality and affective power seem to be mutually exclusive. It's hard to imagine what a general purpose artwork would be like, unless it was one of those generic and vacuous hotel room pictures, whose work is to proclaim a respect for art on behalf of their owners, while safely avoiding the danger inherent in actually being art. This is the fatuous conundrum at the root of the myriad of techno-cultural projects which attend to and intend to automatically generate cultural artifacts. <u>The notion of the general purpose machine has indisputable power and relevance in its place. But we must be wary of the drift of axiomatic assumptions which can flow from a paradigmatic technology of both rhetorical and economic power.</u>

Over the latter part of the C20th, computer based image making became increasingly sophisticated as the technology became more affordable and dispersed across culture. As such image processing engaged the realm of painting, we can observe a degeneration of the bodily and material culture of painting. Painting as a tradition of practice has honed its tools and techniques over hundreds of years, such that the painter trained in and practised a diverse and integrated range of proprioceptive skills, kinesthetic sensibilities and perceptual procedures which taken together, resulted in a practice of infinite diversity, expressiveness and subtlelty. All this then went out with the bathwater when painters were enticed to sit with a fixed focal length at a small scintillating image while pushing a little plastic box around on a small space of desktop nearby.

The interface and tools used some of the language of painting, but the actual physical interfaced was utterly unlike the performative context of the painter: the display was small and of low resolution, the complexity and subtlety of physical skill was completely absent, and the 'output' product was (usually) of small scale. How neatly the rhetorical power of the paradigm of disembodied information dispatched the unnecessary and encumbering bodily knowledge and liberated the abstract and pure idea content of the practice. In the face of six hundred years of refinement, the desktop computer painting emulator had barely sixteen. The technology did, and does, afford all sorts of capabilities which painting did not: actions could be reversed, multiple versions could be kept, product could be sent over network to a remote location – all remarkable and wonderful qualities. But, like the tea produced by the nutri-matic machine, it was almost entirely unlike painting. [29] It is strange to observe that amongst practitioners, teachers and theorist in such contexts (and there are many, not just with respect to painting but to a wide range of other skilled professions), critical assessment of the value and quality of the traditional practices vis a vis the new technologies is rare. Ironically, software developers are more likely to undertake a study of the traditional practices than are the purported guardians and partisans of the practice likely to undertake a study of software tools.

11. THE MIDI INSTRUMENT: PERILS OF GENERALITY

Electronic music interfaces tend to hew to two different paradigms. Some adapt or augment an existing instrument. This approach exploits the richness and specificity of the sensibility developed by the musician to the artifact. In musical performance, the bodily/artifactual cultures of virtuosity compare to similar practices in the visual and plastic arts, and each can be read in terms of interface and interaction design. Here one might consider the assumptions underlying in the term 'interface'. For, as the face is conceived as the sensory front end of the brain, as the windscreen through which the driver of the bodily bus peers, so the notion endorses an archaic notion of perception a one-way sensory information flow into the brain, and simultaneously denies any reality to an 'interbody'. [30]

Traditionally, the facility of the musicians bodily skill with his instrument is regarded as a measure of virtuosity. The sensitivity and specificity of the bodily actions of the musician is integrated, by dint of long training, with the trained ear and the mental characterization of acoustic quality. This is truly embodied interaction in a most refined and virtuosic sense. The alternate scenario is that of the patchable multi-function electronic musical instrument interface device. Such devices are, in HCI terminology, 'controllers' [31]. They afford the performer the possibility of mapping any variable of the computer music system to any perturbable aspect of the device. Such devices therefore import the 'virtue' of 'mappability' or 'assignability' from the purportedly 'general purpose' physical incarnation of the general purpose machine across to the musical instrument. But the musical instrument is a paradigmatic example of the specificity of tools argument. What makes a Stradivarius much more of a violin than a cigar box with a rubber band stretched over it? A history of increasingly refined atunement between the material specificities of the artifact and the embodied intelligences and skills of the player.

The special quality of any instrument is, it would seem to me, its integration with a long standing culture of training and playing, and these things combined permit the subtlety of virtuosity. When played by a trained player, subtle and complex effects are produced. Specific kinds of modulation are associated with specific kinds of physical actions in specific locations on the instrument. The multi-function electronic musical instrument forgoes such possibilities. The range of possible variables can be void of common qualities. The same manipulation might address amplitude, or key, or access different samples on the hard drive. The assignment of any control function to any input sensor, and thus to any bodily modality, is variable and arbitrary. With such flexibility and diversity, a fluent bodily relation to the material artifact cannot be developed.

12. THE MATTER WITH MATTER: SPECIFICITY AND SIMULATION

The difference between theory and practice is greater in practice than in theory (anon)

From now on, lessons in rice planting will occur in the paddy fields. (Notice posted on blackboard in Chinese Cultural Revolution Film *Breaking with Old Ideas*).

In computer science, consistent with the dogma of the general purpose machine, and *platform independent* technologies which succeed from it, hardware is usually taken as a given, and assumed to be adequate or even optimal to the task. The machinations of code can proceed without reference to the real physical world. But in fact, such hardware substrates always come with their specific affordances and constraints, and their interface to the physical world is delimited. In a world of networked databases, required data is (paradigmatically) always unproblematically available in a form which does not require interpretation. Contrarily, the real, biophysical world is a dirty, complex and unpredictable place. Among the robotics community in the 90's, the remark 'fix it in software' was often heard and it was almost always tongue-in-cheek. The remark signalled a recognition that many problems could not be 'fixed in software'. Data is generated by the digisation of signals from sensors which exploit electrophysical phenomena. Specific physically tangible electronic and mechanical technologies have to be designed and tested with respect to specific environments in order to create a context in which code can usefully work. If any part of that 'front-end' process is faulty (wrong alignment or calibration, bad optics, unreliable power supply, unexpected response to environmental factors such as humidity, etc) or if the scaling and parametrisation of the a/d process is inappropriate; then the data representation of the real-world phenomenon is forever flawed. In the spirit of GIGO (Garbage In, Garbage Out), no amount of software downstream can create more accurate and higher resolution representations of the world than that supplied by the interface with that world. At best it can retrofit a simulation of it, based on accurate measurement of the kinds of errors inherent in the faulty sensor. This, of course, can add a second cycle of inaccurate representation.

This tension between the power afforded by abstraction, and the simultaneous loss of precision, is explicit in the case of simulation. By the same (fix it in software) reasoning, computer simulation of real world contexts must be regarded with some reservation. As Eugene Ferguson, among others, has observed, any simulation tool is itself a design artifact, and depends for its representational accuracy on several factors. First, that the designer correctly identified all the relevant physical effects. Second, that such physical effects are amenable to algorithmic representation. Thirdly that these representations are accurate and of adequate resolution. Forth, that all possible interactions of these relevant factors were appropriately calculated and represented. Certain kinds of physical phenomena, particularly those manufactured to reliably embody and express a mathematically simple physical process are more simple to simulate. The behavior of a tree in a storm, or the turbulence of water on a ships hull demand more complex computation, or may be inherently uncomputatable. Here the isomorphic loop of industrialism and engineering stands out in stark relief. A gear train or resistor-capacitor network is easily simulated because these things are themselves produced to embody behavior easily described in newtonian terms. One is inevitably reminded of the Borgesian conceit of the map in 'Of Exactitude in Science". The recognition of the fundamental necessity of computability of a simulation is a reality which seems often forgotten. Inevitably, there are more factors at play in the real world than in the simulation. Thus many practitioners, particularly those trained in the computer science disciplines, are deeply shocked when the real world does not conform to simulation. As Hamlet noted, *There are more things in heaven and earth, Horatio, Than are dreamt of in your philosophy*. [32]

13. CONCLUSION

"A critical technical practice will, for the foreseeable future, require a split identity,-- one foot planted in the craft work of design and the other foot planted in the reflexive work of critique." Philip Agre [33]

If the thesis of this paper is taken to be valid, at least in part, then several paths of action are called for. The first is a thoroughgoing assessment of the effects of the computational paradigms on cultural practices, this is both a theoretical inquiry and a context for historical work and case studies. Practitioners are duty-bound to assess the values inherent in the technological tools they employ, lest they sabotage their enterprise. If and when these ontological booby traps are identified, a new mode of technology development is called for: the imagining, design and development of tools consistent with the values which underly and shore up the practice itself; always allowing for the possibility that any form of technology *could be* antithetical to, or destructive of, the cultural enterprise.

The other, alternative and parallel path is the negotiation of new cultural practices native to the new technologies, in a process which intelligently and attentively assesses the potential disharmonies between the artistic goals and the qualities of the technologies.

Both these kinds of design processes must address the technologies at a plethora of different levels, from the smallest component level to entire devices, from implicit entailments of programming languages to dynamics of the interface and interaction, and everything between.

14. REFERENCES / ENDNOTES

[1] These writings include Simulation Digitsation Interaction: The impact of computing in the Arts, Artlink, 1987, Consumer Culture and the Technological Imperative, in Critical Issues in Electronic Media, SUNY Press 1995, Ed S.Penny; The Virtualisation of Art Practice: Body Knowledge and the Engineering World View. CAA Art Journal Fall1997, etc.

[2] Although ubiquitous, I do my best to avoid the descriptor 'new media art'. In my opinion, all three terms are dubious. It is facile to observe the transience of 'new'. Less often is questioned the assertion that this practice can be described under any of the concurrent definition of media. From my point of view, that these practices comprise 'art' in a sense that is compatible with conventional notions of art is also, at least, an assertion worthy of discussion. Though awkward, I prefer Digital Cultural Practices, or Computationally Automated Cultural Artifacts (CACA).

[3] Inasmuch as institutions of higher learning are hosts to the pedagogical environments where these practices are developed and taught, this inquiry has direct relevance for institutions with programs which address such areas of practice, and specifically to the challenges of interdisciplianrity. Articulation of the details of such contexts goes beyond the scope of this paper, but has been addressed by the author previously in: 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)] (and in forthcoming papers.)

[4] Such practices imply the development of an Aesthetics of Behavior. Elsewhere I have argued for the recognition that such a modality of aesthetics is not only fundamental to such practices but unprecedented in the history of the plastic arts.

[5] see Snow, C.P. The Two Cultures, 1959, reprinted Cambridge University Press 1998, etc.

[6] Theodore Roszak. The Cult of Information. Pantheon, 1986. p217

[7] The Army and the Microworld: Computers and the Politics of Gender Identity. Paul N. Edwards. Signs, Vol. 16, No. 1, From Hard Drive to Software: Gender, Computers, and Difference (Autumn, 1990), pp. 108-09

[8] Towards a critical technical practice: Lessons learned in trying to reform AI. in Bowker, Gasser, Star and Turner Bridging the Great Divide, Social Science, Technical Systems and Cooperative Work. Erlbaum 1997. I make full acknowledgment of the insightful work of Philip Agre in his analysis of the cultures of AI and CS, he is quoted more than once in this paper.

[9] Agre. Philip. Writing and Representation. Michael Mateas and Phoebe Sengers, eds, Narrative Intelligence, Amsterdam: John Benjamins, 2003

[10] Agre. Philip. Towards a Critical Technical Practice. op cit

[11] This useful term was coined by JD Bolter in his pioneering work of digital cultural studies, Turing's Man. North Carolina University Press, 1984.

[12] Friedrich Kittler. On the Implementation of Knowledge- Toward a Theory of Hardware. Found at http://www.hydra.umn.edu/kittler/implement.html, etc

[13] Mintz, Sidney. Sweetness and Power. Viking Penguin, 1985.

[14] This is silly of course, but the staff-faculty class structure of the (American) university is based on this. This is another dimension of academic life which reinforces the hardware-software dualism, and the attendant notion that knowledge-work or creative work occurs exclusively in the abstract mental realm of text and code.

[15] My class "Hardware Intelligence" argues against the dualistic academic dogma which

proposes that the more engaged with the physical world a practice is, the less intellectual or intelligent it is. Far from being just a remedial skill building class, this class brings students who have been alienated from the physical world by software, back into a rich engagement with it. The ACE program has a pedagogical commitment to a holistic approach to technologies and the intelligent manipulation of matter and the production of material product.

[16] Mindell, David. Between Human and Machine: Feedback, Control, and Computing before Cybernetics. Johns Hopkins Studies in the History of Technology, 2004. p321

[17] Ferguson, Eugene, Engineering and the Minds Eye, MIT press, 1994.

[18] Agre, Philip. Towards a Critical Technical Practice, op cit

[19]I use the term 'trickle down' with full recognition of its origin in discourses of military to civilian technology transfer.

[20] Chun ,Wendy Hui Kyong. On Software, or the Persistence of Visual Knowledge. Grey Room, 18.

[21] Ronald Day, discussing Shannon's formulation of information theory, similarly asserts ": information" has, among other qualities, that of being quantifiably measurable and "factual" in the sense of being clear and distinct semantic units." Implied in this conception of information as being susceptible to manipulation presumes the separability and independence of information from materiality. If as a disciplinary partisan, one embraces such assertions (and clearly career success within the discipline depends on it) then a certain kind of process is prescribed, an information-oriented process in which hardware is taken to be generic and software is where the intellectual innovation takes place.

[22] [Ronald Day. The "Conduit metaphor" and the nature and Politics of Information Studies. Journal of the American Society for Information Science51(9):805-811, 2000].

[23] Tiziana Terranova, in her exemplarily self-reflexive consideration of information theory, proposes that for a critical apparatus to effectively address contemporary communication and information issues, it must combine the poststructural critiques of meaning rooted in semiotics and deconstruction with an understanding of mechanisms of transmission which such poststructural approaches ignore, and this supplement must be based in information theory. She notes: "Information is not simply the name for a kind of form meant to survive the attack of noise, but more a quasi cause or catalyst for an active power of constitution and transformation that it does not contain in itself." [Tiziana Terranova, Communication Beyond Meaning: on the cultural politics of information. Social Text, 80, Vol22, No3, Fall 2004.Duke University Press.] The image she conjures, to extend her employment of tropes from complexity theory (elsewhere in the paper), is the image of an agent poised at an energy maximum, for whom the injection of information creates a movement characterized by a "sensitive dependence on initial conditions".

[24] Philip Agre draws attention to another such anomaly, the utilization of introspection as a method in AI. Towards a Critical Technical Practice, op cit

[25] this is what active vision researcher Andrew Blake called "a prescription for the seeing couch potato" (1995). In contrast, in the active sensing view, behavior is tightly coupled to sensing, and behavioral programs operate on minimalist representations of the world that are computed from changes in the sensory information reaching the animal as it manipulates its body, and thus its biological sensor arrays, through space" http://www.cnse.caltech.edu/Research02/reports/macIver1full.htm

[26] Penny, Simon. From A to D and back again: The emerging aesthetics of Interactive Art, First published in Leonardo Electronic Almanac April 1996.

[27] Phoebe Sengers undertook a similar inquiry with respect to another computer science tenet, modularity, in her PhD thesis, Anti-Boxology. Carnegie Mellon University, 1998.

[28] If physics is the study of what is and metaphysics is the study of what "what is " is, then pataphysics is the study of what "what 'what is' is" is. Pataphysics...is the science of that which is superinduced upon metaphysics, whether within or beyond the latter's limitations, extending as far beyond metaphysics as the latter extends beyond physics... Pataphysics will be, above all, the science of the particular, despite the common opinion that the only science is that of the general. Pataphysics will examine the laws governing exceptions, and will explain the universe supplementary to this one...

Pataphysics is the science of imaginary solutions... – Jarry, Exploits And Opinions of Dr. Faustroll, Pataphysician.

[29] The Nutrimatic machine, in The Hitch Hiker's Guide to the Galaxy by Douglas Adams, produced a liquid which was ‘almost entirely unlike tea’.

[30] Music became electronic long before imagery. The act of composition was abstracted from the act of performance and music was resolved to symbolic notation long before computing machines dealt in such notation as currency. This may well be due to the amenability of music to the symbolic realms of computing.

Computer music also seamlessly mapped onto the precursor and parallel technological cultures of audio amplification, transmission and recording. It may be surmise that this history itself led circumstantially to the fundamental separtation of sound and image in digital media, ie it may be an entirely unintentional historical accident rather than being intentional according to some project of theoretical justification.

[31] Eric Singer’s Sonic Banana is one of many examples.
http://www.ericsinger.com/workprojects.html

[32] Shakespeare, William. Hamlet.

[33] Agre. Philip. Towards a Critical Technical Practice, op cit