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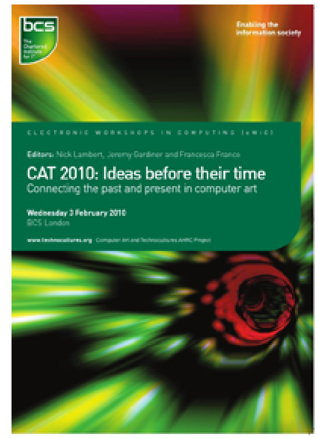

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Session 5: Computer Art & Technocultures

POST COMPUTER ART — ONTOLOGICAL UNDECIDABILITY AND THE CAT WITH PAINT ON ITS PAWS

Brian Reffin-Smith

What comes after 'computer art' depends on revisiting past concepts not fully explored. A true revolution involves seeing the past before returning to change the present.

KEYNOTE

First I'll say how pleased I am to be giving this keynote talk. The speakers presenting their theory, practice and ideas at this conference will, I'm sure, be reason enough to support the premise of 'rediscovering things lost' that I evoked in the text which the organisers have been kind enough to recognise.

I should note here that I'm very much in favour of a 'two for the price of one' approach to conference talks, so the text that I shall perform 'live' as it were, will differ markedly from this one, and the title of both has precious little to do with the contents of either - I just liked it.

I'm also going to allow myself a smile in passing because in a way, it's a kind of vindication. Although I was quite in demand at conferences and other events in the seventies and eighties there was a period during which the phone rang less often, and I know that this was because I tended to reject some of the more — shall we say 'optimistic' — 'blatantly hubristic' — 'hysterically triumphalist' — yet terribly mundane in art terms —products from the world of computer based arts.

I wanted, as did some others, to see a contribution to contemporary art, a pushing of the art frontiers, a recognition that if you were only interested in using state-of-the-art technology, you might end up merely producing state-of-the-technology art. Not everyone agreed with this attitude. Thus art ideas were often subsumed into or consumed by technical ideas. There just wasn't time to follow up the art, because the next new thing beckoned. More colours, more pixels, more processing power…as if the art would become twice as good by doubling the screen resolution. Furthermore the vision of 'art' involved with this process was, I shall argue, deeply spurious, old-fashioned and simplistic. Thus we already have two reasons for…failure.

In Kuhnian terms, there are no periods of 'normal' computer art, which is in constant 'revolution' or the constant appearance of revolution. It is as Marx predicted of late capitalism: ‘All that is solid floats into air’. And really, how we love that! How we shiver with pleasure in front of the virtual, the first generation ever to sense not only that, as Jean Baudrillard put it, the Gulf war did not take place, but that in a sense, nothing does. We think it connects us with quantality and the cosmos, but it’s more likely to be a marketing strategy.

However when I wrote an article for Leonardo Journal in which I stated that much computer art was complete nonsense *qua* art, and that everyone knew this but daren’t say so, it was amazing the response I got, with no critical letters at all, but about 15 people — from within the field — saying how much they agreed. In passing, I also satirically transposed my address from West to East Berlin, and thanked the German Democratic Republic’s Naval Ordnance Laboratory for their support. My phone got tapped; by which side I don’t know.

I now hasten to say that I’m delighted that the speakers today are people who invest their work with critical insight, with an artistic and/or creative impulse that means their contributions go to pushing the envelope, not posting it to Bill Gates asking for sponsorship for some all-singing, all-dancing, meretricious display that in the end goes nowhere. Some of them have been doing this for a long time (I mean the former of course!) working quietly as artists or designers or theoreticians who use computers. I have known some of them for many years, and have been honoured to study, teach or work with them. Other heroes, such as Professor Friede Nake, I am so pleased to have met personally relatively recently, better late than never, and to have exchanged and celebrated ideas with them.

But I have to ask: is working quietly now enough? In an art world — and a technological world — where it often seems that the possessor of the loudest voice, the most cynical gallerist, the most mystified critics or the most gangsterish friends is the one who triumphs — in such a world, can we really rely on the excellence of our ideas, the stoutness of our core values, the rigour of our systems, to get us to a place where our work makes a real contribution to contemporary art? And gets shown, criticised, incorporated not into the academy but into the new avant-garde? Even if we’re not yBa’s, but oBa’s?

We might ask: would it be enough merely to reiterate and re-explore ideas that were current and then neglected in previous decades; or even to go back and unearth dormant or latent art concepts that can be used today to make a bigger splash in contemporary art? And if not, if that quiet, considered, reformist approach would be too little, too late…then what could or should we do?

Let me take just two examples, and try to analyse where they might suggest a reexamination, in their ‘opening up’, an augmentation of their conceptual richness. Both these examples are from rather conventional 2-dimensional computer-based art, and I'm aware that the field was and is vast, and included far richer areas of activity. I'm sure we will hear a lot more about them later today.

Do you remember the early video digitisers, or frame-grabbers? I had three: one for my BBC Micro, with its stunning 32K of memory; one for my later Amiga 1000 with its over-the-top, wholly bloated 256K, and one, home made, for the Research Machines 380Z with its (extraordinary for the time) 56k and a floppy disc the size of a dustbin lid. (In passing, let us remember that a good art idea is a good art idea, whether it be done with a pencil and paper or a top of the range Mac. A bad one won't be saved by all the chips in China. As Oscar Wilde nearly said, there is only one thing worse than too little memory…and that is too much memory.) I knew you'd agree…

These digitisers had one thing in common: they were very…very…slow. They took up to 20 seconds to scan the image from left to right, or was it right to left, and in any case reversed…or not… anyway it took a long time. The Amiga could even do it in colour, you had to do it three times with a bit of red, green and blue plastic in front of the monochrome cctv camera.

BUT…! Because it took a long time, you could introduce things — ideas, crazy stuff — into that time and space. You could think while the 'instant' was recorded. It wasn't photography but it wasn't video either. You could move with the digitising edge, extending the size of your nose, or in my own case trying to reduce it. You could jump up and down, introduce objects into the scene suddenly, you know: 'portrait with half an ash try', or you could, by spinning slowly on a chair, have a 360° — or more! — representation of your head or…anything. With the Amiga, you could make the red, green and blue components of the image be of different things! The naughtiness — the creativity — of that!

Today we have more or less instant digitisation but you can't get at it, so to speak. *Pace* Jean-Luc Godard, if film was the truth 24 times a second, European video the truth 25 times a second, and Siggraph lies once a year, then these digitisers were…something else…somewhere else…some when else, let's say.

My second example is that of the pen plotter. Now I realise that both my examples are not art or computer art ideas per se, but tools or techniques. However, I assert that it was out of these techniques that the ideas came. Doesn't this go completely against what I said before, about work needing to be art led, not technique led? Well, yes and no, in the Derridean sense of being simultaneously true and false. I am going to suggest that the very idea of uncertainty, of paradox, of the fuzzy, of the undecidable, might be central to what we might do in art. Schrödinger's cat has paint on its paws.

The pen plotter differed from today's ink-jet plotter in two significant respects: you weren't limited to using just one method — the spot of ink — because it could draw absolutely continuous lines, vectorially or just, you know, lines…and the image did not usually appear progressively from top to bottom or left to right, but rather in the order the program told it to draw, either algorithmically or following the user's instructions. You could stop when you felt like. Half a pen plotter drawing was a very different thing to half an ink jet print. Further you could replace the pens by pencils, crayons, felt-tips, paintbrushes, charcoal, silver point… It might have a precision of 0.01 mm, but with a wobbly paintbrush in place, swerving round corners, you could develop a trace that was neither computer nor painterly, but 'other' than that. Now, apart from a few specialist machines constructed by artists, there are very few pen plotters left, making art. You go from image on the screen to a photograph-like representation on not very good paper, and can hardly interfere with it. A whole chunk of the process has been removed, with not even the possibility to get in there as you could with a Polaroid instant camera, which of course was not instant at all.

I suggest that in the matter of drawing, there were things done from about 1970 to about 2000 with pen plotters which might have opened new ways of doing, looking at, talking and thinking about that kind of mark-making. Except…they didn't, or didn't much, because ink jets came along, and we wanted solid images, not hidden line or wire-frame drawings.

The act of drawing should have, but didn't really, become — let's say 'become again' — problematised, 'difficult', and even though the process was electro-mechanical, it might in some respects have become even richer.

A reformist approach takes difficult problems and tries to bring them down to a level of simplicity and understanding. A revolutionary approach on the contrary might take what appear to be simple questions or accepted existing 'solutions' and render them problematic or 'difficult'. Conceptual art, I would suggest, was busy doing *that,* whilst computer based art was doing the opposite, reformist task of 'de-complicating' things. This might be fine, but it does go to explaining why there has been a 50 year mismatch between computer based art and contemporary art — they were going in different directions, trying to do different things. They zoomed past each other and there was hardly time to wave hello.

Conceptual art — and neo-conceptual art if you like — were and are busy saying 'What's going on in a video picture of someone or something? Let's slow it down, open it up, question it, play with it, name the parts of it, argue about it… Computer art says 'tch tch tch tch…' the sound of a rapid shutter, or a quiet 'wheeee…' the sound of video going straight to a hard disk. If you want to do something different, it has to be done after, not during. And after is always cosmetic, and always misses the moment, and is always reformist, not revolutionary. Doing art becomes synonymous with correction, with doing criticism, but with very little feedback into the art process itself because, as always, the next new thing came along, to which the critical discourse of last week rarely seemed to apply, of course. We kept thinking we'd make new and better art because of the new and better technology.

I would further suggest that this is in fact contrary to the real nature — certainly the potential, of computer art itself. In other words, computer art might have insisted — might still, secretly, be insisting — that we be revolutionary. Art is not craft. It is NOT pretty pictures or interaction with aspects of a 'normal' world, even if the modes of this interaction themselves are apparently revolutionary. I mean that, for example, to be able to fly round a structure asks no critical questions at all — indeed might suppress them — of the person who imagined the structure.

It may be that ideas and techniques from older periods of computer based art are to be realised today using non-computational methods. Why not? Perhaps we should at least mentally redefine computer arts as being made by, with, or because or in spite of the computer. I know that in my teaching practice since the 1970s, and I'm sure many of you have seen this, the most interesting results have often come from a student involved in another discipline who decides to use a computer to worry at a problem, then goes back to their performance art, photography, painting or installations. That's a revolution. That, for me, is what the information revolution has been about. A revolution is turning in a circle, ending up back where you were before, but everything has changed.

I believe that *'i'*, the imaginary square root of minus 1, is to the real numbers as the computer is — or should be — to art. It adds an imaginary extra dimension to the so-called 'real', or let us say to art, enabling or demanding a new, different way of doing things — a revolutionary leap of the imagination.

I belong to the Paris-based College of 'Pataphysics, where we try to, sort of, do everything like that. You may wonder what 'Pataphysics is: everyone does. The Times Literary Supplement has over several weeks asked the question "'Pataphysics — what's that?" in a debate to which I have contributed. Apart from saying that the College of 'Pataphysics was like Freemasons on acid, and is the science of exceptions, of the singularity, of the unrepeatable, I came up with the following: 'Pataphysics is to metaphysics what metaphysics is to physics:

Physics says: 'I have a computer and it makes art.' Metaphysics says 'I might have a computer and it might make art.' 'Pataphysics says 'I don't have a computer, and it makes art.'

I won't bring in philosophical Zombies here, those beings that are both living *and* dead, yes *and* no, 1 *and* 0, true *and* false — but I'd like to.

It is the difficult, the problematic in computer-based arts that we should keep, rediscover, re-explore. I think we often misunderstood what art was.

The use of potentially revolutionary, multidimensional modes of computer-based or -aided art production, or of quasi-artistic interaction with virtual worlds and so on, will always fail as art, if the idea of art that is addressed is mistaken: an idea of art that was probably never true and was certainly not true in the last 100 years or so.

What can we do about this? Nothing less than a complete re-examination of the history, languages, modes of discourse, theoretical frameworks and practical approaches of computer-based arts. The good news is: they're doing it! Isn't that great? Here's another good thing: I believe that if done properly, our art work and research will feed back into the modes of discourse, etc., of contemporary art as a whole, rendering it necessarily more vivid, more engaged, more investigative and less concerned with appearances. Let us not take things literally. How terrible that computer art has tended to do that! Let us re-imagine computer art.

I would follow George Spencer-Brown in seeing the universe as having — wonder of wonders! — split (whether we believe by supernatural intervention or quantum fluctuation doesn't matter here) into two parts: one of which could, for the first time ever, observe the
rest of itself. Yet in doing so, the universe necessarily became blind to part of itself. It was all OK before, just trundling along being a universe; but it couldn't see. Didn't need to, you see. Then it could see, a distinction was drawn, but it became tragically estranged from itself. This or something like it is nearly universal in myths of cosmic creation and so on.

What to do? We need, after this action, and don't forget the common etymology of 'act' and 'agony', a Truth and Reconciliation Committee. If science is the truth ('this thing happened') then art is perhaps the means of reconciliation ('we can't really mend it, but this is what it might be like if we could').

Science is perhaps socially constructed; art certainly is. Imagine Schrödinger's Cat in its box not only with a randomly triggered weapon of cat destruction but also with some paints. We don't know if it's doing art until we open the box and even then the waveform collapses not into a fact but into questions: has the cat got a gallery? Do the critics notice it? Is it in *Art Monthly*, *Art Presse* or *Künstforum*? If so, it's art.

The computer is its own box, cat, paints, experimenter and decaying isotope. It should also contain and examine its own modes of discourse and critique. Use that to make art and we necessarily bring new dimensions into play, we render art and computing ‘difficult’ in a positive sense. The social construction of art itself has thus opened up, allowing us to manipulate it.

We need to open everything up, to make space and time and a new dimension in the work. When the crowds of people stood around the Senster in the Evoluon in Eindhoven, as it flicked its head hither and thither, its quadrophonic microphone ears and doppler radar eyes scanning for the simplest of points of interest but giving rise to a most wonderful behaviour, it was not only the beast/sculpture to which people attended, but to the very interaction between people and Senster. A new space opened. The best interactive art always makes you look at the participants.

Let’s make a revolution! Let’s turn round slowly, once, and see everything, everything that was done, and then finish back here again; but everything has changed. Let’s look properly at what was done, analyse it and reincorporate all the best bits, but going much further, with a new energy, the energy of the square root of minus one, of crazy ’Pataphysics, of…not Post Modernism but, perhaps, ‘Post Computer Art’.

DIGITAL PIONEERS: COMPUTER-GENERATED ART FROM THE V&A'S COLLECTIONS

Douglas Dodds
Senior Curator, Word & Image Department
Victoria and Albert Museum

The Victoria and Albert's acquisition of major computer art collections is part of an ongoing project to document and preserve the history of this field. The V&A's pioneering work in this area is connected to the Computer Art and Technocultures project, in collaboration with Birkbeck College.

INTRODUCTION

The Victoria and Albert Museum is one of the world's leading museums of art and design. The V&A's Word and Image Department holds the Museum's Western collections of prints, drawings, paintings and photographs, plus books, archives and manuscripts. The Department has more than 2 million objects in total, including some 750,000 prints, drawings and paintings and a similar number of printed books. Any works that are not on loan or display can be consulted in the Museum's Prints and Drawings Study Room or the National Art Library.

The V&A is currently engaged in a research project with Birkbeck, entitled Computer Art and Technocultures and funded by the UK's Arts and Humanities Research Council. One of the outcomes is this symposium and another is Digital Pioneers, a book and associated display based upon the Museum's computer-generated art and design collections. The following sections provide more details about the Museum's collections, the project and the display.

THE V&A'S COMPUTER-RELATED ART COLLECTIONS

In a review entitled Notes on the crisis in technological art, Gustav Metzger produced a thoughtful and highly prescient commentary on an early exhibition organised by the Computer Arts Society. In a section entitled The Art World, he writes:

> It is impossible for the museum and commercial gallery structure to accomodate [sic] the volume of art that will be produced in the next few decades. It is therefore vital to begin developing new structures that will enable these new works to be produced and exhibited. .. Dealers and museums see to it that there is the minimum of technological advance, since they cannot afford the expense of advanced technologies, they are faced by new and complex problems of installing advanced works... [1]

It is certainly true that most – if not all – museums and galleries have struggled to come to terms with digital methods of making art. Nevertheless, the V&A has been collecting computer-generated artworks from the late 1960s onwards, at around the time when Metzger was writing about the challenges involved. Some of the Museum's earliest acquisitions were a series of prints produced in conjunction with Cybernetic Serendipity, the groundbreaking exhibition at the Institute of Contemporary Arts in 1968. The V&A's Prints, Drawings and Paintings Department (as it was then called) went on to collect other works by computer artists during the 1970s and 80s, but these were few and far between. Notable examples include a number of prints by Manfred Mohr, from his Scratch Code series. At the time, computer art was seen to be deeply unfashionable among many art historians and commentators, and the V&A's curators were probably influenced by this attitude. In hindsight, it seems fair to say that many of them did not anticipate the full significance of the emerging medium. They were also understandably concerned that the original material – plotter drawings, computer printouts, or whatever - might be difficult to preserve and display.

Until recently, though, the Museum held relatively few works that illustrate the early years of computer-generated art and design. However, following the acquisition of the Patric Prince Collection and the archives of the Computer Arts Society, the V&A now holds an internationally significant collection of computer-generated art from the 1960s to the 1990s and beyond. Practitioners represented in the Museum's holdings include Paul Brown, Harold Cohen, Charles Csuri, David Em, Herbert Franke, Jean-Pierre Hébert, D.P. Henry, Ken Knowlton, Tony Longson, Manfred Mohr, Vera Molnar, Frieder Nake, Georg Nees, Barbara Nessim, Michael Noll, Lillian Schwartz, Roman Verostko and Mark Wilson, among many others. The bulk of the artworks consist of plotter drawings, screen prints, inkjet prints, posters and photographs, but there are also examples in other media, including 3D images and computer files.

The founding-stone of the V&A's expanding collection is the material assembled by Patric Prince, an art historian and archivist of computer art. Based in California, Patric actively collected computer-assisted art works for many years. In addition to some 200 individual artworks, the Patric Prince collection also contains a huge quantity of books, archival material and ephemera, including monographs, manuals, exhibition catalogues, slides, off-prints and interviews with practising artists. Because the early history of digital culture is still under-documented, the material she accumulated is now of great significance to researchers.

In addition to the Patric Prince collection, the Museum also holds the archives of the Computer Arts Society (CAS)[2], which amounts to another 200 artworks. As computer artists passed through London, they often gave the Society examples of their work. These were stored until the V&A acquired the collection in 2007, along with the

Society's working records of its own activities. Thankfully, the CAS material complements the Patric Prince collection perfectly, with very little overlap between the two. Together, these major acquisitions have formed the basis for the V&A's emerging national collection of computer-generated art.

Inevitably, the fact that the Museum is now known to be collecting in this area has already resulted in the offer of additional material, from the early 1960s onwards. Indeed, the founding collections have recently been supplemented by a number of other donations and individual acquisitions that have significantly expanded the range and quality of the V&A's holdings. In practice, though, we need to ensure that anything we do acquire is of museum quality and fits the profile of the V&A's collections. For example, we would be reluctant to acquire works that document the early years of computer-generated music, other than where these clearly inform the early years of computer art. Similarly, the V&A does not generally collect contemporary sculpture, so we would be reluctant to acquire too many three- dimensional works.

Nevertheless, the Museum has actually acquired relatively few born-digital works for its permanent collection until now. Instead, in recent years we have commissioned a number of temporary exhibitions and installations that have provided a showcase for digital artists. The V&A's Contemporary programme, in particular, has been responsible for displaying a wide range of innovative works. Examples include Digital > Responses (2002-3), in which artists created works in response to objects and spaces in the V&A; Volume (2006-7), a luminous interactive installation in the Museum's John Madejski Garden; plus many Friday late-night events on specific themes.

THE COMPUTER ART AND TECHNOCULTURES PROJECT

When the V&A first began to acquire the Patric Prince collection, we were conscious that we needed to acquire more resources in order to make it fully accessible. Given Birkbeck's previous involvement in the CACHe project, it made sense to build upon the strengths of the two institutions. The project was therefore conceived as a joint study between the School of History of Art, Film & Visual Media at Birkbeck and the V&A's Word & Image Department. A bid was submitted to the Arts and Humanities Research Council's Resource Enhancement Scheme, and in July 2007 we finally learnt that we had been awarded the full amount requested.

The aim of Computer Art and Technocultures (CAT) is to study the development of computer-based art during the expansion of digital graphics techniques that occurred in the US and worldwide from the 1970s onwards. Although the computer is now so widely used in the applied and fine arts, the origins of computational artwork have not been much explored until very recently, when historians of "Media Art" started to turn their attention to this field. The initial CACHe Project (2002-2006) was one result of this new interest in the history of the digital arts.

The CAT project team consists of Dr Nick Lambert, Professor Jeremy Gardiner and Francesca Franco at Birkbeck, plus Douglas Dodds and Honor Beddard at the V&A. The project uses the Patric Prince collection as the basis for the team's research, but it also draws on information obtained from the rest of the V&A's computer art collections, plus the earlier CACHe project and other resources elsewhere.

DOCUMENTING THE COMPUTER ART COLLECTION

The Museum is currently cataloguing the entire collection and digitising the artworks wherever possible. The sheer range of material presents particular challenges, since the collection includes artworks, publications and Patric Prince's own records. The curatorial objects are being described in the V&A's Collections Information System (CIS), and are becoming available on the Museum's website via a service known as Search the Collections. The vast majority of books have now been catalogued on the National Art Library's computer system and are now included in the library's online catalogue. The archival parts of the collection are being listed using Encoded Archival Description (EAD), an XML schema used by many archivists. The digital images are stored in the Museum's digital asset management system, VADAR. In addition, the V&A's website now includes a section dedicated to computer art, with zoomable images and brief biographies of some artists.

The V&A has recently re-launched its Search the Collections database, which now includes more than a million records for objects in the Museum's collections. The amount of information varies from record to record, and the Word & Department is currently engaged in a project to create detailed descriptions and digital images for all of its holdings. As a result of work undertaken via the Computer Art and Technocultures project, a high proportion of the computer art collections are already included in the database and are fully accessible. Search the Collections is available via the Museum's website and can also be accessed directly . [3]

As an additional outcome of the project, the V&A has recently published a picture book entitled *Digital Pioneers*. This forms part of a highly-affordable series of books on pattern in the V&A's collections. As such, computer-generated art has been absorbed into the mainstream, alongside other topics in the series, such as William Morris, The Fifties, and Indian floral textiles. The first four books in the series – including Digital Pioneers - are also available as a limited-edition boxed set. [4]

In parallel, Nick Lambert and his colleagues at Birkbeck are constructing a critical and contextual history of this under-explored area of the visual arts. The research undertaken by Birkbeck is also helping to inform and enhance the records created by the V&A. For more information, see the project website at:
http://www.technocultures.org.uk

DECODE AND THE DIGITAL PIONEERS DISPLAY

Some time after Birkbeck and the V&A were awarded the grant from the Arts and Humanities Research Council, it became clear that the V&A's Contemporary team were planning to organise a major exhibition called **Decode: Digital Design Sensations**. Curated in collaboration with the leading digital arts organisation onedotzero, the Decode exhibition opened in December and continues until April 2010. Highly interactive and technologically driven, it sets out to demonstrate some of the latest developments in digital design, from small screen based graphics to large-scale installations. The show includes works by Daniel Brown, Simon Heijdens, Aaron Koblin, Golan Levin, John Maeda, Random International, Casey Reas, Daniel Rosin and Troika, among others. The exhibition explores three main themes: Code as a Raw Material, Interactivity, and the Network. Most of the exhibits are on show in the Museum's Porter Gallery, but there are also installations in the main entrance, the garden, the sculpture galleries and the exterior of the building itself.

In conjunction with Decode, the Computer Art and Technocultures partners have organised an "historic" counterpart, entitled **Digital Pioneers**. This display is one of the outcomes of the CAT project, and is designed to provide an overview of the first decades of the computer's history in art and design. It includes some of the earliest computer-generated works in the V&A's collections, many of which have never been exhibited in the UK before. Digital Pioneers seeks to offer a historical context for contemporary digital practice, and has been deliberately scheduled to coincide with Decode.

Museums such as the V&A generally make distinctions between exhibitions, which contain works borrowed from elsewhere, and displays, which consist of works from the institution's own collections. All of the works in Decode have been borrowed for the duration of the exhibition, though the Museum is actively considering acquiring some pieces for its permanent collection. In contrast, Digital Pioneers consists purely of works from the V&A's own holdings, including objects donated by Patric Prince and the Computer Arts Society. The artworks in Digital Pioneers are organised chronologically, and in broad groupings. The first section is entitled **From Analogue to Digital**, and begins with two early "Oscillons" by Ben Laposky. It also includes a number of analogue works by Herbert Franke and D.P. Henry, who used modified analogue bombsight computers to create highly distinctive machine drawings.

The second section, **Early Practitioners**, begins with digital works by Herbert Franke and Georg Nees, followed by additional algorithmic works by Frieder Nake, such as *Homage to Paul Klee* (1965). Other works in this section include Charles Csuri's *Flies* (1967) and his *Random War* (1967), which contains iconic images of American toy soldiers. Another famous work, Ken Knowlton and Leon Harmon's *Study in perception* (1967), is represented by a recent laser print. (The V&A also holds an early photographic print of this, but the image is inexplicably reversed.) Knowlton also collaborated with Lillian Schwartz, one of a number of pioneering women in the show.

The third section, **The Artist as Programmer**, begins with Vera Molnar, who started to use computers in 1968. The Museum holds a number of early works by Manfred Mohr, who has spent much of his artistic life examining the possibilities presented by the cube. In the display, Mohr is represented by four prints from his *Scratch Code* series. The author of the Aaron computer program, Harold Cohen, is represented by no less than six early works, including two hand-coloured computer printouts that precede his Aaron program. Another significant British-born artist, Paul Brown, makes extensive use of tiling and cellular automata.

The last section, **Computer Art after 1980**, begins with three delicate computer drawings by Jean-Pierre Hébert, who has said that the creative process he uses is 'very much akin to composing or choreographing, or simply … thinking'. Another artist who makes extensive use of his own software, Roman Verostko, is represented by four unique plotter drawings from the 1980s onwards, including some that incorporate large plotter-driven brushstrokes produced on a modified pen plotter. In 1995 Hébert and Verostko began describing themselves as "Algorists"– artists who employ original algorithms in the process of creating their art. Verostko's plotter drawings are followed by two large works by Mark Wilson, who had also used pen plotters in his earlier work. More recently, Wilson switched to using large format inkjet printers to produce highly complex multi-layered abstract images such as the two included here. The wall display ends with *Dark Filament* (2007), a recent work by James Faure Walker, who marks the beginning of the following wave of artists who make extensive use of "paint" programs in their work.

Digital Pioneers also includes a number of early publications, shown in broadly chronological order and starting with the catalogue of a touring exhibition of Laposky's *Oscillons* (1952-3). Other exhibitions include Cybernetic Serendipity and MOMA's The Machine as seen at the end of the mechanical age, both undertaken in 1968. The display also attempts to make pointers to other important organisations and events. Examples include the Computer Arts Society's Page magazine, plus a variety of SIGGRAPH ephemera collected by Patric Prince. Artists' books include Barbara Nessim's *Random Access Memories* (1991) and two copies of Roman Verostko's limited edition of George Boole's *Derivation of the laws* (1990), with unique plotter drawings and single brush strokes created using the same algorithm. The display's four desk cases end with William Gibson and Denis Ashbaugh's *Agrippa* (1992), which contains a self-destructing floppy disk that echoes Gustav Metzger's concept of auto-destructive art. The text of Gibson's self-destructing poem was subsequently published on the emerging Internet, in an early example of subversive use of the online medium.

CONCLUSIONS

The Computer Art and Technocultures project has proved to be highly influential in helping to increase awareness of the significance of early computer-generated art. Many of the promised outcomes have now been completed, or are well on the way to being achieved. In addition, the project has also resulted in additional acquisitions that will enable the V&A to undertake major exhibitions and displays in future years. Digital Pioneers presents an overview, but there is real scope for additional detailed examination in specific areas such as illustration or computer aided design.

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BIOGRAPHY

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THE INTERACTIVE ART SYSTEM

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A formative journey from encounters with signals intelligence and cybernetics to work with colleagues, students and engineers between March 1968 and June 1972 on interactive art systems that seemed (40 years ago) to be significant. Though widely exhibited, in once case at the VI Paris Biennale, the programme was aborted in 1972 for the lack of arts research and development funding. Two conceptual frameworks: the artwork as a system; and what an engineer termed the art work's 'logic engine'. The paper asks whether the time of these ideas did, should or ever will come.

AN EPIPHANY

In late 1967 or early 1968 the *Sunday Times* invited sculptors to compete for the opportunity to have one or two sculptures commissioned for a concourse through Woolgate House, a new development in the City of London. This was to be my first experience of documenting an architectural site where, as I drew, took measurements and photographs, I suddenly saw my father striding through the precinct. In the same instant I knew it was not he (my parents had recently moved to the West country). Nevertheless, in that instant, I had suddenly seen my sculptural *oeuvre* in what had been his stamping ground for 40 years, and through his eyes. The eyes, we might say, of Everyman.

Some years later, as a research student at Lancaster, I modelled the art world as a population of ‘tribes’ (painters, critics, historians, curators, and so on). One of these was the contemporary (then thought of as Modern) art world, constituted as a tiny international coterie of *Artforum* readers – artists, curators, critics – who conducted a kind of debate through the primary medium of the exhibition. On that day at Woolgate House I had exiled myself from the contemporary art tribe! Having experienced an epiphany, what presented itself was a new problem: how to engage and, more important to sustain the attention of Everyman? How to involve those who knew little of the issues so earnestly debated in the private views and art press? (It is worth noting here that, four years later, the remoteness of art world debate from the general public was dramatised when news of the acquisition of 120 standard bricks by the Tate Gallery reached the tabloid press.)

The answer to the new problem would not, I conjectured, be authored entirely by myself as the sculptor, and any sense of meaning would have to come from somewhere other than the debate so earnestly carried on in the pages of *Artforum*; instead, it would have to arise out of whatever was going on at Woolgate House, including the comings and goings of folk just like my father.

At the age of 16 I had gone to art school. In the 1950s one learned to draw. How to represent forms such as the human body, landscapes and architectural structures, very much in the spirit and using the techniques of the Italian renaissance. Then I went off into signals intelligence with the Far East Air Force, which fed a natural preoccupation with what Harold Wilson was to call the ‘white heat of technology’. I returned to Britain to study sculpture further, and went on to practice and exhibit. But it took me until 1967 to finally grasp a sense of artistic identify. In that year I established a vocabulary of forms, and a kind of logic or narrative linking a body of works. Then, just as I was beginning to exhibit these new sculptures, the epiphany swept it all away!

BANDERSNATCH

In September 1965 I had joined a team led by Roy Ascott at a college of what is now a university in East Anglia [1]. There I was immediately confronted with something called cybernetics. This (and an accompanying battery of terms) was both mystifying and beguiling as the Jabberwocky and the frumious Bandersnatch, invented by Charles Dodgson to amuse his young companion Alice Liddell. Ascott referred me to a paper on the topic [2]. From there I progressed to the works of Norbert Weiner and later worked with members of the Open University Systems Group before embarking on research in the field at the Lancaster University's Department of Systems. I mention this strand of the story because the concept of systems is so fundamental to the responsive class of artwork discussed here.

Heraclitus prefigured systems thinking when he spoke of a river as a process rather than a thing. This conceptual framework has continued to draw on a variety of disciplines in enabling us to think about, to model and manage such processes; they involve organic and inorganic control, human organisations and the geophysical environment [3], [4], [5], [6]. In the realm of the visual arts the process-oriented approach was informed by an exhibition held at the Tate Gallery London in 2005 [7]. But another and distinct set of cultural and artistic connotations of the term 'system' exists, with strong links to mathematics and logic. In the realm of music one thinks of canonical fugue, serialism and the early works of Steve Reich; while in the visual arts the associations would be with tessellations, logic, chance and order [8]. These two distinct uses within the art world reflect a general bifurcation of the uses of the term 'system'; mention has already been made of a process-oriented strand of systems thinking but, when the term 'system' began to find wide usage, it was in the context of engineering and organisational design, after WWII.

Broadly, then, there are quantitative and qualitative and approaches (that is, of course, an over simplification) one rooted in mathematics and engineering, and the other arising out of efforts to describe natural processes - each associated with a distinct pattern of artistic activity.

GEMINI

The Woolgate House concourse was long enough to separate two sculptural sites by more than 100 feet. It was open to the sky, and used both by employees and by members of the public passing through. What this suggested was a pair of structures that regulars might begin to perceive as able to reflect not only the seasons (as might a

Figure 1. Photomontage made using scale maquettes of *Gemini* structures.

deciduous tree) and diurnal rhythms (as is the case with many flowers) but also to make some contribution to the life of the concourse, as the flow of visitors waxed and waned.

Drawing on a system theoretic model of the situation, my first instinct was to look for some very straightforward forms of input and output. On the input side the technology was familiar (temperature and light sensing, infra-red beam detection paths). The use of electrical power had been greatly refined since WWII to enable the engineer to achieve smooth and controlled movement; halogenic with dimmer controls and powerful, directional beams had become available.

As a description of the raw materials for an art work this sounds cold, mechanical and uninviting. The antithesis of the artist's supposed inner turmoil. But subtlety would lie not in the fact of light or movement, but in the ability of the viewer to detect *pattern*. To treat the sum of the mechanical outputs over time as behaviour and, crucially, behaviour perhaps subtely related in some yet-to-be-determined way, to something in the environment.

This points ahead to readings around human psychology, for such an artwork would be predicated on our human predisposition to look for more or less meaningful patterns in stimuli encountered. It was central to this whole line of work that there be such a predisposition, that it be strong and that it be universal. [9]

THE LOGIC ENGINE

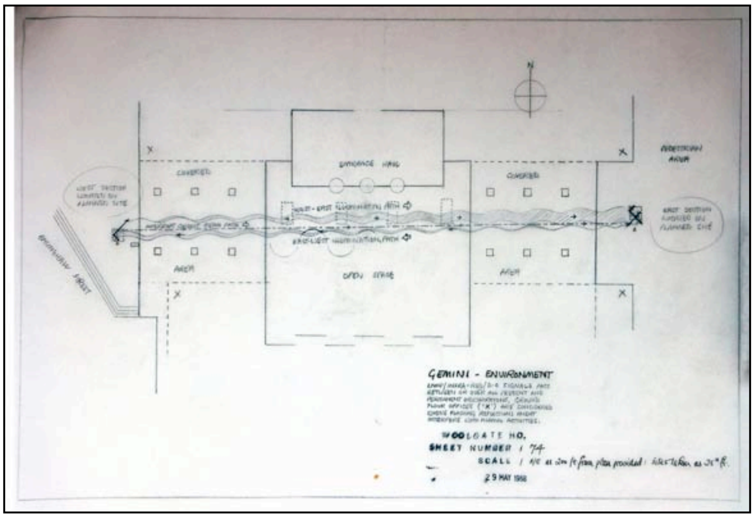
Having formulated a strategy for a pair of mechanical devices equipped with sensors and activators I somehow came across a young Canadian engineer who fizzed with enthusiasm and ideas for the project. As I rambled about the need to mediate between inputs and outputs so as to detect and to impose pattern, his response was laconic: "Stroud, what we need is a logic engine!" At the time the word 'computer' was limited in its associations with large American businesses (or it was in my mind – we need to remember that this well before we learned of the work of Alan Turing at Bletchley Park). Three years before the Woolgate House epiphany I had received IBMs Eastern Region Data Processing Manager at what is now a college of an East Anglian university to discuss the Media Handling concept. But computers were something seen in American films, as reel-to-reel magnetic tape drives rocked to and fro. Later I was taken into the bowels of an IBM office on Newman Street to see what was proudly proclaimed to be the first example of the successor technology in Europe: a disc drive the size of a washing machine into which was inserted a stack of plastic dinner plates. Even then I have no recollection of seeing the computer itself – one had little idea of how many boxes, cables, lamps and so on constituted such a device. It was around

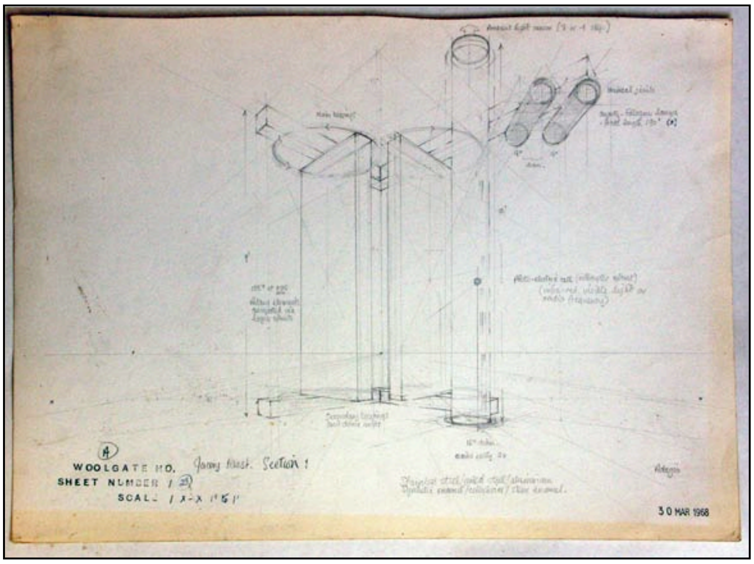
1970 that I watched something called a Stantec Zebra being wheeled away on sack trucks to the waste disposal and entered a corridor whose internal windows looked onto a succession of cabinets in an air-conditioned suite devoted to the Stantec's successor – a Boroughs mainframe. Shortly afterwards, my colleagues and I gained direct access to a Honeywell DDP-516.

One respect in which this proposal was an 'idea before its time' is that it needed to be put forward as a development project. Traditionally a proposal would commence with a visualisation in the form of a drawing or maquette; an aesthetic judgement would then be made and only then would practical questions that might involve engineering be addressed. In this case however, any judgment on the merit of what was proposed would require attention to a narrative account of the processes that the proposed structures were there to support, plus some sort of initial evaluation of the engineering drawings, circuit diagrams, safety provisions proposed, and so on. It would have been literally impossible for the judges to look at maquettes and *see* what was proposed, or even to realise that they were related. But that is what happened: each maquette (in steel, aluminium, paint and additional elements) was placed on a short list, but the plans and descriptions were left unopened.

Both had been selected on a set of criteria that had been consciously excluded in their conception!

The author undertook no programming in drawing up proposals for projects. Instead, a careful narrative description was drawn up in each case, so that Nealson's logic engine could be developed to identify input patterns and generate a repertoire of distinct output patterns.





Figures 2 and 3. Sheets 23 and 74 from the set of materials submitted as the *Gemini* project.

This was an approach that was successfully used in encouraging art and design students to explore the possibilities of early computer graphics at Leicester around 1970. The area had a certain glamour, but was dangerous in that it was only a minority who could devote the tremendous effort and time required to achieve useful results by programming using the systems then available. Others were spending an inordinate amount of time attempting to write vector graphic routines. Even to specify and then output simple shapes - squares, triangles and spirals – would require pages of coding, the production of punched cards and paper tape and waiting for hours for a printer to churn out inked line segments on sprocketed paper rolls. As with other technical vogues (such as the vacuum forming machine), the result might have little to do with learning about fine art practice. The author was an expert in drawing and had helped to set up the university's first computer centre. (What was at the time City of Leicester Polytechnic, now De Montfort University, convened a committee whose report led, around 1969, to the establishment of a Computer Centre with a staff of engineers and programmers).

Together with a recently appointed Chief Programmer, a project was mounted to create software (dubbed $ART) allowing the user to record a number of entries via a newly-acquired graphic digitizing tablet, manipulate them (scale, rotate, group, etc.) and store the results for outputs via VDU and plotter.

This all sounds obvious now, but the author was aware of only three related systems. One was a programme called PICASO that was being developed at Middlesex [10]; the second was an architectural visualisation system realised in the USA [11]; finally, there was a wonderful but costly digitizer-plotter, developed and marketed by Imperial College [12]. Of these the only accessible system was PICASO; perhaps unfortunately, it had been described to the author as a menu-driven library of ready-made shapes (coke bottle, Africa, and so on) to be manipulated by people who could not draw.

The other thing to say about the author's emphasis on the 'logic engine' as a tool with which to manage the pattern of inputs and outputs is that the only realised example seen by the author during this period (i.e. designed, built at full scale, programmed and then operated in a public space) was Edward Ihnatowicz's *Senster*. The author spoke with Edward in the engineering department of University College London, where the *Senster* was under construction, and also visited the work when it was installed at Philips Evoluon in Eindhoven.

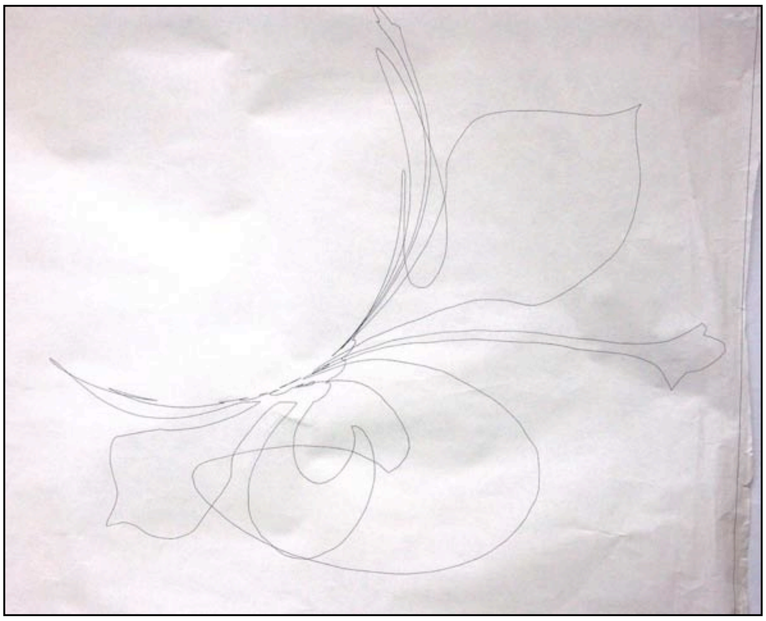


Figure 4. Digitized image of Florentine lily made using the $ART software. A number of distortions were requested by the painter Tom Phillips, in preparing illustrations for his translation of Dante's *Inferno*. *Circa* 1976.

Sadly, it appeared to have been a deeply frustrating project for the sculptor: the system appeared to have been treated by Philips as a mechanical toy. Schoolchildren were regularly crowded around the piece, waving and shouting as it went through a repertoire restricted both by Philips and by the system's inability to cope with the overload. Edward himself, anxious of course to explore various patterns of inputs so as to tune the system's responses, was frustrated by the limitations imposed on him by Philips' staff, and was later excluded altogether. [13]

FIVE PROJECTS

Some time around 1970 my colleague Ernest Edmonds recommended use of the term 'interactive' to describe the management, via a human-computer interface, of the pattern of inputs and outputs by the decision-making device used in an artwork (Nealson's logic engine), and some of the implications were subsequently unpacked by the author [14]. Between 1968 and 1972 a number of interactive art systems and projects were exhibited, of which those summarily described below (in chronological sequence) are those involving computer management. *Datapack* is important because it ran as a live demonstrator - out of Leicester Polytechnic on a Honeywell DDP-516, and at Computer Graphics 70 on a GEIS terminal, in both cases to plotter outputs. The projects were otherwise represented in scale models, drawings, descriptions and technical plans exhibited at the *VI Paris Biennale* (Musée de l'Art Moderne, Paris, 1969), *Event One* (Royal College of Art, 1969), *The Invention of Problems* (Leicester Polytechnic, 1970), *The Invention of Problems II* (Leicester Polytechnic, 1971), *Cognition and Control* (Midland Group Gallery, 1972) and *Kinetics* (Glynn Vivian and Talbot Rice galleries, 1972).

Gemini (1968)

The first of the projects, described earlier, was undertaken in collaboration with Nick Nealson, a Canadian electronics engineer.

Datapack (1969)

The second project, designed and realized in collaboration with Ernest Edmonds in 1969, was described and exhibited at the Computer Graphics 70 conference [15].

Interplay (1969)

Figure 5. *Interplay* simulator and supporting documentation.

A group including an architect, artists, designers and an engineer devised this ambitious scheme. The group divided into two teams to design and build a structural model and a simulator that were exhibited, together with engineering studies, as a project for an environmental and computer-managed scheme for adult creative participation.

Machina Ludens (1971)

A group divided into two teams to design and build a simulation of a computer-managed scheme for adult creative participation, and produce a video document for exhibition.

Rover (1971-72)

This research and development project was conceived jointly with Ernest Edmonds as electromechanical test bed for studying the psychology of art and interaction. In order to achieve high resolution in driving an interactive visual display in three dimensions an analogue test bed was configured as a pyramid supporting three axles driving large diameter wheels on the rims of which were mounted transverse idler wheels. Viewed at close range under controlled lighting conditions the surface could be moved with three degrees of freedom on the X, Y and Z axes. The decision to take the nalogue route was an acknowledgement of the fact that the project was before the time of personal or even local computing.

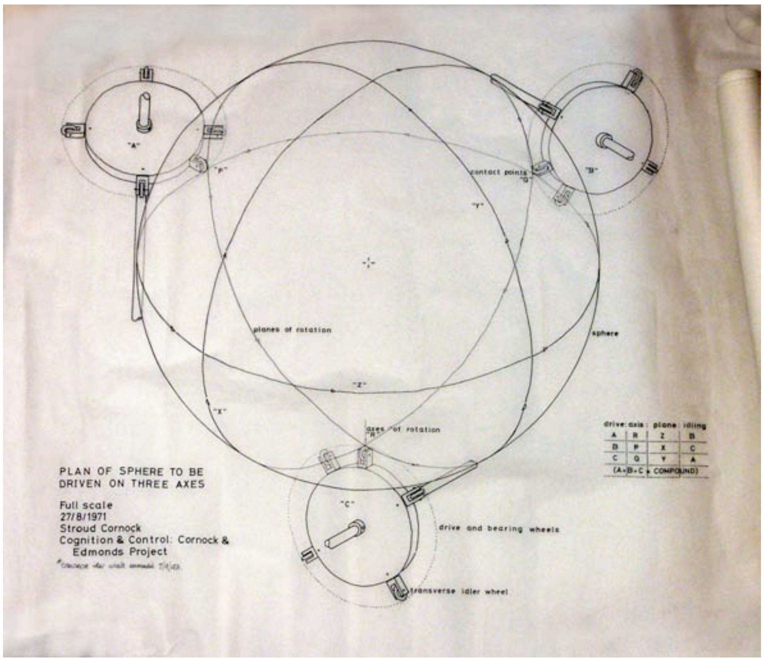


Figure 6. Working drawing for the Rover project showing the sphere supported by orthogonal drive wheels.

EVALUATION

What value might be assigned to the ideas underlying the projects described? Earlier it was suggested that the contemporary art world has the character of a debate – a restricted debate, where the aim of all of the participants is to influence or to set the agenda. In this sense the achievements of Marcel Duchamp – scanty when measured in terms of wider public fame, representation on the walls of public art galleries and in the value of auction sales – can be said to rival those of Picasso. But none of the projects described in this paper had the slightest impact on the course of the debate that is art. More ominously (though the author has continued to visit public and private exhibitions of art, including surveys such as the Frieze Art fair), works involving managed interaction have rarely been encountered and have certainly not achieved a high profile. Numerous examples of both projected and realised interactive works are to be found online, with a history stretching back over a quarter of a century. But such work does not appear to have the status of a movement, or genre; more that of a curiosity. As Riccardo Rabagliati stated when introducing a body of work in the Venice *Biennale* art exhibition: "Interactive works of art having a digital basis are still confined to specialized events; very few of them are yet represented in the main contemporary art museum and international shows of art." [16] Such ideas have not received the blessing of Charles Saatchi, the Lorenzo de' Medici of our time (Saatchi does, however, claim the world's largest interactive art *gallery*).

There are some related developments that have achieved some prominence, one of them being the introduction of physical movement into the form of the art object. An early example is provided by the work *Kinetic Composition*, produced in 1920 by Naum Gabo. In the mid-1930s Alexander Calder used small electric motors to drive structures he called his mechanical ballet. But Calder seems to have rejected this in favour of breeze-driven mobiles. This I take to be a rejection of the central proposition of Kinetic Art: that motion in some way contributes to the artistic merit of a work. Facts concerning a medium – pencil, brush or chisel - do not, of course, confer such merit; but they can help to give a work its distinct form, as in the case of etching, and clay modelling. What the projects described argued is that the advent of information processing introduced the possibility of an artwork that can function as an open system: a system that initiates interactions with its environment. This all seemed portentous at the time [17], [18], [19], but the moment for such a fully-realised interactive art system is yet, if ever, to come.

(Photographs by the artist.)

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ART OF CONVERSATION

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Abstract – The paper discusses early work that predated Internet Art and that was concerned with active audience participation in electronic art and describes the path of development of the first author's artworks that have looked at human to human communication through electronic (computer) systems from 1970 until today. The fundamental concept has been to make artworks that explore human communication through conversations using restricted languages. The initial inspiration was a set of studies of early infant language development. By 1990 Edmonds showed much more elaborate work using computer-based local area networks.

CONTEXT

Today, it is sometimes hard to imagine the world before the internet and the World Wide Web. This is as true in art as in the everyday use of modern phones. The paper is concerned with art experiments in conceptual social computing prior to the invention of that notion. A concern in art for human communication, for the underlying concepts of conversation is not confined to the digital world, but the developments in that area in recent decades has enabled significant developments.

In the introduction to the 1983 *Electra* exhibition catalogue art historian Frank Popper explained how the introduction of new forms of energies in art from 1945 until 1970 created a significant ground for the development of art seen as a social phenomenon. Similarly, the appearance of happenings in the late 1950s and their flourishing in the 1960s stressed the importance of a much closer relationship between the artist and the public. According to Popper, both technology and participative art contributed to make art a more social oriented phenomenon [1].

In the mid 1960s the aesthetic discourse around the viewer's active participation fostered by various continental European groups merged with the composite context and ideals of the student movements that had formed internationally around the same time [2]. Kinetic movements such as the French Groupe de Recherche d'Art Visuel (GRAV) for instance were interested in defining aspects related to the creative process of art triggered by the spectator's interaction in order to awake people from their apathy and to encourage individual action and people's initiative. Only by actively participating, transforming, and interacting with the artwork the spectator would be the maker of his or her own "revolution in art" [3]. The result was *Labyrinths*, a series of experiments of immersive environments created for the 1963 Paris Biennale and exhibited at the Contemporaries Gallery in New York two years later. *Labyrinth I* was an immersive environment that consisted of several cells where the spectators would find a variety of elements that would be altered and animated by their dynamic participation. One of the cells had walls covered in polished aluminium and the spectator was surrounded by mobile reflecting plates. Mirrors and lights would create 'transformable reflections' that would give to the viewer the impression of being in an instable environment [4]. The seminal work produced by Gustav Metzger from the mid 1960s onwards followed these lines, too.

The notion of the active audience as an integral part of the aesthetic creation developed even further with the introduction of new technologies, including the computer, in art. The UK was at the forefront of such developments. One issue in particular, i.e. that of human communication through conversation using restricted languages, was explored since the late 1960s. Some of the old examples presented by Ernest Edmonds in this paper represent some of the pioneering experiments in this field.

Edmonds and Stroud Cornock's *DATAPACK* represents another seminal example of an early interactive computer-based art system. Created for the *Computer Graphics'70* conference held at Brunel University, *DATAPACK* was, as Cornock described it in 1973, "an example of a matrix that consists of participants, a display, a computer installation and a designated area around the Vickers Building next to the Tate Gallery in London" [5]. *DATAPACK* was a networked system that allowed participants to have a "pseudo-English conversation" with the computer. The results of this conversation were then processed by the machine connected to drum plotter. This was able to identifying a volume space around the Millbank Tower and allocating it to the active participant [6].

Two works are particularly interesting when analysing the history of computer applications in human to human interaction for art practice. These are George Mallen's *Ecogame* [7] and Ernest Edmonds's *Communications Game* [8].

George Mallen's *Ecogame* represented the first UK interactive, multimedia, computer-controlled game. It was the result of a collaborative team effort conceived and largely programmed by Mallen for the *Computer '70* trade exhibition held at Olympia, London, in September 1970. *Ecogame* – which was a work grounded in cybernetic theories pioneered mainly by English cybernetician and psychologist Gordon Pask – has been described by Mallen himself as a "computer mediated interactive, multi-media, multi-user game using computer controlled slide projectors to create a visual environment reflecting the decisions players made about allocating resources in a simple model of an economic system" [9]. The main notion of the game was to highlight issues arising from the first oil crisis and to encourage participants to consider their behaviour in the system. The game was set up in a small geodesic dome where players sat at terminals and made decisions via light pen interaction. The results of their choices were then fed back to a mini-computer linked to a projector that would show images in the dome, producing an online photographic art show [10].

Communications Game was originally a proposal for the same *Computer '70* trade exhibition slot for which *Ecogame* was selected, but it was not carried out and the detailed design of required input/output devices was not specified. It was proposed that the system of the project be controlled by a digital computer.

The proposal provided stations for a maximum of 15 participants and for a minimum of two participants. The stations are arranged such that a participant can only see one, two, three or four stimulus-providing units within his station and a station is part of the group activity only when it is occupied by a participant. Each unit can be acted upon by the participant in response to a given stimulus. No instructions are given to participants on the manner in which the system of units operates.

A simple example showing how the system could work is as follows: a participant looking at a unit sees the flashing of a stroboscopic light. He may then turn a large dial located above the unit. At first no response is seen, but shortly thereafter the light turns off. He turns the knob to another position but nothing happens. Then he turns the knob rapidly between its extreme positions. After doing this for a few seconds, the light comes on again but at a higher frequency ... and so on.

The notion of the interactive audience was fundamental for another British artist working since the late 1950s as an art theorist and practitioner, Stephen Willats. A statement he made in 1968 indicates his main interest in engaging socially with his audience:

"The audience become not just an after-thought, but the prime reason for the provision of triggers...The relationship that the observer has with most of these works is that of a receiver to a transmitter, the problem becoming one of transmitting the necessary conditions for trigger in via the shortest time; the feedback between the audience and the work being a result of this triggering." [11]

But it is Roy Ascott who explored the potentials of interconnectivity and found a wider range of meaning. By anticipating the convergence of cybernetics and telematics in the mid 1960s [12], Ascott was one of the first artists to experiment the potential of computer networks when they became available in the late 1970s. Amongst the works that exemplify such a discourse are *The Pleating of the Text*, presented at the exhibition *Electra* curated by Frank Popper between December 1983 and February 1984 at the Musée d'Art Moderne in Paris; and *Planetary Network*, shown at the Venice Biennale in 1986.

The Pleating of the Text gave Ascott the opportunity to create a telematic event that combined together his ideas of cybernetics, interactivity and telematics in a way that they would lead to a process of "dispersed authorship" [13]. Fairy tale roles were assigned to eleven cities distributed between North America, Europe and Australia. Through remote exchange between artists based in each station, the emerging story was actively unfolded through text and images.

Similarly, *Planetary Network* was a project for the 1986 Venice Biennale that included a number of telecommunication stations installed at the Arsenal's Corderie within the *Technology and Computer Science* section. Artists from three continents (America, Australia, and Europe) created nodes through which information and images were exchanged and modified. Digital images transmitted slowly via phone lines were altered by artists participating to the initiative and by external contributors such as writers, engineers, computer programmers and media activists. Through such projects the term 'artist' has expanded its meaning to 'participant'. In the same way too, the 'artwork' has become the work of several individuals and the notion of artist meaningless.

THE *COMMUNICATIONS GAMES*

Persons in an unfamiliar situation try to 'make sense of it', even though initially it may appear to consist of random factors. Their major problem is to comprehend the situation in question; some would say that the problem is to discover its logic. But Edmonds wished to avoid this notion, as it seemed to imply that there is only one way to understand it, whereas in practice different people often make sense of the same situation in different ways. It can be said that when one has learnt how to deal with people one understands their actions, not always in the strict sense of being able to predict them but simply of not being bewildered by them.

In no sense are these projects based on a scientific theory of cognition, although participants in one of the projects may be led to question their ideas about cognition. In each project, participants are able to make contact with each other only through very restricted interfaces, ie, with a very limited set of possible actions and responses. One might say that they try to make sense of the responses that they receive. The responses are such that the participants are likely to understand each other's actions only partially and even that understanding may be transitory.

Communications Game was based upon the ideas of the proposed *Computer'70* project, but a computer is not used. It was shown in the *Invention of Problems II* Exhibition at the City of Leicester Polytechnic in 1971 [14]. Only three networks of units are used and each unit is equipped with an input switch for turning on lights in units of the same network and a single light for output. For each participant, the lights provide the stimuli and the switches are the means for the participant to respond.

The work has six stations and there are three networks of three units. Screens or barriers keep participants from seeing the units in another station. Each participant has before him one or two units. The illumination of a light on one of his units is controlled by the other participants by opening or closing their switches in the network. The possible on-off illumination of the lights in any one network is given in Table 1. Further details on this work, including a circuit diagram, are given in [15].

Experience with *Communications Game* showed that, when there are more than three or four participants and several networks, the multiplicity of signals is beyond the comprehension of the participants. Hence, a simplified version of the game was developed with only one network and three participants, called *Communications Game 2*. It was installed at the *Cognition and Control* Exhibition at the Midland Group Gallery in Nottingham in 1972.

Significantly later, a new version of Communications Game was produced that employed a computer-based local area network but deployed exactly the same concepts. The work was shown in the exhibition *Art Creating Society* at the Museum of Modern Art Oxford [16].

COMMUNICATIONS GAMES THROUGH THE WWW

The *Shaping Form* pieces by Edmonds are individual stand alone works that were first exhibited in Washington DC [17]. In *Shaping Form*, images are generated using rules that determine the colours, the patterns and the timing. These are generative works that are changed by the influence of the environment around them. Movement in front of each work is detected and leads to continual changes in the program that generates the images. People can readily detect the immediate responses of the work to movement but the changes over time are only apparent when there is more prolonged, although not necessarily continuous, contact with it. A first viewing followed by one several months later will reveal noticeable developments in the colours and patterns.

The *Communications Games* concepts were applied to a development of the *Shaping Form* works using the World Wide Web. The original *Shaping Forms* worked from an individual memory. This aspect is significantly changed in the Web version. The community made up of the work's distributed audience collectively influence the progress and development of the work.

The Web version of *Shaping Form* uses a collective history. It has a memory that combines all of the experiences that the system has noted through all of the cameras that have been connected to it. Individual experiences are shaped in part by the behaviour of that individual and in part by this collective memory [18].

The approach adopted extends the notion of interactivity to collective behaviours in the context of web art and so illustrates a creative computational mechanism that embodies an interesting new form of influence, as discussed above. It provides a new form of communication that takes place through the collective memory across the internet.

CONCLUSION

Our appreciation of visual art depends on seeing it in context. The atmosphere, the light, the space, the audience are all part of the experience of a work. When we view an oil painting screened by plate glass, the glass is a component of the experience of the work. When we peer through to a work surrounded by a crowd, the audience becomes part of that experience too. In interactive art, the audience is deliberately made a component of the work: the person in the art space becomes an active participant. In participative interaction, the artefact is just one element of the whole experiential space. But what exactly do we mean by interaction? The words influence, stimulus, interchange are more evocative and appropriate for my works. If we add a layer of meaning to the situation, we can say that the influence of the human system on the art system comes about as a result of stimulus, interchange or even co-operation and conversation. The artwork and the audience are interacting systems that influence one another [19]. Generative art systems like Shaping Form are open to influence and develop over time as a consequence of that influence. This kind of computational generative art is an open system at the very heart of its design. The influences that occur in such open systems provide a mechanism for a form of communication that is entirely in sympathy with the ideas that inspired the early *Communications Game* art works.

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THE COMPUTER-GENERATED ARTWORKS OF VLADIMIR BONAČIĆ

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Scientist Vladimir Bonačić began his artistic career 1968 under the auspices of the international movement NewTendencies (NT), at the Gallery for Contemporary Art of Zagreb, which had pushed for his inclusion. From 1968 to 1971 Bonačić created a series of "dynamic objects" – interactive computer-generated light installations, five of which were set up in public spaces. The author shows the context of Bonačić's work within the Zagreb cultural environment dominated by the New Tendencies movement and network (1961-1973). The paper shows his theoretical and practical criticism of the use of randomness in computer-generated art and describes his working methods as combining the algebra of Galois fields and an anti-commercial approach with custom-made hardware. It seems that Bonačić's work fulfills and develops Matko Mestrovic′'s proposition that "in order to enrich that which is human, art must start to penetrate the extra-poetic and the extra-human."

INTRODUCTION

Vladimir Bonačić (1938-1999) worked at the Croatian national research center Ruđer Bošković Institute in Zagreb from 1962 to 1973. There, he headed the Laboratory for Cybernetics from 1969 to 1973. He earned his Ph.D. in 1968 in the field of pattern recognition.[1] Vladimir Bonačić's artistic path is inseparable from the New Tendencies international movement and its established world view regarding the synergy of science and art.

The Galerija suvremene umjetnosti [Gallery of Contemporary Art] organized five New Tendencies exhibitions in Zagreb from 1961 to 1973; in addition, international exhibitions were held in Paris, Venice, and Leverkusen, West Germany. A group exhibition of European artists in 1961 grew into an international movement that would be referred to as "NT". NT act as a gathering place of artists, gallery owners, and theoreticians during the Cold War, first from Eastern and Western Europe and South America, and, from 1965 onwards, also from the USA, the Soviet Union, and Japan.

Such a unique situation was realized by the cultural and geopolitical position of Zagreb, in the then socialist and non-aligned Yugoslavia.

In the catalogue of the first New Tendencies exhibition in 1961, the artist François Morellet, member of the Paris-based Groupe de Recherche d'Art Visuel [Visual Art Research Group] wrote: "We are on the eve of a revolution in art which will be just as large as the one in the field of science. Therefore, common sense and the spirit of systematic research need to replace intuition and individualistic expression."[2]

Further New Tenencies ideas - that can be completely applied to Bonačić's work - were presented 1963 in the catalogue of the second New Tendencies exhibition in a text by the Croatian art critic, theoretician, and co-founder of the New Tendencies movement, Matko Meštrović. The text was later revealingly republished under the title "Ideologija novih tendencija" [The Ideology of the New Tendencies], which it surely is according to its programmatic and theoretical structure.[3] The demythologization of art and demystification of the creative process were also proclaimed through a positive approach to the industrial production of works of art (the possibility of multiplication was essential), collective work, and a rational approach.

Meštrović called for speeding up the evolution and synthesis of science and art, within the framework of rendering humanities and art more scientific, as part of the long-term utopian process of the overall rendering of all human activity into science. Meštrović considered that this process can be actively started within the framework of art immediately, ditto for the display of a global model, striving to act in the sphere of culture using a smaller scale, e.g., through the appropriation of scientific methods, such as the experiment. The problems of scheduling all material and spiritual goods in equal measure and the return of scientific results into the public domain emerge. Meštrović did not consider artworks as unique goods for the artistic market, but as: "plastic-visual research, with the aim of determining the objective psychophysical bases of the plastic phenomenon and visual perception, in this way a priori excluding any possibility of including subjectivism, individualism, and romanticism […]" [4]

Further, the thesis on the final surpassing of art as we know it was developed, through developing the conscience of the world using a metamorphosis of the social into the artistic act, which actively transforms the whole world.[5] We can trace such developments in practices of numerous New Tendenies artists and researchers in the early 1960s forming the context for the inclusion of scientists-artists such as Bonačić later on.

During the first half of the 1960s, the New Tendencies attained notable international reputation as a leading international platform of avant-garde of visual art that preferred rationality, social engagement, and interactivity with the user, which was achieved through scientific experimentation methodology and algorithmic programming of visual elements in the execution of objects, as well as environments made of industrial materials, movement, and light. While, in Matko Meštrović's words, "artists at the beginning of the movement intuitively strived towards science", often lacking a notion of what it implied,"[6] this situation radically changed in 1968 when the program Kompjuteri i vizuelna istraživanja/Computers and Visual Research started and a larger number of scientists began to actively participate in the New Tendencies.

In the conferences and exhibitions which were part of the program, a number of scholars, who left the realm of pragmatic scholarly work by creatively using computers, participated along with the artists.

The art critic Radoslav Putar noted and explained that gradual shift of forces within the New Tendencies in his preface to the 1968/1969 exhibition catalogue for Tendencije 4 [Tendencies 4]: "[…] many followers of the NT have tried to give their work the habit of the machine, or else they have based their procedures on the use of mechanical or electric devices; they have all dreamt of machines - and now the machines have arrived. And they have arrived from a direction which was somewhat unexpected and accompanied by people who were neither painters nor sculptors."[7]

Vladimir Bonačić, who actively participated in all parts of Computers and Visual Research within the Tendencije 4 during that short and obviously intense period, along with his scholarly work at the Ruđer Bošković Institute in Zagreb, started and realized a wide range of artworks, simultaneously developing its theoretical elaboration. Bonačić participated in both conferences related to Computers and Visual Research - the colloquy in 1968 and the symposium in 1969, the papers of which were published in the bit international journal that was launched by the Galerije suvremene umjetnosti in 1968.[8] Within the two exhibitions of 1968 and 1969, Bonačić displayed one joint work, created together with the artist and designer Ivan Picelj, as well as 21 individual works. In addition he presented a large, 36-meter computer-controlled light installation, DIN PR 18, in public space.

JOINING THE NEW TENDENCIES

During the preparation of Tendencije 4, organizers from the Galerija suvremene umjetnosti sought collaborators at the Ruđer Bošković Institute in Zagreb. Alongside other scientists who were to take part in the symposia, New Tendencies organizers met at the institute the young scientist Bonačić at the Ruđer Bošković Institute, who used visual research in his scientific work. Also at this time, Ivan Picelj, New Tendencies primary graphic designer, was asked to design the poster for the Tendencije 4 events. He decided to use punch cards of the institute's computer for a collage. Picelj then had the idea to take his work a step further and to produce a light object following his Površina [Surface] series of reliefs in wood and bronze, which he had been developing since 1961.

Here, Vladimir Bonačić entered the scene, and they began the collaboration that resulted in the electronic object entitled t4, the abbreviation of Tendencije 4. It was presented in 1969. The front panel of the object is made of a grid of round aluminum tubes, each holding a small light bulb. Each tube is cut at an angle. The upper part displays the characters “t4t4t4t4,” animated to move from left to right and in several similar animations. The rest of the panel lights up asymmetric light patterns, and four knobs on the back of the object allowed for certain manipulations. Bonačić's experience in physics and electronics helped a great deal, as did the excellent production conditions in the workshops of the Ruđer Bošković Institute.

The first exhibition of computer graphics during the Colloquy at the Centar za kulturu i informacije [Centre for Culture and Information] in 1968 contained eight of Bonačić's computer-generated pictures titled RB 1-8, whereby “RB” denotes the place where the works were created, the Ruđer Bošković Institute, and the numbers are just markings that help distinguish the exhibits. All the exhibited works were photo reproductions of oscilloscope screenshots in different formats. The oscilloscope was an integral part of a self-constructed light-pen system linked with a PDP-8 computer. The programming language in use was “Assembler.” One work marked as RB-9, depicts a figuratively outlined female figure while other works are abstract. A computer drawing of the human figure in the work RB-9, an experiment finally not publicly presented, questioning author's repeatedly stressed desire to create “something that has not yet been done” by using the computer, and the conviction, in concordance with that statement, that the “computer must not remain simply a tool for the simulation of what exists in a new form. It should not be used to paint in the way Piet Mondrian did or to compose music as Ludwig van Beethoven did. The computer gives us a new substance, it uncovers a new world before our eyes. In that world after so long a time scientists and artists will meet again on common ground, stimulated by their common desire for knowledge.”[9]

The reference to Mondrian was a critique of A. Michael Noll's experiment with a computer-generated Mondrian-like drawing.

THE “GALOIS FIELD”

The “Galois field,” named after the French mathematician Évariste Galois (1811-1832), who outlined group theory, was a source of general inspiration to Bonačić. In abstract algebra, finite fields are known as Galois fields, and Bonačić studied them in connection with his work on the roots of polynomial equations. First in his scholarly work, but then also in the artistic, Bonačić developed his own, original method of studying the Galois field, in the way that he visualized it. In his article “Kinetic Art: Application of Abstract Algebra to Objects with Computer-Controlled Flashing Lights and Sound Combinations” (1974) he noted: “One of the most interesting aspects of this work [on Galois fields] is the demonstration of the different visual appearance of the patterns resulting from the polynomials that had not been noted before by mathematicians who have studied Galois fields.”[10]

In 1969, using the PDP-8 computer, Bonačić created ten photographic works with oscilloscope screenshots the title of which contains the letters “PLN.” In their name, those five works contain the exact algebra of the Galois field shown by the picture, e.g., IR.PLNS.0044.7714.7554.7744, whereby “IR” means irreducible (indivisible), “PLN” polynomial, “S” symmetry, and the numbers are linked with the polynomial properties. Bonačić described this work in the exact language of mathematics, as a “successive depiction of generating a maximal period in four irreducible polynomials of the tenth degree, x10 + x3 + 1 (0044), 7714, 7554, 7744.”[11]

In the visualization of algebra of the Galois field, the calculated algebraic result can be shown in both symmetrical and asymmetrical visual compositions. In the description of the work RS.PLNS.0374.1024.0064 which depicts a two-dimensional polynomial of tenth degree, depending on the starting number, Bonačić has written a note that the shown case features “a rare symmetrical structure in a polynomial of tenth degree (it can not be expressed by means of the existing mathematical apparatus) 0374, 1024, 0064. Symmetry cannot be disrupted by a change of starting number.” [12] Photographic reproductions show a sharp image of points projected onto the screen of the oscilloscope. In the series of works marked as “PLN,” visual representations of Galois fields were used, where visualized numeric combinations, of which there are thousands or millions, depending on the degree of polynomials, are shown within fields (rasters) of 16 x 16, 32 x 32, or 64 x 64 elements. Because of the limited size of the oscilloscope screen, some works where photographed and then collaged together with other screenshots into a larger format by hand. In this way, a higher “resolution” was achieved, which means that the number of depicted elements was increased. In the mentioned work, IR.PLNS.0044.7714.7554.7744, the collage was made out of 28 photographs of the oscilloscope screen, which enables simultaneous insight into different stages of visualized algebra.

Bonačić's entire work is characterized by an innovative and creative approach, as well as an examination of the possibilities of standardized peripheral units (outputs) that show the final result of the work on the one hand, and the usage of personally created or adapted hardware on the other.

The next five photographs from the series of works with “PLN” markings have no numerical descriptions of the applied polynomials, but they are presented only under the title PLN with added numbers 5-9, derived from the sequence of altogether fifteen exhibits displayed at Tendencije 4 in 1969. PLN 5, PLN 6, PLN 7, PLN 8 and PLN 9 differ from other PLN series works in the way that they do not show sharp contours of points “frozen” in the screenshot. In this series, there is no collaging of photographs, there is only one photograph of the whole screen, so that all the photographs are developed according to one rectangular frame from a 6 x 6 square of the photographic negative.

The works PLN 5-9 resemble experiments with photo focus and exposure time, but they have been obtained by creative usage of hardware and software parameters, which led to a new dimension in depicting static elements and their spatial relations. The works PLN 5, PLN 6, PLN 7, and PLN 9 look like a photograph in their long exposure time, where the shown elements no longer have a sharp outline. Because of the technical specificity of these works, collaboration with Marija Braut, that time's photographer at the Galerija suvremene umjetnosti, was established. Five works selected to be displayed at the exhibition Tendencije 4, later titled PLN 5, PLN 6, PLN 7, and PLN 9, had been chosen from a large quantity of photographic material.

DYNAMIC OBJECTS

Bonačić further elaborated the dimension of time, achieved through the combination of technologies of computer-generated images and the medium of photography in the described works, in a series of computer-generated light objects and installations which he named “dynamic objects”. All Bonačić's dynamic objects contain the possibility of interaction with time dynamics, in the way that viewers (users) are enabled to control the rhythm of images or stop them.

From 1969 to 1971, Bonačić created a series of Bonačić's dynamic objects consisting of different computer-programmed light patterns displayed on originally designed panel made of metal tubes of different shapes and sizes. For all dynamic objects Bonačić made use of the “pseudorandom” algebra of Galois fields (see “GF” in the title of work). It was programmed on a SDS 930 computer in Real-Time FORTRAN, allowing direct usage of Assembler too, thus having an excellent tool for various bit manipulation techniques.[13] The software co-programmer was Miroljub Cimerman.[14] Bonačić used custom-made hardware for all his dynamic objects, that were produced or assembled of electronic components by himself and experts at the Ruđer Bošković Institute. They were embodied statements of what he later elaborated in his critique of the influence on the computer-based arts of commercially available display equipment. [15] In his 1974 article “Kinetic Art”, Bonačić emphasized that this was “akin to an artist being limited to the use of only two or three colours in a painting. It is true that much can be done with such equipment but one can hope that ways will be found to take better advantage of computers."[16]

In 1987, almost twenty years after his first artistic experiments, Bonačić explained that a dynamic object was a "sculpture and the concept in art in which impregnable unity is established between the computer system and the work of art."[17] In 1987 he added: "To integrate computer systems and art, without allowing one to dominate the other, is seen as a step toward the common language. This means that the artist and their work of art are able to communicate; artists and their art use a common language."[18]

The dynamic object GF.E 32-S (1969-1970) generates consecutive Galois field elements at maximal distance from each other and displays them as symmetrical patterns by synchronous selective flashing on the front panel of the object. It resembles a screen made of a 32 x 32 grid of squared aluminum tubes containing light bulbs. The total "screen resolution" is made of 1,024 monochrome "pixels." The Galois field generator is part of a special-purpose computer located inside the object. The unit is self-contained.

The clock that controls the rhythm of the appearance of the visual patterns is variable. The rhythm can be adjusted between 0.1 seconds and 5 seconds by the observer. At a frequency range of 2 seconds, the same pattern will repeat itself in approximately 274 years. On the rear of the object, the observer finds "manual controls to start, stop, control the speed and for selecting or reading out any of the patterns. With the binary notation, 32 light indicators and 32 push buttons enable any pattern from the sequence to be read or set."[19]

From a contemporary perspective, Bonačić's dynamic objects are a pioneering example of use of interactivity in computer-based art. As many other artworks made within the New Tendencies context[20], dynamic objects by Bonačić are designed both as artworks that can be experienced aesthetically and instruments or tools for visual research. Especially the latter aspect could lead us to the cognitive process (visual learning of mathematics and its hidden lows), a quality mentioned by Bonačić while describing his art production. [21]. All dynamic objects were made to be manipulated either by author (or someone from his team) or by the observer. Such experimentation and visual research (in the literal sense of the term) can be done within the controlled environment of an artist's or scientist's studio or laboratory by assistance of the artist or his collaborators, or by gallery visitors.

The front panel of the dynamic object DIN. GF 100 (1969) is made of a 16 x 16 matrix of luminous elements in 16 different colors, each one appearing 16 times. By using the Galois field generator, DIN GF 100 can produce 65,535 different pictures or patterns.[22] Depending on the decision of the user or observer, the image changes according to the clock every 200 milliseconds or 2 seconds, introducing the observer into a pseudorandom process. The object can be set in both “auto run” mode and interactive mode [23], as it was exhibited with remote control at the Tendencije 4 exhibition 1969. The observer can manipulate the light patterns by both the control panel that is at the back of the object and the remote control that is connected to the object by a four-meter long wire, a long enough distance for experiencing immediate interaction while observing the object from a larger distance. The controllers make possible to manipulate the sequence's speed rate and to switch on manually operation of the sequences step by step, including the freezing of the chosen pattern. [24]

Bonačić introduced a higher level of interactivity in the dynamic object GF. E (16,4) that was conceived, developed, and built in Zagreb from 1969 to 1971.[25] It is 187 x 187 x 30 cm in size and half a ton in weight. The front panel shows a relief structure made of 1,024 light fields in 16 colors. Several Galois field generators operate in order to light the grid in different patterns and to produce the sound played through four loudspeakers, which create a quadraphonic sound system within the installation space. The field of the interaction extends from the sole object. The researcher/user/observer can influence both sound and image by using tenths of various knobs and switches at the (custom-made) special-purpose computer that is placed next to the object. Sound can be manipulated by the exclusion of some tones. The speed of the visual display can be adjusted as well by looping the selected sequences. A remote (radio) control is at the disposal of the viewer to manipulate some basic features. Yet, the observer cannot change the logic.

The entire “composition” of this audio-visual spectacle, which consists of 1,048,576 different visual patterns and 64 independent sound oscillators, can be played within 6 seconds or with a duration of 24 days.[26]

The bcd - cybernetic art team was founded in 1971, consisting of Bonačić, the software designer Miroljub Cimerman, his colleague from Ruđer Bošković Institute, and his wife, the architect Dunja Donassy. They would work together until Bonačić's death in 1999. bcd cybernetic art team continued to develop the dynamic object GF.E (16,4) over a number of years and experimented with different forms of external hardware. It was an instrument that changed interface design not only by taking up the newest technical possibilities that were rapidly changing between 1969 and 1974, but also by developing original new solutions.

Between 1972 and 1974 several upgrades that extended the interactivity level of GF.E (16,4) were created by using an external computer and a light pen: the computer offered a new interface - an interactive monitor - and the light pen enabled a more intuitive interaction with its graphic interface. The object was also connected to standard computer industry hardware as the GT40 graphic terminal with printer, but the use of human brainwave activity was also considered as possible interface of interaction. Both the object's calm audio-visual output and the transcendental quality of the cognitive and bodily experience of higher mathematics led to its setup in St. Kilian church in Wiesbaden, Germany, from 1983 to 1985, "where it helps the Franciscans to prepare for mediation."[27]

ART INSTALLATIONS IN PUBLIC SPACE

Bonačić also developed computer-based light installations for the public space that enabled another kind of interaction: an interaction at the social level. As part of the Tendencije 4 exhibition in 1969, he set up the large-scale dynamic object DIN. PR 18 on the facade of the Nama department store on Kvaternik Square in Zagreb. The 36 meter-long installation consisted of 18 elements; each element had a 3 x 5 grid light matrix. The installation performed a light show that flickered 262,143 patterns of the irreducible 18th-degree polynomial (x18 + x5 + x2 + x + 1). [28] The clock was adjusted at 200 milliseconds, but there was a possibility to adjust it to different rates "upon the border of the perception of the observer and frequency clock."[29]

At that time, the square was rather dark, with little public lighting, so the installation also acted as additional illumination. In July 1969 art critic and curator Želimir Koščević published in the daily newspaper Telegram an affirmative evaluation of the "message" of this public light system, used for an aesthetic rather than a commercial purpose, as opposed to the lit signs of companies that had started to appear in Zagreb's city center.[30] Koščević also found that this public installation showed a refinement of the idea of democratization of art within the context of the NT movement. He observes that Bonačić, "with his ideas, is a part of the front that within the 'Tendencies' movement attempts to open a path for art that would simply be work, the results of which will be meant for everyone, without the obligation to take our hats off and buy an entrance ticket for the unavoidable museum or gallery before we face it. Tomorrow is, as it seems, meant for just that kind of art."[31]

In 1971, the installation DIN.PR 18 was replaced by a more complex installation, DIN.PR 16, set at in the same place, at the top of the facade, but now in the form of a triple frieze of light elements. An additional spatial extension was made by new light elements set in the continuation of the freeze on the other side of the building, as well as into the indentation of the front.
A year before in 1970, another dynamic object was set up in the facade of the Muzej savremene umjetnosti Beograd [Museum of Contemporary Art] for the 4. Trijenale jugoslavenske likovne umetnosti [4th Triennial of Yugoslavian Art] in Belgrade, [32]. When Bonačić replaced the installation at Nama in 1971, he also set up a another installation on facade of the Nama department store on Ilica street, the dynamic object

DIN.PR 10. Finally, another dynamic object was exhibited only several hundred meters further at the facade of the Kreditna banka Zagreb building on Ban Josip Jelačić square in Zagreb. None of the “outdoor” works mentioned that were set up in public spaces are still in place, nor are their original elements traceable at a moment. At least, however, all of Bonačić's “in door” dynamic objects still exist and are in good condition;[33] they belong to the small group of computer-generated interactive objects from the 1960s that are still functioning today.

CRITIQUE OF TRUE RANDOMNESS IN COMPUTER ART

“I am especially sceptical of the attempts to produce computer art through play with randomness and the deliberate introduction of errors in programs prepared for non-artistic purposes,”[34] wrote Bonačić in 1974. He supported art practices where, like in his dynamic objects that make use of pseudorandomness, the “feedback loop might be closed with an aesthetic output to an art object, which would then provide semantically relevant information to a viewer. I believe that such interactions will add to cognition, which will be reflected in language and perhaps provide improved means of communication.”[35]

In his paper from 1969, he discussed the notions of information and entropy, redundancy and originality in the writings of George David Birkhoff, Max Bense, and Abraham A. Moles: “Observing the qualitative relation for the aesthetic measure, we come to conclude that the maximal originality (namely, disorder created by random selection of symbols) brings immense aesthetic values. Let us suppose we have created the program in some other way; but still it is the program that will result in an aesthetic object. Using the random generator, we shall carry on with random distribution of the existent information. While consistent in use of the random generator, we speak of 'maximal originality,' no matter what the results of the program might be. The random generator creates the accidental and unique presentation, which has neither value nor importance for human beings. Such information can evoke various associations in the observer. But a computer used in such a way lags far behind the human being. Even if the expressive potentialities of the computer were equal to those of a human being, the essence of Pollock's world and creation would not be surpassed, regardless of the complexity of future computers or peripheral units. That, of course, does not mean that a man (or a monkey or other animal) aided by a computer could not create an aesthetically relevant object if they consciously or unconsciously act obeying the law of accident.”[36]

This critique inspired the creation of the object Random 63 (1969), making use of 63 independent true random generators; each of them caused the activation of an electric lamp. The geometric pattern of the placement of the light bulbs at the object's front was calculated with a PDP-8 computer using the pseudorandomness of the Galois fields.

This is the only dynamic object by Vladimir Bonačić that makes use of true randomness for the dynamic control of the lights.

In his paper "Computer Graphics and Visual Art," published in bit international 2 in 1968, German computer art pioneer Georg Nees asked: "Shouldn't information aesthetics be able to use certain modeling techniques? The information it should model is aesthetic information, such as appears in nature and art. However, the dependency of aesthetic information on processes should be modeled as well, while conceiving the processes themselves as temporarily dependent information."[37]

Similar ideas are found in writings by Jonathan Benthall, who participated in two Tendencies conferences and observed: "Max Bense writes that mathematical aesthetics is a process which is 'devoid of subjective interpretation and deals objectively with specific elements of the 'aesthetic state' of as one might say the specific elements of the 'aesthetic reality.' These elements include meanings as well as sensuous or formal qualities. Bense proposes a 'generic aesthetics' which would explain how aesthetic states are generated in the same way as generative grammar in linguistics attempts to explain the logical processes by which sentences are performed and interpreted; but a prior stage of analytical aesthetics is held to be necessary. The main mathematical techniques proposed by Bense are semiotic (the study of signs, originated by Charles Sanders Peirce and others), metrical (concerned with forms, figures and structures), statistical (concerned with the probability of appearance of elements), and topological (concerned with the relations between sets of elements)."[38] Benthall continues: "Vladimir Bonačić is sceptical about the applicability of information theory to aesthetics, since it takes so little account of semantics. But he approaches visual phenomena in a mathematical and systematic way."[39]

BONAČIĆ'S DEVELOPMENT AFTER 1972

Contradicting Bonačić's wishes of 1968 that computer art should not mimic human-made images, computer-generated art pursued a different path. Computer graphics explored the possibilities of computer-generated figurative visuals and entered - with the provision of animation and special effects for the mainstream film industry - the commercial world, as well as the military sector, advancing virtual-reality techniques that mimic "real life." This development, within the context of the dominance of emerging practices of conceptual and non-object art that utilized post-Duchamp ideas of art and representation, led to computer-generated art's almost total exclusion from the contemporary art scene by the mid-1970s. This development was propelled by a rising anti-computer sentiment among the majority of the new generation of artists, in view of the negative impact of the use of science and technology by the military-academic-corporate complex in the Vietnam War and elsewhere.[40]

Bonačić was one of the rare artists who found and constantly reinvented a way to use computers and cybernetic art for humanistic purposes. After the period of the first series of dynamic objects, Bonačić's work from 1971 emerged within the bcd - cybernetic art team.

In 1972, Bonačić and the bcd cybernetic art team moved to Israel and founded in 1973 the "Jerusalem Program in Art and Science," an interdisciplinary program for study and research at the Bezalel Academy of Arts and Design in Jerusalem, which he directed until 1977. For this program he established collaborations with the Hebrew University of Jerusalem and the Israel Museum. In 1974, he organized an international seminar on "The Interaction of Art and Science," in which several New Tendencies protagonists, such as Jonathan Benthall, Herbert W. Franke, Frank Joseph Malina, Abraham A. Moles, A. Michael Noll, and John Whitney, participated. In 1975, Willem Sandberg, a Dutch typographer and director of the Stedelijk Museum, received the Erasmus Prize in Amsterdam. On Sandberg's recommendation, half of the prize was dedicated to "The Jerusalem Program in Art and Science."

The "Art and Science team" that included alongside others Willem Sandberg and the bcd cybernetic art team were approached by Radoslav Putar to propose one of the exhibitions for Tendencije 6. [41] Many members participated, and some disappointedly left the organizational board of Tendencije 6 [42] that over the five years searched for appropriate concepts for follow up New Tendencies, discussing many different options ranging form Naïve art to socially engaged video communities. The Art and Science team, represented by Bonačić, proposed the exhibition Meta Language in Development of Computer Art [43]. Finally, Tendencije 6 started with the conference Umjetnost i društvo/ Art and Society in 1978 in Zagreb, but the planned exhibition(s) never took place. The conference was the very last manifestation of New Tendencies. As the focus had shifted to video, Conceptual, and non-object art, next to the conference, a different exhibition was shown presenting Conceptual art from Yugoslavia only, entitled Nova umjetnička praksa [New Art Practice] (local synonym for conceptual and body art and related practices). Bonačić participated at the conference with the paper "Čovjek-jezik-materija ili dematerijalizacija umjetnosti" / "Man, Language, Matter - The Dematerialization of Art" [44] that discussed "an operational relationship between matter and thought," but also the relationship of a Darwinian evolution model and artificial intelligence along other subjects. He concluded his paper with the following thought: "The establishment of a common denominator would lead to a greater probability of an ethical evolution and thus, the creation of a new paradigm for society."[45]

CONCLUSION: TEMPORARILY REALIZED NEW TENDENCIES

From the beginning of his artistic activity, the work of Vladimir Bonačić was drawing the attention not only of his colleagues who participated in a part of the program Computers and Visual Research but also of the older generation of New Tendencies participants.

At the Tendencije 4 exhibition in 1969, Bonačić showed a total of 15 works in the gallery, as well as the outdoor installation DIN.PR 18, and for this participation he was awarded one of the prizes of the competition related to the exhibition.[46] The jury, consisting of Umberto Eco, Karl Gerstner, Vera Horvat-Pintarić, Boris Kelemen, and Martin Krampen, appreciated "the harmony between the mathematical consequences within the programming and the visualizing of the process resulting from the programming. We praise especially Bonačić's new approach entailing the solving of problems by including a picture and not a number as a parameter, rendering possible thereby the solution of much more complicated problems."[47]

The statement of Brazilian artist Waldemar Cordeiro for the Tendencije 5 conference that "[t]he Constructive art belongs to the past, its contents corresponding to the Paleocybernetic Period being those of computer art,"[48] i.e., that computer art had replaced Constructivist art, found its proof in Bonačić's artwork. What's more, probably with his dynamic objects, especially the ones set in public space, Bonačić managed to make real the utopia outlined by Matko Meštrović and other New Tendencies theoreticians by the beginning of the 1960s. His work is exact research leading to cognitive insights. Science has been humanized, and art has been scientificalized. Works have been realized through the use of machines, and their basic materials were time and light. They refer to the viewer as an active participant, sometimes in physical interaction with dynamic objects, and they are both socially engaged and democratic. It is possible to multiply the works by programming purpose-targeted software and constructing hardware.

It seems that Bonačić's work fulfilled and propelled Meštrović's visions from 1963 introduced at the beginning of the text, summarized in idea that "in order to enrich that which is human, art must start to penetrate the extra-poetic and the extra-human."[49] Bonačić's work has, at least temporarily, realized the program of the New Tendencies that at a certain point of time looked utopian. However, today it is being reactualized in a new geopolitical, technological, and cultural climate.

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[20] For example, Reljefometar [Relief-Meter](1964-1967) by Vjenceslav Richter, manipulable lumino-kinetic works by the group MID, or Un instrument visuel (1965) by Michel Fadat, all exhibited at New Tendencies exhibitions.

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[22] *Tendencije 4*, 1970, exhib. cat., Galerija suvremene umjetnosti, Zagreb, 1970., n.p.

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[24] ibid.

[25] This computer sculpture was first exhibited 1971 at the 7th Biennale in Paris in the section "Interventions" at Parc Floral, Bois de Vincennes from 24th September until 1st November 1971, followed by display at the UNESCO building in Paris, on the occasion of the 25th anniversary of the UNESCO from November 1971 until November 1972.

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[31] Ibid. Translated from the Croatian.

[32] 4. trijenale jugoslovenske likovne umetnosti, Muzej savremene umjetnosti, Belgrade, 3rd July until 15th September 1970; curator: Jerko Denegri.

[33] In total, eight electronic dynamic objects were presented at the bit international exhibition: seven objects at Neue Galerie in Graz, 2007, and three at the ZKM | Center for Art and Media Karlsruhe, 2008/2009. Miroljub Cimerman, Dunja Donassy, and ZKM technicians restored GF. E /16,4 for the first public display since 1985.

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ON THE RELATIONSHIP OF COMPUTING TO THE ARTS AND CULTURE - AN EVOLUTIONARY PERSPECTIVE

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Our increasing knowledge of human evolution and of cognitive science combine to provide new insights into the function and roles of that wide variety of skills and products which are gathered under the heading "art". Since all homo sapiens cultures produce it, art is on a par with language and tool making as a fundamental characteristic of what it means to be human. Why do we do it? What is its survival value? Historically it seems that, about the time humans evolved language, tool making skills were diverted into decoration and symbolic representation and thereafter cultural evolution was rapid – from shell shawls to a diamond encrusted skull, from flint axes to the Large Hadron Collider in only 80000 years! Just what is the relationship of computing to the arts and culture in our modern world of externalised, accessible knowledge and rapidly evolving technologies? This paper addresses that question.

THE LONG VIEW

My goal is a deeper understanding of the place of computer art in the broader scheme of 21st century culture. In the 40 years since the Computer Arts Society was founded not only has the technology evolved at a staggering rate but our knowledge about the world around us and of ourselves has also hugely increased. So my aim is to see how all that new knowledge might illumine the processes begun by encouraging artists to explore computing as an artistic medium.

To do this we need to take a long view of human evolution, the last million years or so from homo erectus to homo sapiens sapiens and then from chipped flints to the Large Hadron Collider in only a quarter of a million years. Of particular importance is that most human of all facilities - being able to imagine and represent non-present things, those products of hand, brain and tool which we call "art".

The story of life on earth is unfolding as the tools and techniques of palaeontology, anthropology, archaeology and, more recently neurophysiology and cognitive science, develop. Current understanding is that from the formation of the planet some 8 billion years ago for half of that time life has been present – algae 4 billion years ago, shell fish and corals 3 billion years ago, first mammals over 2 billion years ago. Mammalian evolution has continued since then as life adapted into environmental niches. That long evolutionary haul of more than 2 billion years eventually produced our early ancestors, australopithocenes, some 4 million years ago, and then the more clearly established ancestry of homo habilis (2 million years ago), homo erectus (1 million years ago) and then throwing up our species, homo sapiens sapiens, so very recently, just 200,000 years ago.

In evolutionary terms from homo habilis to homo sapiens there have been two major spurts of brain growth. The first, between 1 and 2 million years ago, was round about the time of the emergence of homo erectus and probably marks the emergence a new level of sociality, embedding the collaboration needed for successful hunting and gathering and, with that, a more sophisticated "theory of mind", ie recognition that other individuals were capable of similar thought processes to oneself. The second growth spurt was about quarter of a million years ago and seems to mark the emergence of homo sapiens sapiens. However our near cousins, the neanderthals, were also around at this time, at least in Europe and we now know that they had bigger brains than us. Theirs was 1.5litres whereas homo sapiens have an average brain size of 1.3 litres. So brain size alone is not what gave us whatever evolutionary advantage led to our survival and the extinction of the neanderthals. What then did?

Archaeological evidence indicates that that most recent spurt in brain gowth also marks an increase in the types of tools which humans made. For about 2 million years there had been a slow progress in the development of tools and the things made with them, shelters, garments and containers. Then around 200,000 years ago there is a dramatic increase in the range of things made – very sharp long flints, pots and importantly some evidence of ornament. At this time too language was developing. Stephen Mithen argues in "The Singing Neanderthals" [11] that there was a long period before the emergence of language proper when sounds - socialising hums, grunts of encouragement, warning cries - and gestures were how early hominids communicated. It has also been argued that the loss of body hair meant that infants could no longer cling to their mothers so they had to be set down and baby noises and cooings would be the means of linking mother to child. Thus it is likely that sound and musical noises predate language. The long period of slow evolution of tools corresponds with this pre-language evolution of sound making. Then both these processes change at that interesting point 200,000 years ago when it looks as if sound making reached the point of abstract language and there was a rapid increase in the sophistication of tool making. Mithen, in his earlier book "The Prehistory of Mind" [9] argues that this key event in brain development was the point at which hitherto different functional capabilities, for example those for knowing what to eat and what to avoid, the toolmaking abilities already referred to, the social capabilities for working in groups and getting a mate, quite suddenly, through some as yet not understood brain event, became able to influence and communicate with each other. For example the tool making capability could work with the social capability to make things which were symbolic of social relationships, strings of beads, shell shawls, bone and stone "sculptures". It looks as if a new form of brain organisation had appeared by which attention could be allocated to different functions according to awareness and circumstances. Was this "attention organiser" what we now call consciousness, taking over some of the functions previously carried out unconsciously or instinctively?

So the story so far – about 100,000 years ago evolution on our planet had resulted in the human animal equipped with a big brain capable of using sound and music for communication, language, tool making, social collaboration, awareness of self, probably conscious thought and probably the ability to represent things not present, such as remembered images of animals or objects. There were probably around 1 million such individuals mostly in the Africa and the Middle East though with growing evidence of pockets elsewhere.

And there the story almost ended. 73000 years ago a huge volcanic eruption at Mount Toba in Sumatra almost extinguished human kind. The ensuing 10000 years of a dust enshrouded, cold planet brought the population down to a few tens of thousand, some estimates are as low as 15,000. Whatever capabilities these individuals had for survival these are the characteristics which underpin our modern culture. From that time, when humanity fully emerged from this extreme threat, around 50,000 years ago, the human population has grown seemingly inexorably to its current 6 billion or so. Instead of just finding an ecological niche and living symbiotically within it, as most animals do, the human has used its functional capabilities to spread over the planet and adapt to all but the most extreme environments and, indeed, modify environments to its needs.

The survival capabilities which brought our ancestors through the 10,000 year Toba winter have evidently been more than enough to see the species through subsequent environmental challenges, such as glaciations. My argument is that the human propensities which came from that time are crucial to our understanding of our culture now. I suggest that the functional capabilities of the human animal which were in place around 100,000 years as the key characteristics of homo sapiens led up to what I consider to be a defining characteristic - the ability to externalise internal thoughts and imaginings. Language would have allowed the expression of internal thoughts and needs, the more sophisticated tools could have been used for making marks and the beginnings of drawing and painting, the ability to represent externally something not immediately present. The extreme pressures of the environmental cataclysm of Mount Toba would have placed very high value indeed on the ability to externalise and communicate. With a very short life expectancy the ability to teach off-spring the basics of survival would have been paramount. Those who could pass down skills and understandings quickly and effectively would survive, those who couldn't wouldn't! Very soon after the emergence from that cataclysm there is evidence of the exercise of such externalisation and communication skills namely the cave paintings and rock art dating from those times. Such works are still mysterious in their purpose and use, is it possible they were a celebration of a hard won skill which enabled the ancestors to survive?

So our human evolutionary trajectory comes to a focus around 50,000 years ago with the spread of humanity as successful hunter/gatherer across the globe and the beginnings of our modern cultural history. Intervening environmental challenges such as glaciations have been survived and, since the last glaciation which ended about 13,000 years ago, human cultural evolution has been dramatic. The last 10,000 years have seen the transition from hunter/gatherer to agriculture, settlements, division of labour, counting, writing, governance structure, laws, cities, empires, wars, mass religions, science, technology, art and all the stuff that makes modern humanity. Underlying all this are four key human propensities:

1. The propensity to externalise emotion (affect) through sounds, images and words;
2. The propensity to externalise images using hand and tools;
3. The propensity to externalise thoughts using words and other symbols;
4. The propensity to understand/manipulate/empathise with external others using theory of mind

Our modern world is the result of the interworking of these propensities over hundreds of generations and millions of people and are concerned with externalising stuff that is originally in our heads. From these have come the main "organs" of global culture - governance, religions, science, art and wealth creation. As with the organs of our biological selves, which are built from proteins expressed by our genes, so these organs of our mass culture are built from the propensities described above which in turn arise from the brain functionalities evolved 100,000 years ago and refined by the near extinction event. There isn't space here to develop the analogy between biological organs and cultural organs, that would take us well into meme territory and must await another discussion. The organs most relevant to this discussion are art and science but we must remember that all the organs, as in our bodies, are interdependent and must all function harmoniously together to provide a healthy totality. Going back to the list of propensities, all are involved in differing proportions in the functioning of the five cultural organs.

The arts "organ" has produced a rich history of image and object from the interplay of hands and brains with many different tools and technologies. Artists, and here we should remind ourselves of Gombrich's opening statement in "The Story of Art", "There really is no such thing as Art. There are only artists" [5], have sometimes been the servants of church, state or wealth and sometime been freer spirits, exploring the fringes of what's possible. Overall the history of art presents a record of a multitude of things, tangible and intangible, offering endless opportunity for historians and critics to classify and reclassify, interpret and re-interpret. But above all we should remember that the art process is one of externalising, projecting from the mind, using and adapting whatever materials and tools are to hand

In contrast the science "organ" has through the evolution of the evidence based scientific method, tried to build reliable, accessible knowledge repositories. These now tell us about the evolutionary history of human kind, which I have crudely summarised above, but also about the beginning and end of the cosmos, about psychology and biology and brains and everything else. But science is always "work in progress" and the shifting sands of theory and hypothesis can never provide absolute certainty. Nevertheless the scientific method has provided perhaps the only globally successful consensual human endeavour. Though science and technology are often lumped together in the belief that science spawns technical innovation this is an overly simple belief. Certainly the scientific requirement for ever better instruments is a great spur, perhaps the greatest spur, to technological innovation. But it does also seem that the root of the urge to technical innovation goes much deeper, in the propensity to externalise images and thought using hands and tools. The innovations in flint tool making 200,000 years ago were the first sign of the avalanche of innovations which would thenceforth propel human cultural development. At that point art and technology were very closely linked indeed.

COMPUTERS AND ART

How does all this help us understand the rather curious relationship between computers and the arts? At one level it is fairly straightforward. What the Computer Arts Society has done over the past 40 years has been simply to add the computer to the list of tools available for propensities to externalise images and for communicating emotion and affect. As a result there have been many additions to the list of "things created" and the fact that a significant proportion of these now constitute the beginnings of a national digital art collection at the V&A [1] signals a recognition of their place in art history. They are there now for historians and critics to mull over and interpret.

However from the overview developed above there is more to it. As we have seen, the last great evolutionary adaptation in brain function 200,000 years ago was the hypothesised “attention organiser” which enabled different functional characteristics of natural intelligence to overlap and work together and create self awareness and consciousness as we now know it. Today, especially after the apparent failure of the Copenhagen climate change conference, it is clear that the “organs of culture” are not working together. The wealth creation organ pursues its own goals through globalisation and disregard for the environmental and social costs involved. The science organ produces data and knowledge at ever increasing rates which the governance organ seems unable to assimilate and act upon. The governance organ itself seems caught by the conflicting demands for democratic fairness, which requires time to achieve, and the need to respond quickly to threats and challenges. The religious organ seems unable to engage in other than extremist discourse. The arts organ creates its own internal discourses which often baffle outsiders. However of all the organs the breadth of engagement of the science and the arts in creating and adapting new technologies to their communication ends does offer a glimmer of hope. There is, in my view, an urgent need to get all the organs of culture to work together if we are to survive this next looming, self inflicted environmental catastrophe. Can we conceive of a cultural equivalent of the brain adaptation which led to our multi-faceted human intelligence?

I think the answer to that question is “Yes” and that cultural equivalent is the computer. It already has capabilities to support externalised knowledge repositories, to augment natural intelligence, to provide extensive modelling and analytical tools and to provide new social communication channels. Currently the computer has these as separate capabilities, so reminiscent of the separated early human intelligences. All the organs of culture currently use one or other or several of these computing capabilities. It is now a challenge to computer people and artists is to try to work together to create the systems which will enable all the organs of culture to intercommunicate and function as a cybernetic whole.

Stated baldly this is a rather grandiose objective. But it is worth recalling that 40 years ago, in 1969, a group of scientists, computer engineers and artists came together, under the aegis of the Computer Arts Society, and created a system called Ecogame [8] which sought to illustrate how computers might be used in the 1980s. The multimedia, economic game environment which resulted was played by many of the leading industrialists, economists and politicians of the time at the Davos symposiumin1971. My call now is for a 21st century multi-disciplinary equivalent of the Ecogame project, scaled up appropriately for the current challenges and to help design the collaborative, culturally aware information/knowledge systems needed to see us through. Can we do it?

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PARAGRAPHS ON COMPUTER ART, PAST AND PRESENT

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Sol LeWitt published "Paragraphs on Conceptual Art" in *Artforum*, June 1967. They became an influential theoretical text on art of the twentieth century. They played the role of a manifesto even though they appeared when their topic – concept over matter – had already existed for about a decade. Digital computer art had had its first exhibitions in 1965. It seems it never produced a manifesto, with the exception, perhaps, of Max Bense's "Projects of generative aesthetics" (1965, in German). Since computer art is a brother of conceptual art, it is justified in a late manifesto to borrow the style of the old title.

An art movement that is by now 45 years old and that has gone through a tremendous development, cannot create *ex posteriori* its manifesto. However, *A Software Manifesto* was also written only *after* software and information technology had become the most important technology of our times. The following paragraphs may be read as a belated manifesto.

1. There are no images now with no traces of digital art. Digital Art exists as computer art, algorithmic art, net art, web art, software art, interactive art, computational art, generative art, and more. When it made its first appearances, in Stuttgart and New York, the name "computer art" was thrown against art history and into the faces of art critics. It was a proud name and a bad one. "Algorithmic art" would have been the correct term. The superficial "computer art" disguised the revolutionary fact: the algorithmic principle had entered the world of art.

2. The algorithmic principle is the principle of computability. Whatever exists in the domain of computability, exists insofar as it is computable. Alan Turing, Alonzo Church, and others had in the 1930s saved mathematics as the only discipline of the human mind that can say clearly what it says. Those heroes had

clarified the concept of computability. They had thus created a new basis for mathematics. Soon after, the computer appeared as the machine to turn science into engineering. There had, of course, before been devices for mechanical calculation, but no computing automaton.

3. The computer was about twenty years old, when computer art appeared. Was this late? Was it early? It was in time. The times were times of deep social unrest. The hypocracy of the war generations came under attack, and Karl Marx had a revival. Ideas of the cultural revolution from far East conquered young minds. The algorithmic revolution started its long march overturning all of the technological infrastructure.

4. Three years later, computer art was recognized internationally. In 1968, two exhibitions became the forerunners of the development of digital media. One was called *Cybernetic Serendipity. The Computer and the Arts*, at the Institute of Contemporary Art in London. The other one was *Tendencies 4. Computers and Visual Research*, at Galerije Grada Zagreba in Zagreb, Croatia. *Serendipity* established the event component of digital media, and linked to the computing industry. *Tendencies* established the research component of digital media, and linked to the world of art.

5. Computing machinery in its form as digital media incorporates three great principles: computability, interactivity, and connectivity. Computability appears in the arts as algorithmic art. Interactivity appears as interactive installation. And connectivity appears as net art or software art.

6. Earliest computer art (as digital art, and not as electronic art) is art from a distance. It is art done by brain, and not by hand. It liberates the artist from the limits of handicraft skills. It automates the production of the perceivable, material component of the work. The artist in algorithmic art creates an entire class of individual works. He or she is an artist insofar as she works in the realm of possibilities and potentials, not of realities and facts. The work of art in algorithmic art is the *description* of an infinity of possible works. They all share some common features that the mind can discern, even if the eye cannot see any similarities. The description is a sign of signs.

7. Computer art is almost entirely happening in the semiotic domain.

8. Algorithmic art has denies the concept of a masterpiece. This is to say that in algorithmic art, there cannot be a masterpiece any more in the traditional sense of the word. Each and every individual piece of algorithmic art is no more than only one instance of the potentially infinitely many from the class of works

defined by the algorithm. The tragedy is that the algorithm itself does not often show visual qualities. Its qualities arethe potential to generate visual works. But each of its visual products is a shadow only of the algorithm. It is one of its traces, a left-over, a consolation for those who need to see rather than think. If you want to find the masterpiece, you must compare algorithms. Critics and art historians are not prepared to do this. Nor is anyone else.

9. Computer art is conceptual art. However, concepts in computer art are different from concepts in conceptual art. They here appear as operational descriptions. Algorithms are descriptions. They are finite descriptions of infinite sets. They are static descriptions of dynamic processes. These descriptions are operational and executable. I.e. they are text *and* machine, at one time. When the algorithmic artist designs a work (an algorithm), he writes a static text. He may print the text on paper. This shows the text quality of the work. It is a quality for the human reader to perceive and acknowledge. But the text's description is also operational. It can be executed by a computer. When the computer executes the description, it reads it in its own, peculiar way: it realizes exactly what the description requires it to do, and nothing else. Reading always is interpreting. The computer, when reading the operational text, interprets it. Absolutely different from our interpretation, the computer's interpretation is a determination: no freedom allowed The computer interprets by determining the one and only one interpretation that makes algorithmic sense.

10. Computer art is concept art insofar as it describes an idea and does not show the material work. However, since its descriptions must be operational or computable, the concept can be carried out immediately, without mediating media. If the conceptual artist ever wanted to realize his description of an idea, he would need media of an appropriate kind to do so.

11. Emerging at the same time as conceptual art, algorithmic art as the elder or younger brother clearly went beyond the confines of conceptual art. Concepts and conceptualizations had always been present in art since, without an idea, without a concept, art would not emerge (at least not in modern times). Conceptual art was another step in the continued modern reduction of the work of art. This reduction reached the point of the concept or idea itself. No work exists without a concept at its root. In conceptual art, the concept is considered more important than its realization. Algorithmic art goes the other way. Ideas and their descriptions, in algorithmic art, must be codes that incorporate their own execution. Where conceptual art dances around the possibility of, perhaps, realizing a piece and drawing pleasure from imagining it, algorithmic art immediately delivers the conceptualized piece free of charge. It could go on

realizing works of the same concept for centuries. Harold Cohen, Manfred Mohr, and Roman Verostko, and dozens of other algorithmic artists know this.

12. The algorithm is the concept in its strictest form of description. Conceptual art usually is “free from the dependence on the skill of the artist as a craftsman”. Some years before Sol LeWitt wrote this in 1967, algorithmic art had already eliminated the skilled craftsman. We see: algorithmic art is the final form of art in times of industrial production. Beyond all craftsmanship and aura, the work is produced automatically. This comes at the price of the artist turning himself into an engineer. What the futurists and others may have dreamed of vaguely, becomes deed in the algorithmic age.

13. “The idea becomes a machine that makes the art.” Exactly this, dear Sol LeWitt, had happened some years before you wrote it. Insofar, algorithmic art is the mother of conceptual art. Art critics and others should finally become aware of this when trying to study a phenomenon so alien to them.

14. The greatest idea before its time, in computer art, is its *generative* approach. The algorithmic artist does nothing that is not generative. At a second look, nothing is so great about this. Once an artist decides to use a computer for his production, he is bound to design a program (an algorithm). Without an algorithm for art, no algorithmic art. It is as simple as this. The artist turned algorithmic is a generative artist by birth. Not necessarily does he know this. Therefore, the philosopher had to tell him. For this end, Max Bense wrote his short essay, *Projects of generative aesthetics*. In a book of 1974, I mathematically defined the concept of an analytic aesthetics. A synthetic aesthetics is, of course, the inverse of an analytic aesthetics. A generative aesthetics is a computable form of a synthetic aesthetics.

15. The generative principle had existed since Noam Chomsky had studied generative grammars. To him, they were devices not only to describe syntactic structures of sentences in a language. A generative grammar was also capable of producing syntactically correct phrases of a language. Of course, they played an eminent role in the definition of programming languages. Max Bense only borrowed the attribute “generative” from Chomsky.

16. The generative principle was soon forgotten again as a machinic device for the creation of art. Only recently the generative approach has re-emerged. It is now applied in an almost trivial way whenever a computer is used in the course of some creative work. There is generative design, generative architecture, generative art, generative music, and probably more. The question has become: How can you do anything now *without* a computer?

17. The first artists who used digital computers, and thus discovered for art the algorithmic principle, had before been working as mathematicians or engineers. This was just what they had studied. They had access to computers and were, most likely, computer experts, which was a very special kind of expertise in the early 1960s. Almost all critics, journalists, culture types by the time loved to accuse and insult those pioneers of a new kind of art. The pattern of their degrading comments was: "Quite nice, but boringly geometric and constructive. It needs a real artist to create something fine and remarkable." Pioneers not often reach great accomplishment. They rather create the vision. It was appaling to see how little the experts of art understood when the machinic principle of computation reached out for art.

18. Earliest computer artists had to tame their naked machines. They kept totally erotic relations with them. Their programs were written in machine language (which is immediate binary code). They had to test and run their programs without support by an operating system. Soon enough, this situation improved, and Algol60 or Fortran became the programming languages of choice. Is this important? Yes, it is. The software and hardware support compares with the brushes, oils, acrylics, and whatever other materials and tools an artist may be using outside the digital world. A language of choice would now be Processing or one of the scripting systems. Such symbolic devices still keep the artist at a distance from his visible work. They still require the kind of thinking that is genuinely new, and was an idea before its time. The artist who wants to do computer or algorithmic or interactive or net art and, therefore, wants to program the computer, must learn to *think how the machine would think if it could*. Read this statement twice, memorize it, and then start doing it. An entirely new world will open up for you. It is the world of digital media whose forerunner was algorithmic art. It is the postmodern. You are leaving industrial production. You enter post-industrial performance.

19. Photoshop is a great piece of software. It is a huge collection of marvellous functions in the guise of tools. Other programs are as great. They open options that most of us have never dreamed of. They open the world of the digital Sunday painter.

20. Artistic production requires activities of selection and composition. The artist selects her materials and tools, forms and colors, her elements with which to work. She does so even if not explicitly. The artist works with her elements by combining, connecting, arranging, positioning, transforming them: she composes. Viewed more abstractly, the artist has at her disposal primitve (or elementary) signs (in their material state). She is free to compose them into

groups and systems of signs of signs, and supersigns, etc.: signs of signs of signs ... – always only on the material, syntactical level. Low and high level compositional decisions influence the gradual building of agglomerations of signs up to the highest levels. Decisions in detail, concerning only tiny parts, gain influence in an often miraculous way up to the top of the work. Such a semiotic view of the generative process is helpful when writing programs for art.

21. Computer art shares with conceptual art (and some others) a neglect of materiality. In fact, the revolutionary step at the very beginning of algorithmic art was the total loss of the material dimension. Only after the program had been developed, tested for correctness, and run for production, could the artist finally, if he so wanted, see what he had achieved. The drawing automaton generated, from an abstract encoding of the drawing, a concrete paper version in ink. Drawing with the brain becomes possible only if all material aspects and components are given up. Early computers did not have display units. They may have been interactive in some way. Such interaction was, by the time, not mediated by icons or indices we have become so familiar with to observe whenever we open our notebook. Interaction was mediated by symbols to think. Meanwhile, materiality has returned in form of the "graphic user interface". It is a fluid kind of materiality. The principle of algorithmic, of interactive, of software art is still omnipresent: "Think of infinite sets, not of their individual representatives."

22. Was there any individual inventor of computer art? Certainly not. Machines, devices, institutions existed, people worked there with their differing backgrounds and interests, in their various situations and diverse contexts. The idea to make experiments in two dimensions instead of one, with open ends instead of pre-set goals, in a playful spirit instead of consecutive logic, such an idea emerged here and there until it was realized and proven as viable. Such processes took place between 1962 and 1965 at several places in the world, and nobody should be surprised if some day a new name appears besides those that are usually credited for having been the first pioneers.

23. Did Max Bense, the philosopher and writer of concrete poetry, invent or predict computer art? Would this not be a beautiful idea? You may occasionally find indications in this direction in the literature. The title of one of the four volumes of his *Aesthetica* was *Programmierung des Schönen* (Programming the beautiful). The books were first published between 1954 and 1960. The term "program" was used here, as in similar contexts, in a more general meaning of the word than "computer programming". Generally doing something according to some programmatic rule, principle, or method differs from the program on a computer precisely in the radical requirement of computability. Claude Monet

worked programmatically in many of his series of paintings depicting one and the same object, but under varying conditions. So did Josef Albers in the long series of his *Homage to the square* paintings. Chaotic as the results may look, Jackson Pollock was following programmatic schemas in his drip paintings. The list could be extended, and it could give rise to similar lists in music or in poetry. The principles of series, of experiment, of construction, permutation, variation, transformation have all been used in art long before computers had arrived. The technique of perspective projection, so important in the Renaissance, is proof of a strict constructive schema that all painters had to learn, and from which they decided to deviate when they thought it was necessary. So what came into the world of art in the early 1960s, is the principle of computability. Max Bense was too much a philosopher to surrender to restrictions of computability.

24. Behind computability we discover mathematics. Throughout the centuries, a friendship has existed between art and mathematics. The two stand for the two most basic capacities and activities of the human mind and of human practice: counting and drawing. Both are ways of abstracting from what we experience directly, i.e. bodly. When counting, humans reduce the world to numbers. When drawing, they reduce the world to shapes. In numbers and shapes, the digital and the analog aspects of the world appear. They are aspects only, not objective givens. We decide to look this or that way. Humans did this early in their existence as humans, early in cultural history. The walls of caves show numbers (as groups of strokes), and they show shapes. With the algorithmic description of an operation to be carried out by machine, art gained the option to incorporate mathematical processes into artistic creations. This is a strong idea. Before its time? Certainly before its time if we look at quantities.

25. It took twenty years into the history of the digital computer before digital art appeared. Not really a long time. To force a computer to create two-dimensional drawings, the machine for calculating must be told drawing. The question must be solved, how to draw when the machine at your disposal can only calculate. As we know, this has been solved completely.

26. Randomness is essential for the aesthetics of computer art. It has been suggested that probability distributions and random numbers simulate in a computer program the artist's intuition. By intuition the artist takes decisions during the creative process. An external observer has no chance to say what the reason was for a particular intuitive decision. Other than by random choices, there is no way algorithmically to simulate such internal decisions. Used in clever ways, randomness must not be the same as throwing dice. It can be controlled in many ways such that macro-structures emerge inspite of randomness on low levels of a program. Randomness is much broader a concept than uniform probability.

27. Generative methods can be designed as structured sequences of decisions. Top level decisions concern global aspects of the visual work. Lowest level decisions concern primitive aspects of the visual work. Any number of intermediate levels can be inserted. Conditional probabilities can be used to create local control dependent on neighborhoods. Hierarchical data structures can be used to move up and down between global and local aspects and levels of an image.

28. Early computer art was revolutionary but, at the same time, traditional. It was traditional insofar as it resulted in paper work to be put up on the walls of a gallery. Why use the most modern technology in order to generate the most traditional formats of the art world? Apparently, the activists of the time were hoping for recognition in the art world by sticking to traditional forms. Computer art was, at the same time, revolutionary on all other accounts. It was a radical turn to an aesthetics of the object. The individual human subject simply did not exist anymore, once he or she had set the boundary conditions for the image to be computed. Computer art, in its early years, was radically rational. It was done in thinking, not in dreaming. Computer art remains a rational art of the object even though its appearances of today have hardly anything in common with those of its early years.

29. Computer art left its McLuhan phase when it took on the form of interactive installation. In its McLuhan phase, a new medium – despite its revolutionary break – still has an old medium as its contents. Algorithmic art as paper work on a wall is of this kind. Computer art gained its inherent historic height only when it took to interactive works. The computer is the machine for precise and rapid repetition with small changes. Only when this essential feature is exploited, does computer art become more than a gimmick. In interaction, this is the case. It is also the case in animation. Digital art has become an integral part of virtually all films. The virtues of algorithms for this genre were demonstrated very early by A. Michael Noll, John Whitney, Sr., Ken Knowlton, Bill VanDerBeek, and others. Interactive works needed more devoloped technology. They are the truly new genre. In them, digital art triumphed. Connectivity is celebrated in the rapid world of software art.

30. The earliest pioneers of algorithmic art worked in solitude. But very soon, cooperation came up. During some great happy years at Bell Telephone Laboratories, exciting things were happening that came out of a group of engineers, mathematicians, and artists. During a few years of the 1960s, they demonstrated many of the technical possibilities that had become available and were waiting to be used. In 1966, also with support from Bell Telephone, *Experiments in Art and Technology*, headed by Billy Klüver and Robert

Rauschenberg, put up a spectacular series of events in New York, but with moderate success only. Even though they continued for some years, cooperation turned out to be not a trivial task if the product was to be of high quality in both aspects, aesthetically and technologically. The amount of shared time, of disciplinary autonomy, and of allowing oneself deeply getting involved with the other’s expectation, is tremendous. Early computer art has, perhaps, demonstrated, that *inter*disciplinarity is not really what is needed. Maybe, that’s *trans*disciplinarity. It happens in the individual.

PROGRAM, BE PROGRAMMED OR FADE AWAY: COMPUTERS AND THE DEATH OF CONSTRUCTIVIST ART

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Why did Constructivist artists of the 60s and 70s find it so hard to switch from calculators and graph paper to BASIC and PCs? Was there something in their pre-computer 'programmatic' ways of working that did not readily transfer to computer programming – something that could now be recovered and used to refresh current software based art practices that constantly struggle with the limitations of proprietary operating systems, desktop interfaces and network protocols?

INTRODUCTION

"Today we stand between a society that does not need us and one that does not yet exist."
El Lissitzky,Theo Van Doesburg and Hans Richter, "Statement by the International Faction of Constructivists", 1922 [1].

History has not been kind to the Constructivists. Unlike the other big hitters of the Modern art movement, they have almost become figures of fun in art history – the first artist geeks with their rulers and protractors, polishing their little Perspex maquettes and planning their rectangular utopias. It seems as though Constructivism has been unable to maintain its relevance, its enthusiasm for science and engineering superseded up by the rise of mass digital computing and telecommunications. Paradoxically it feels as though Constructivism has become the victim of a kind of success story. Many of Constructivism's core values of interdisciplinary working and research, of objective process as opposed to subjective meaning and deference to the machine as a source of artistic inspiration have now been absorbed into the assumptions of current new media art practices and funding strategies in the UK.

The Constructivist approach is an aesthetic and a technique that values openness, clarity and the structuring process in opposition to predetermined content, completeness and individual subjectivity. If we accept that this idea of the 'programmatic' – the recasting of artistic working into an objective, reproducible discipline – was a central tenet in Constructivism then it is a little hard to see why the movement should have declined precisely at the point at which the 'programmatic' seemed to reach its fullest potential - the programming of the digital computer.

THE FIRST RISE AND FALL OF CONSTRUCTIVISM

It was at “The Congress of International Progressive Artists” in Dusseldorf in 1922, that El Lissitsky, Theo Van Doesburg and Hans Richter issued a joint statement entitled “Statement by the International Faction of Constructivists”. One passage in the statement sums up the basis of their shared interests succinctly – their opposition to the “tyranny of the subjective” and their belief in the “systematisation of the means of expression to produce results that are universally comprehensible” [2]. Its artistic inspiration could be traced back to Vladimir Tatlin’s sculpture known as the “Corner Counter Relief” of 1915. Tatlin’s sculpture was both a development of Picaso’s Cubist aesthetic and also an ‘opening up’ of the previously unified technique of art making into a series of manufacturing operations. Not only did he ‘return to reality’ by including real industrial materials like synthetic Cubism had but also ‘returned’ art to everyday activity by making it possible for the audience to discern how one might go about making ones own DIY relief sculpture from bits of tin sheeting, wooden laminates, rods and bolts. This explains an important sense in which a “systematic means of expression” could lead to those “universally comprehensible” results – as though it were an IKEA flat pack wardrobe complete with multi-lingual instruction book and a set of Allen keys.

Of equal significance for us in this early period is Gabo’s “Kinetic Sculpture” of 1920. Through its rapid oscillations, a vertical wire generates the image of a ‘standing wave’, a perceived physical space yet one without physical mass or solid boundary. At once this work was able to demonstrate not only the dependence of physical form on structure, time and motion, but also its construction as an intangible image in the mind of the observer. Yet Gabo pulled back from the further deployment of electronics, giving his reasons in terms of his fear of “killing through mechanical parts the pure sculptural content” [3]. Unlike the open construction of Tatlin’s reliefs, Gabo could not see how you could open up the construction of things like electric motors, coils and capacitors and still meet the aims of an art based on the visual knowledge of physical forces. A bunch of electrical parts soldered together just did not express anything. It was the first recorded instance of what would later become known as the Black Box Syndrome.

PROGRAMMING BEFORE COMPUTERS

After the Second World War, Constructivist refugees such as Gabo who had fled to England began to exert an influence. It began in 1948 when Victor Pasmore, a successful figurative painter, shocked his patrons by announcing his complete conversion to abstraction. Later in 1967 he wrote of this need to search for a new artistic premise “…concentrating on the nature of objects and processes as ‘things in themselves’ whether they be a sheet of paper, a blot of colour, the mark of a tool, the movement of the hand or the motion of a machine” [4]. By 1951 Pasmore had been joined by artists such as Kenneth and Mary Martin, Adrian Heath and a young ex-student of his called Anthony Hill. It was during this search for a new direction and identity that the young Hill emerged as the chief theorist of the group and started corresponding with three very different influences – the Swiss Concrete artist Max Bill, the American Structuralist Charles Biederman and the spiritual father of conceptualism Marcel Duchamp.

Anthony Hill became drawn to the mathematical work of the Swiss Concrete artists Max Bill and Richard Lohse. Their use of mathematics had moved away from the metrical relationships and geometrical proportions of the pre-war period to a level that was no longer tied to the visual world, "The mathematical approach in contemporary art is not mathematics in itself… It is primarily a use of processes of logical thought towards the plastic of rhythms and relationships" [5]. By taking a definition of mathematics as the "theoretical phenomenology of structure", Hill sought to find a new place for an abstract formal language in art by fusing it into the structural process of creative thought itself.

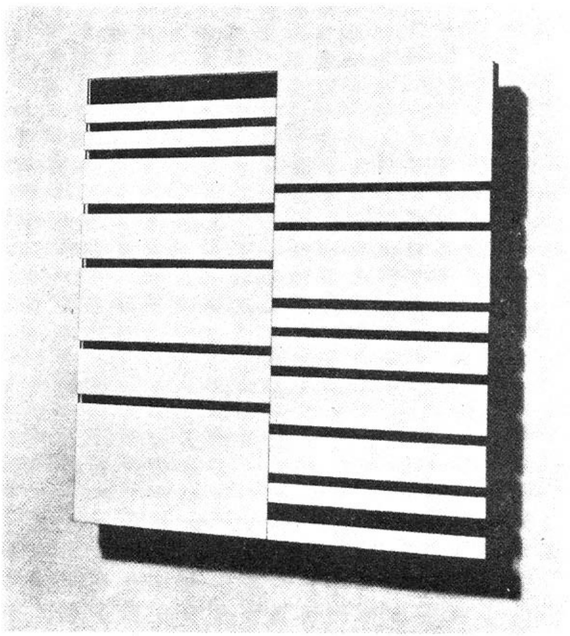

Fig. 1. Anthony Hill, *Prime Rhythms (Constructional Relief).* Perspex and vinyl sheet, 1958-60. (Coll. Adrian Heath, Clio Heath)

In "Prime Rhythms", a low monochrome relief constructed in 1958, Hill had moved towards mathematical 'themes' [Fig 1]. By 'theme', Hill was referring not to the subject of the work but to its starting point at the level of formative structural processes. In this particular work, Hill took all the prime numbers less than one hundred as his "thematic idea" and used them in a succession of what he termed "structural modifications" [6]. This consisted of operations such as throwing out all the even numbers, selecting only consecutive primes and then a whole myriad of systematic procedures based on "distribution, deviation and density ratios, equalities and inequalities". These were always derived with reference to the visual properties of the relief such as the use of planar intervals to embed the sequence in the form of two sets of horizontal bands. Hill was at pains to point out that the work was not about the prime numbers as such. It was simply about what you saw when you looked at the relief, a particular visual rhythm, prime numbers forming the "idea in the work as opposed to the idea of the work". As to the significance of the procedures that he applied to this idea, “Certainly other procedures could have been found to achieve the same sort of end, but the satisfaction of the one chosen lies for me in the fact that it had to be worked on and did not involve chance or ‘aesthetic trial and error’ at every level, nor did it carry with it some notion of finite ideal order”.

At each stage in the development of his relief sculptures, aesthetic judgements were allowed to favour the direction taken. It was not simply that Hill chose the most attractive option resulting from a set of mathematical permutations, but that he adjusted the perceptual properties of the work with reference to mathematical ideas in order to achieve a bodily perception of their spatial structure. His works were not like the result of running a program – not even an interactive program that relies on being steered. Nor were they like the visualisation of a program through its decomposition into a series of discrete graphic elements like an elaborate flow chart. They were more the result of a mathematical logic or ‘thematic structure’ being articulated or ‘worked on’ by applying the varied refractions of different visual or sensory logics.

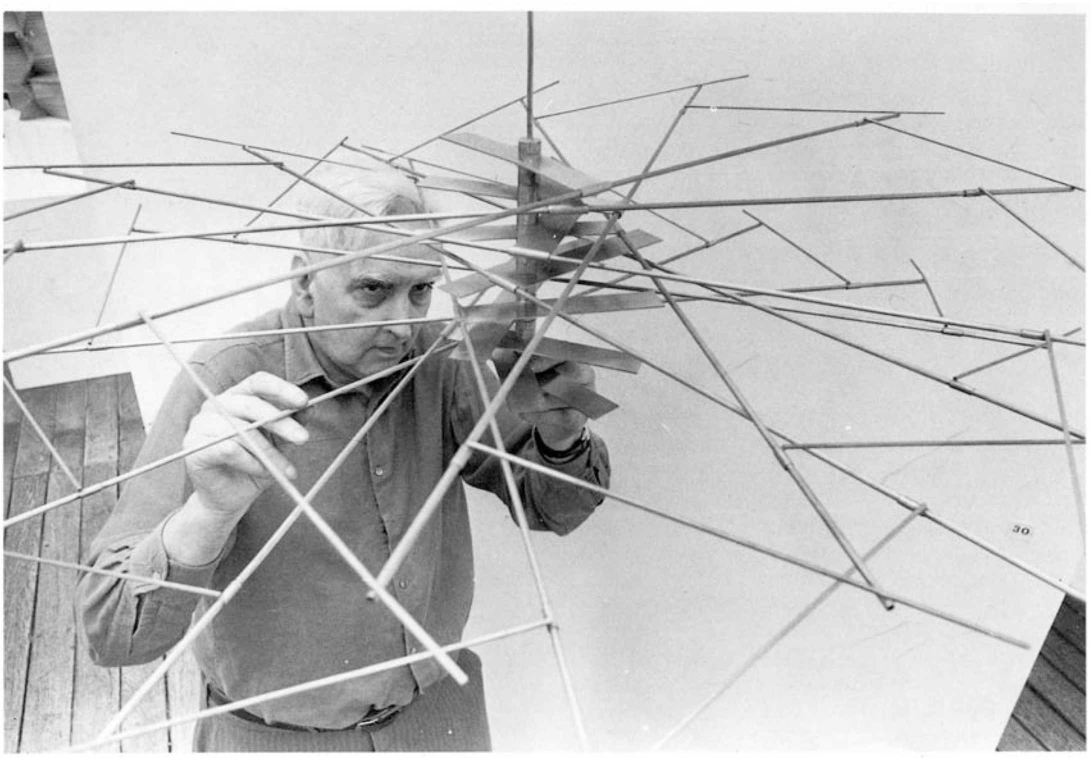

Fig. 2. Kenneth Martin with *Screw Mobile*, 1967. Courtesy Annely Juda Fine Art, London. Copyright the Estate of Kenneth Martin.

It is worth comparing Hill with the practices of his contemporary Kenneth Martin. Whereas Hill started with the theoretical structures of maths, Martin started with movement. During the fifties Martin started to produce a series of “Screw Mobiles” and “Transformables” which were made by applying sequences of transformations to simple metal objects - typically bars, rings and rods [Fig 2]. The resulting sculptures exhibited the spatial displacements he applied by shifting and rotating them, twisting, expanding and contracting them in the form of a progressive series. Rings and bars might first be positioned in such a way that their relationship defined a set of possible actions or measured intervals. Sometimes the movements they defined could be described and replaced by the shape of a parabolic band or a cylindrical extrusion. The effect of forces like gravity to roll or oscillate objects when suspended was noted. These domains of movement were repeatedly exercised, transcribed, ordered by number sequences, transformed into shapes and then re-examined for the next stage of development.

Martin tried to structure the creative process itself by recasting each stage as one of a series of rhythmic changes. In this sense his approach was more general than that of Hill's - "To be interested in the kinetic is to be consciously interested in sensation as such, for not only is form-making a corollary of movement, but so are sensation and feeling" [7]. It was as though he was trying to choreograph, as they happened, all the shifts and unfoldings that his mind, body and senses went through over the course of a creative enterprise. For Martin the kinetic experience was in the practice itself and he was therefore able to express movement without having to engineer actual movement, thus removing the necessity for any of Gabo's hated 'mechanical parts'. Although he described his analogue methods as 'programmed' transformations, this form of programming would be as difficult for us to appreciate today as if you had to create a computer program not by writing a highly restricted text but through all the actions of mixing, kneading and rolling the dough for a perfect pastry crust. They were programmed in the sense that "…a logic and a counter-logic are set in operation and the results are accepted" as his wife Mary Martin stated [8] [Fig. 3].

Fig. 3. Mary Martin working on maquettes for *Tidal Movements*, 1960
Courtesy Annely Juda Fine Art, London. Copyright the Estate of Mary Martin.

SYSTEMS FROM ANOTHER PLANET

In 1969 Jeffrey Steele founded the Systems group, including John Ernest, Gillian Wise, Malcolm Hughes, Jean Spencer, Michael Kidner and several others. As they took advantage of the techniques provided by post war mathematics and cybernetics, the intimate connection between their generative systems and the works they produced started to become strained. The different levels of materiality that could exist as a single 'system' began to multiply – knowledge, documentation, feeling, perception - it began to tax the Systems artists as to how they could tie together all these different bodies. The question of whether it was important that the 'underlying system' should be apparent in the final work, and in what sense the 'system' could realistically be called the content of the work began to be asked more and more. One way to prevent the work splitting between a conceptual procedure and a perceptual result was to follow what Kenneth Martin had advised in 1964 that "…construction must start with the simplest and most practical means and to avoid confusion aim at the simplest results" [9]. But as the resources of formal logic became more and more sophisticated and prolific there was mounting pressure to move beyond the processing abilities that the human mind could keep up with.

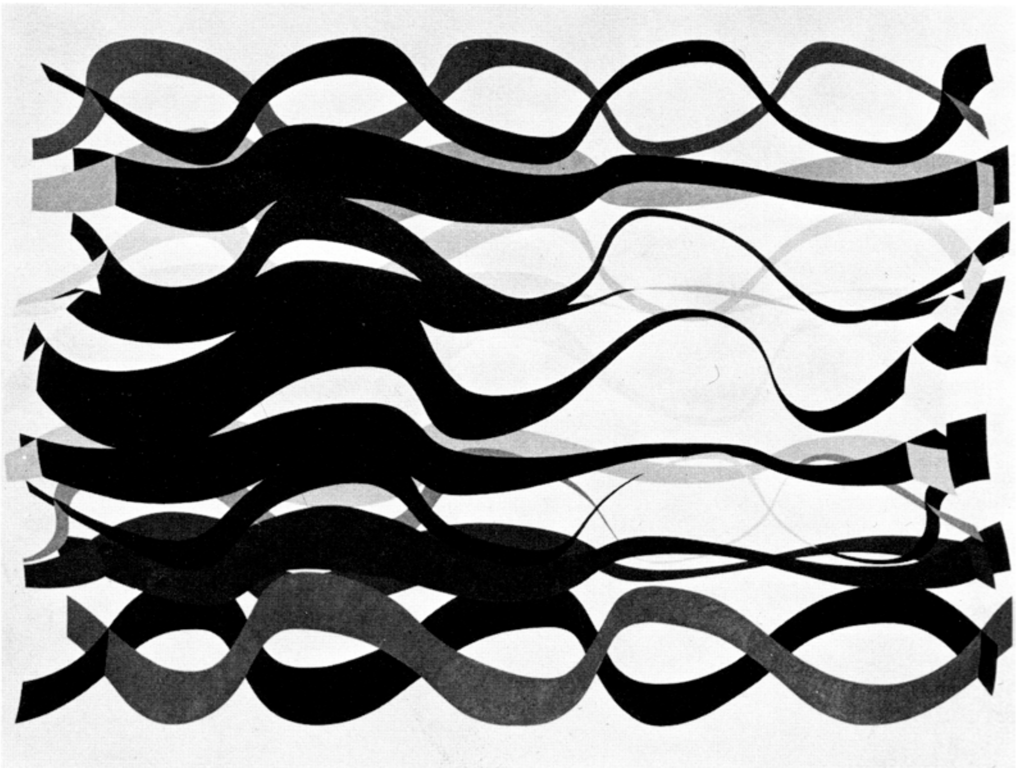

Fig. 4. Jeffrey Steele, *Medusa*. Oil on canvas, 914 x 1219 mm, 1969. Courtesy the artist.

Some artists like Steele now pushed ahead in the direction of what we would now recognise as a fully materialist 'generative' art practice, including a renewed acceptance of the irrational [Fig. 4]. "To grasp the full extent and power of systems entails giving as much attention to chance, deranged, anarchic systems as to those with a more manifest regard for law and order" [10]. By examining the kinds of information that these systems could generate they might find a way to test or 'validate' them, not for their truth value or meaning but for their productive capacities, as engines of chaotically fertile invention. Systems could now be freed to move beyond human categories of order and disorder. To try to constrain them to the production of comfortable human meaning would be as pointless as "…trying to communicate by signals with an intelligence on another planet with whom we have no common experience and therefore nothing to communicate about" [11].

There arose a danger that the system would disconnect from the artist altogether, becoming a completely autonomous machine. An overview of the situation was provided by Kenneth Martin in 1968 when he divided systematic work into three types [12]. Firstly there was the completely predefined system which once set in motion could generate work independently of any further artistic input. Secondly there was a system that may be initially predefined but constantly altered through feedback, bringing into contact with other systems, etc – the 'program' is thereby written in conjunction with the work itself. Finally there is the system which builds up from a primary act without any previous planning, like a self propelled aggregation of logical steps – the writing of the program is indistinguishable from the practice itself. For Martin, the more the system is predetermined like the first example, the more problematic things become, not just because of the marginalisation of the artist but because of the systems distance from the specificity of any given situation – "…it is difficult to predetermine a system for forms whose properties one is in the way of discovering". It is more a question of how one can be expected to work with a form of logic without the direct motivation and stimulus of the object of that logic – such as its material consequences or its physical or historical situation. One is inventing a process, not just a program. It is this awareness of trying to retain a purchase on formal systems as the computer made them more and more autonomous that would become an increasingly pressing concern.

PROGRAM, BE PROGRAMMED OR FADE AWAY

Despite the mounting complexity of their 'programs' and the opportunities for practical implementation afforded by computer programming, there are several reasons why the reticence of Systems artists to engage with computing might have made sense. To begin with, formal programming languages made it difficult to mix together very different kinds of logic. Everything had to be reduced and encoded into the same terms. Constructivists were by this time used to switching freely between different number systems, geometries, topologies and the plastic possibilities of the picture plane. To have to find a way to translate an act as fundamental as a shift in ones cognitive mode into Cartesian coordinates and conditional statements sounded pedestrian.

The Constructivists were used to identifying their systems with the concrete actions, matter and sensations that had inspired them. Artist Jean Spencer had stated that "…a system cannot be taken out of the context it originated in" [13]. The making of a constructed relief was derived from structuring processes like moulding, resistance, mass, occlusion and the acting of rational operations upon them. The inclusion of physical and analogue systems gave them a richer perspective than one restricted to formal logic. When objects are defined inside the computer one must approach their potentialities from some point of interest in order to avoid becoming lost in them, as

Kenneth Martin had hinted. If one was modelling the properties of metal rods and rings in a computer simulation one could model any properties one liked but a decision must be made. And once that decision is made then the rods and rings themselves tend to be lost as sources of unknown procedural insight. What then, the Constructivists might have asked, can take their place?

Some artists did try to use techniques such as interactive sculpture to make computer programming part of a wider system of human behaviour and cognition with some success such as Edward Ihnatowicz's famous "Senster" sculpture of 1970. But the more complicated these constructions became with all their logical, electronic and mechanical components, the more they began to suffer from Gabo's 'Black Box' problem of sculptural awkwardness and procedural inscrutability. These sculptures did not communicate an underlying coded 'theme' and did not offer the audience a completely 'open' construction, instead moving towards explicating themselves as effects.

It should have been possible to put software into the mix of a wider practice of systematic art. Yet computer software is a jealous mistress. From the beginning of the eighties, the development of interactive applications software replaced all manual operations with the menu lists, parameters sliders and icons of the modern windowing environment [14]. By the middle of the eighties computer based art would largely be produced on desktop boxes and consumed through desktop boxes. For artists who avoided pre-packaged applications and took on the challenge of computer programming itself, the increasing dominance of structured programming styles threatened to narrow their practice due to the kind of expertise required – having to relate to each proprietary component of a system through its technical specification rather than its technical potential. The Systems artists couldn't use the intimate physical and perceptual qualities they were used to as a basis for their investigations in programming languages and this lack of bearings threatened to turn the unfettered formal power of computer logic into a blizzard of arbitrarily designed information ordered only by contingent commercial agendas. Under these conditions it was hard for many artists to find much enthusiasm for a visual space that was increasingly colonised by unsympathetic interests.

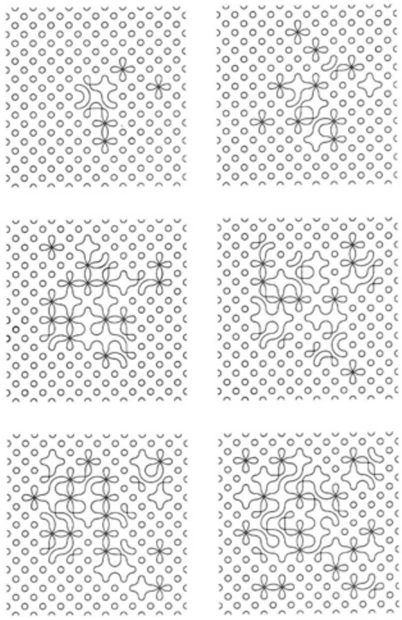

Fig. 5. Paul Brown, *Lifemods Series1*. 8 computer assisted drawings, ink on card, 1978-79.

Yet some artists were willing to throw themselves into the maelstrom and take on the strictures of the code. In 1978 the Computer Artists based at Malcolm Hughes Experimental and Electronic Art Department at the Slade School of Art published a catalogue of their recent graphics and sound work with the help of Jean Spencer. "Working Information" featured pieces including Chris Briscoe's generative audio, Darryl Viner's animations and plotted graphics by Peter Beyls [15]. The following year there was a student show "EXP at P.C.L." featuring Paul Brown's computer simulations, Steve Bell's interactive graphics and perceptual studies by Dominic Boreham [16]. The most striking feature was the sheer quantity of graphics and audio that was now being produced by computers, something approaching a continuous torrent of sensory data [Fig. 5].

The increasing continuity of the visual surface now possible in computer graphics made it very difficult for it to retain an explicable connection to the program that generated it. There was a kind of numerical image that flourished in SIGGRAPH Art Shows, IMAGINA conferences and glossy coffee table books like 'The Beauty of Fractals' [17]. This image was like the result of collections of different systematic components yet without an actual system itself – being guided instead by executive opportunism, scientific curiosity, engineering prowess and artistic confusion.

Unlike the Systems Artists, rising Conceptual 'systems' artists like Sol Le Witt and Adrian Piper were more openly critical and oppositional, self-reflexive and increasingly ironic. English Constructivists like Roy Ascott and Stephen Willats that were closer to this conceptual approach and less resolutely visual artists survived better, able to adapt their practice to a wider range of technological and discursive contexts. So too did the Computer Artists, who eventually found a practical outlet that could support their hunger for complexity and scale in the form of television production and other "creative industries” [18]. But for the Systems Constructivists there was nowhere left for them to go.

THE SYSTEM OF SOFTWARE

It was the internet that finally turned the computer into a mass medium and brought with it a new technology, a new audience and a new system – the network. Everyone now has to use software to work, to communicate, to spend their leisure time and so programming can become the subject of art as well as its technology. By the end of the nineties this shift was finally recognised in the emergence of “Software Art” – that the formation of subjectivity and social relations were now within the domain of software encoded exchanges [19]. For these reasons Software Art has seen itself within the tradition of Media Art or Conceptual Art rather than the progeny of Constructivism.

But this mass implementation of computing has also brought mass normalisation. By the end of the twentieth century the expectations of computer users had settled into universally accepted strictures of browser navigation, digital rights management, search engines and the standardisation of Object Orientated functionality [20]. To oppose these edifices much faith has been put in practices like Free and Open Source Software (FLOSS), yet without a creative agenda its main achievement to date has been free imitations of Microsoft applications. In the art world the dominant discourse of Conceptualism is also ill equipped to deal with the demands of software culture. The success of software and Software Art is dependent on the actualised contingencies of engaging with it directly, yet critics regularly evaluate software based art by reading publicity mailouts. Like conceptualism in art, government sponsored agencies and corporations use code to construct social reality in isolation from the full implications of that reality. And the means by which that code is itself constructed through the discipline of software engineering is also guided by standards designed to achieve industrial and commercial efficiency.

Systems were about process, computer programming was about control. Software is about fitting in, observing standards, listening to the message queue, relinquishing control over context. Under these conditions, where does the artist’s ‘system’ end and software begin? The proliferation of materialities – codes, interfaces, platforms and output devices creates confusion about where the focus of our attention should lie and how to keep the construction ‘open’ under such conditions. Yet it is in the tracing of the passages and leaks between these levels that the art of the system now lies.

CONCLUSIONS

Systems Artists were the last programmers before the digital computer made that practice synonymous with itself. Through their intimate proximity to the many varieties of order they absorbed the programmatic into the very core of their thought processes until the logic of series, modularity and permutation became an indistinguishable part of their perceptions and sensibilities. But for an audience, the work could be as inscrutable as the most introspective of subjective art, as though each work a private programming language, emphatic yet utterly remote, produced by ‘an intelligence on another planet’. Without the ability to share and disseminate their techniques more widely and without an external context for their work that was familiar to their audience, Systems artists diversification of the ‘programmatic’ turned in on itself. It became a hermetic practice - a faint reminder of a kind of deliberate psychic objectification that has perhaps not been seen since the alchemists of the pre Enlightenment era aligned their own subjective inflections with the drama of chemical experiments.

Constructivists did retain a belief in the power of aesthetic and sensory perception to make a significant contribution to knowledge beyond the theoretical or cognitive. ‘Precise feeling’ can tackle problems that reason cannot formulate [21]. And Systems artists in particular integrated formal language into creative thought to the degree at which an artist can reclaim the rational as part of a more heterogeneous intuitive practice. There is now a fresh desire amongst artists to open up the wider expressive potential of formal logic and abstract machines beyond the atrophied state of software, to make code directly perceptible, embodied, ‘affective’. Can a ‘systematic means of expression’ bring the operations of modern software within the human range that the Systems artists enjoyed yet retain a relevance to the complexities of the networked society? Can we use the wider range of expressive means that are now available in digital media to get such a practice out of an artists’ head? It is at this current point in history that the problem of how discursive categories arise from computation, of how ‘conceptual structures’ and ‘mathematical themes’ might be realised in a form that has a relevance for the uninitiated might become more tractable.

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Illustrations

1. Anthony Hill, *Prime Rhythms (Constructional Relief)*. Perspex and vinyl sheet, 1958-60. (Coll. Adrian Heath, Clio Heath)
2. **Mary Martin working on maquettes for "Tidal Movements", 1960. Courtesy Annely Juda Fine Art, London. Copyright the Estate of Mary Martin.**
3. **Kenneth Martin with *Screw Mobile*, 1967. Courtesy Annely Juda Fine Art, London. Copyright the Estate of Kenneth Martin.**
4. **Jeffrey Steele, *Medusa*. Oil on canvas, 914 x 1219 mm, 1969. Courtesy the artist.**
5. Paul Brown, *Lifemods Series1*. 8 computer assisted drawings, ink on card, 1978-79.

IMPERMANENT ART- THE ESSENCE OF BEAUTY IN IMPERFECTION

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The notion of beauty as imperfection has become more significant over the last century. Directly related to advances in technology, it is the capabilities that technologies provide in making it possible to get closer to the ideal, perfect form that have challenged what constitutes beauty. Focusing on Interactive art, the idea that beauty can be found in an impermanent space shall be explored. What is it that moves us about a rare moment that will not last?

BEAUTY, PERFECTION AND THE IDEAL

When we say that something is perfect we mean that it is 'complete'. Beauty is measured by its completeness. It has met the limits of its criteria and this also suggests that there are in fact universal 'rules' that art must follow in order for the judgement of beauty to be made. This judgement of beauty is an *objective* one. The birth of geometry enabled the Greek's to measure aesthetic value based on geometrical study which led to the discovery of 'Golden section'. This was a mathematical solution that determined the perfect proportion.

Throughout history the origins of beauty have been debated. For Plato, the universal idea of beauty had an objective existence. In Plato's Republic, art can only come close to beauty while attempting to copy form *perfectly*. Beauty is a question of harmony and proportion. Perfect proportions cannot be realised in the ideal. We can conceptualise a perfect circle but it is impossible to draw one. As a result, beauty of the mind is more superior and leads to 'the beauty itself': the concept of universal beauty. For Plato, Beauty holds an a priori existence.

Kantian forms of intuition should also be acknowledged. In making a distinction between the object and the representation of the object, attention is drawn to the notion that beauty resides in the relationship between the viewer and the object. Therefore, the judgement of beauty is based on how this representation makes us feel. Not whether the representation of the object provides empirical knowledge (much like platonic analysis) but whether it provides an intuitive experience of it.

In order to make a judgement of pure beauty, the viewer has to take a *disinterested* view, one that is non-conceptual.

> The notion of an aesthetic judgement made without moral or sensory concepts has been heavily contested, as it is impossible to conceive of something outside of conceptualisation or imagine that the pleasure we derive from something can be present independently of trying to comprehend it. Allison [1]

Refuting the Platonic and classical position, Kant contends that whilst judgements of pure beauty are not grounded in any definite concepts, judgements of perfection have a concept of the object's ideal condition in mind. Perfection is quite different to pure beauty. Kant instead defines perfection as adherent or dependent beauty. It is a purpose-related beauty, adhering to sensory charm. It is a beauty of *purposive* nature [6], a more conceivable definition.

We can chose to take from this that regardless of whether beauty holds an a priori existence or one that is a human construct, perfection can be described as being related to form.

In contemporary art, we now have the technology to produce art that has the potential to interpret form perfectly. Photography has enabled us to produce exact copies of natural form and photo manipulation software allows us to illustrate 'perfect' beauty in a much more heightened manner. This can be achieved through altering the composition and manipulating human form to create the 'ideal'.

IMPERFECT BEAUTY

Although new technology can create such perfection and a heightened sense of beauty, we seem to be regressing in the progress of absolute perfection and producing art that is ultimately and quite intentionally *imperfect*. This is not a regression in technology as technology continually advances; it is instead advancing in order to undo the portrayal of perfection. The demand for this type of aesthetic suggests that in fact beauty can be found in imperfection. For example, it is commonplace nowadays to see computer made art that has grunge filters applied in order to give the appearance of an aged object.

One explanation for an imperfect aesthetic could be due to the appeal of that which is *authentic,* art that is truer to life and not an ideal form. A large proportion of contemporary art is created for the purpose of reproduction. These arts come in such forms as: photography, film, print and computer art. As there are no authentic versions, they are described as arts that are designed to make multiple copies.

Walter Benjamin argues that an authentic piece of artwork holds a certain aura [7]. He defines aura as something that has a presence in time and space. Its unique existence determines its history. This includes any changes the artwork may have gone through, such as decay or changes in ownership. Whilst the significance of an object changes with tradition, its uniqueness is preserved. The presence/uniqueness of the original denotes its authenticity and thus becomes an object of aura.

Benjamin also contends that the development in technology that has led to mass reproduction has resulted in a decay of aura. A technically (not manually) reproduced piece of work detaches the reproduced object from the domain of tradition. When the historical testimony is threatened, the authority of the object is affected, resulting in the loss of aura. A separation has occurred between the original and the mechanically reproduced version. The notion of aura, therefore, has a possible effect on the judgement of beauty. It could be said that a loss of aura has resulted in the *referencing* of authenticity in aesthetics, in the form of imperfection.

The idea of aura implies an authenticity. However, there is no authenticity without its destruction in mechanical reproduction. As recognised by Harmen, the idea of authenticity only emerges when it is threatened [9].

Only through mechanical reproduction can authenticity be referenced and if aura only exists with the invention of mass reproduction, this may explain a need for imperfection in potentially perfect objects. For example, a print that has been misprinted (what should in theory be a perfect stroke is mottled or has bled) gives a viewer a sense of its history and its producer; even though many other copies exist that have the same misprint. Advances in technology have a direct link to the appeal of imperfection.

This could be described as an evolutionary change in aesthetic judgement due to technological development. The changes that are evident in aesthetics are subversive to the destruction in aura that is brought about by mass reproduction. There is evidence in mass-reproduced art that challenges Benjamin and Plato by suggesting that perception of beauty is not relevant to space and time and does not require a need for perfection. So, art can be beautiful because it is incomplete. As we shall now discuss, this does not just apply to form but in the experience of viewing.

Improvisational art both satisfies the need for authenticity and challenges the significance of aura in art in terms of its relevance to space and time. To illustrate this point we shall look at the improvisational process of jazz, which seems to sit outside of what Benjamin constitutes as art.

In his discussion of mechanical reproduction, Benjamin identifies two categories of art. One category is defined as: work of art designed for reproducibility and the other as: pre-reproduction artwork. It is noted by Coulthard that jazz cannot be described as 'work of art designed for reproducibility' because it existed decades before the invention of recording [8]. However it also cannot be described as pre-production artwork because prior to the first recordings jazz was rarely written down and therefore does not have a historical existence. Its existence is in the transitory space of performance and this suggests that jazz lacks the physical place of origin that is necessary for the possession of aura.

Both written scores of jazz and recorded jazz containing head arrangements and chord progression provide a framework for spontaneity and improvisation. Jazz is a good example of artwork that is not bound to space and time yet has an aesthetic process in which beauty can be found. It could be described as impermanent art of which its beauty can be found in its imperfection. We could say that the appeal of imperfection is that it represents the changing nature that is true to life.

The Buddhist and Tao philosophy of Wabi Sabi also seeks to find beauty in imperfection. It is an appreciation for things found in a constant state of flux. It seeks beauty in the truths of the natural world, these truths being that everything in the natural world is in perpetual movement- impermanent and ever changing. This Japanese aesthetic is most commonly found in things that are in decay, and death. As outlined by Juniper:

> Rooted firmly in Zen thought, Wabi Sabi art uses the evanescence of life to convey the sense of melancholic beauty that such an understanding brings.[5]

Wabi Sabi art could be described as a more accurate interpretation of the world contrary to technological developments that practice the art of perfection. Nothing in reality is perfect or completely still, this idea only exists conceptually.

On the one hand we could say that Wabi Sabi completely supports Benjamin's notion of a loss of aura in mechanical reproduction. The nature of arts that are created for the purpose of reproduction means that art, in theory, never goes through the process of change. It needn't age nor decay and as an object of reproduction has lost its presence in time and space.

However, when considering more contemporary art forms which also encompass mass reproduction, such as digital art, we can see how imperfection and impermanence in art are represented. The Wabi Sabi aesthetics could also be found in arts that neither strive for perfection nor have a fixed position in time and space. These are improvisation art and as we shall discuss, interactive art.

BEAUTY IN INTERACTION AND ALTERNATIVE SPACES

It could be argued that art created for mass reproduction has progressed further in favour of a more subjective experience, subverting the idea of a mass culture and embracing the idea of impermanence. The subversion being referred to here is the art of imperfection, in the form of impermanence, in favour of a less objective view. The art we are focusing on here is Interactive Art, which provides a subjective experience in which the beauty is found in the "self- reflexive relationship between oneself and the work of art". Ascott [1]

Interactive Arts that are technically reproducible can also provide this kind of subjective experience based on impermanence. Cybernetics is a scientific discipline that studies the process of communication, particularly the *control* of communication. The premise being that to make something happen, actions must be taken and to achieve an outcome requires some form of feedback.

Cybernetics operates using constraints, much like the theory of evolution. In evolution, natural selection happens by eliminating what does not fit as opposed to creating selection.

Although it started out as a science, Cybernetics entered the art world in the 1960 with such exhibitions as 'this is tomorrow' and Cybernetics and Serendipity. One of the first people to create work of this nature and give cybernetics an artistic context was Pask. At the Cybernetics and Serendipity exhibition in 1968, Pask displayed 'The Colloquy of Mobiles', a computer based system consisting of 5 mobiles. These were machines that could interact with people and each other. He referred to the installation as an aesthetically potent environments designed to stimulate pleasurable interactions [2].

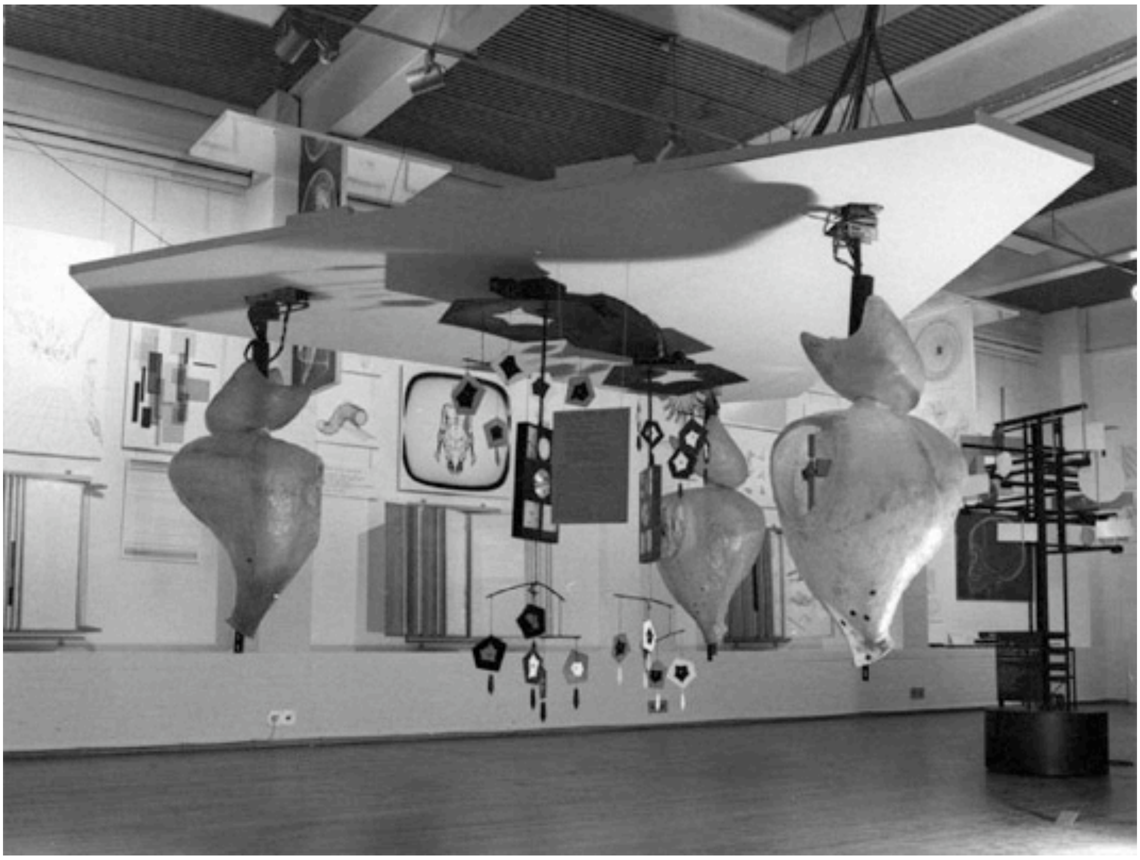

Fig. 1. The Colloquy of Mobiles

Pask's ideas of self-organised systems influenced later developments in digital art in the early 1970s by Myron Krueger. His concept of "responsive environments" was used to create artworks that responded to the movement and gesture of the viewer [10]. He used floors with sensors and video cameras.

"Roots", (see fig. 2) created by Roman Kirschner demonstrates how the theory behind Cybernetics is used today. Inspired by Pask's work, Roots is a fluid tank that grows iron crystals. Electrical wires are pulsed through branch like wires, encouraging the crystals to grow. The growth changes the flow of the current, which in turn manipulates the growth. The results of this exchange produce an organic display and an evanescent experience.

Fig. 2. Roots

In the context of imperfect impermanent art, cybernetics shares an integral part- interaction and feedback. For impermanent art to 'work' the process of interaction has to take place, whether that is between the art and the viewer, the art and its environment or the art and itself. Interactive Arts are all reproducible in the sense that they are built on a transferable model, which is intrinsic but separable from the artistic experience.

What is it that gives this type of impermanent art the aesthetic of beauty?

BEAUTY IN WONDER

It is possible that the emotional response of wonder is present in the beauty of impermanence. Descartes spoke of Wonder as the first of 6 primitive passions, the others being, love, hate, joy, sadness and desire. The emotion of wonder is a passion of the soul, a mental state that arises as a result of brain activity. It produces a feeling of surprise that is present when observing something that it rare and extraordinary [3].

Wonder is the first passion for Descartes because it is a pleasure that comes before all others. To wonder at something that is rare or extraordinary moves us to learn more about it. Perhaps impermanent art is connected to the aesthetics of rare experiences and wonder is at play in producing moments of beauty.

In his analysis of wonder and the sublime, Fisher argues that wonder has been neglected as a category of the aesthetics of rare experiences [4].

The appeal of wonder along with ‘newness’ is not the inability to understand the thing in question but the idea that it is something we don’t quite *get.* It is a stimulus to cognition. It is the process of thoughts or ‘steps of thoughts’ that are the experience of wonder. The delight comes with the anticipation of the results and an intellectual effort to make sense of something new. Wonder leads to intelligibility or partial intelligibility. In this sense we can see how cybernetics continues to be developed, it is not necessarily the outcome that is important but the process involved in getting there via feedback.

Francis Bacon referred to wonder as ‘broken’ knowledge’ and suggested that it acted as the impulse to repair or add to the imperfect or incomplete body of knowledge. Socrates first acknowledged this impulse in the platonic dialogue Theaetetus, as the beginning of philosophy. Later, Descartes restated this as “human existence begins in wonder.” [4.1]

The experience of wonder is a symptom of human intellect as explained in Fisher’s example of the beauty of rainbows. The experience of seeing a rainbow relies on three elements, light, the observer and water. The scientific principle is that light passes through water droplets where it refracts then reflects off the back of the droplet and refracts again to reach the observer to display the different colours that make up light. These events are visible only when the observer is at the correct angle, 42 degrees between the sun and the water droplet. As it is dependent on these three features, the rainbow can be described as a rare experience and the very specific requirements such as the angle of the observer, makes the experience unique and subjective to each observer. This is when we experience a moment of wonder. A rainbow is always rare, impermanent and therefore evokes feelings of surprise and the unexpected.

One vital question about the aesthetics of wonder in art is that if wonder intrinsically requires newness and unexpectedness, do these types of artwork become stale and uninteresting once an explanation has been provided for them? For Fisher this is true of the aesthetics of shock and the sublime. The neglect he talks about of wonder over the sublime has led in to dissatisfaction in post-modern art. The shock factor becomes quickly tiresome because it doesn’t appeal to our drive for intelligibility. Wonder does not concern the value of shock, it is only odd or obscure things that are considered ‘new’. Fisher suggests that art that isolates recognition is also ‘new’ and this provokes the thought process of wonder. As memory, a basis for recognition, allows us to recognise details of our own traditions and supply us with instant answers. It does not lead us to intelligibility.

Applying this theory to the work of Olafur Eliasson, we can see how the process of explanation creates wonder. Eliasson’s works deal with the politics of enchantment; they are evanescent and impermanent experiences. In his installation entitled *beauty* (see fig. 3) installed at The Museum of Contemporary Art, Los Angeles 2003 Eliasson constructed a wall of mist under a spotlight in a dark room. When the viewer moves around the room they can find a rainbow in the mist.

What is interesting about this piece is that the aesthetic has been partially demystified by the fact that he doesn’t hide the workings of the installation. We see all the apparatus used in the piece, the spotlight, and the machine that produces the mist. The aspect of wonder is not lost in this; the exposure aids and prolongs the experience of wonder. The process of explanation consists of both knowledge and error. Throughout history we have been given partially successful explanations about how a rainbow works, it remains mystifying because light itself has no explanation. We have both a wave and a particle theory of light. We use a mixture of false components of knowledge and 'local intelligibility' knowledge we consider certain based on our own cultural traditions, in a moment of wonder. It is human nature that we proceed with trial and error, this is one of the elements of the poetics of thought. We find pleasure in the process of trying to find answers.

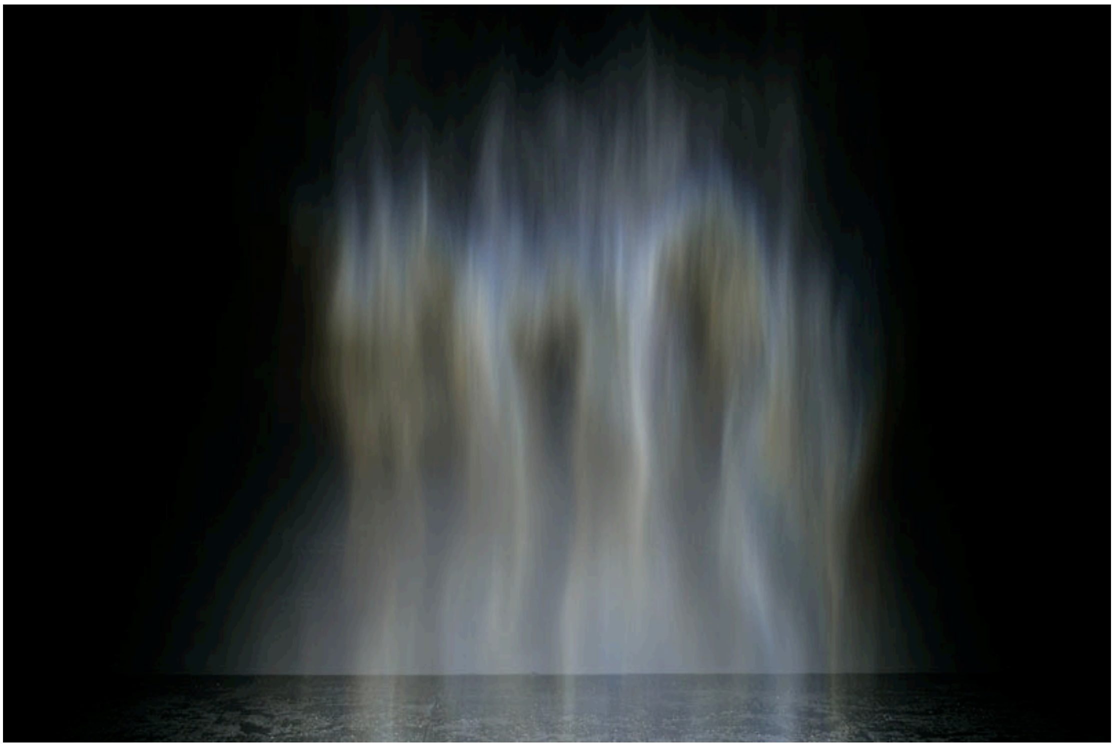

Fig 3. beauty

IMPERMANENT ART

Currently I am developing a piece of work that was originally shown at the University of Brighton, 2009 in an exhibition entitled 'Thinking Machines'. The aim of this piece was to encapsulate the essence of impermanent art. When entering the space, the viewer is presented with a sculpture in the form of a plant and a watering can. You are encouraged to water the plants leaves. Upon doing so, the plant responds by illuminating the areas that has just been watered and the corresponding flowers. As the light fades in, the plant also produces sound. Each light works independently and only lasts for a few seconds. Any light can be activated at anytime and simultaneously allowing the user to produce personalised ever-changing aesthetic. Imperfect in form, it represents something that is continuously evolving, life.

The redevelopment of this piece will transform it into an outdoor space where it will react to natural elements, playfully demonstrating interaction that is beyond our intervention. The rain continues to excite and surprise us even though it may sometimes not be welcome. It can patter, descend in the finest mist and pour. The sculpture will both compliment and enhance the spontaneous nature of the rain.

When the idea of perfection can be achieved i.e. within the advances of technology, we find that there is an aesthetic need for imperfection. Beauty can then be found in something that is imperfect. Retrospective of Benjamin's analysis, mass reproduction preserves art replacing its presence in time and space with stillness and permanence and subsequently losing its aura. A look at improvisational and interactive art shows that modern technology can be both reproducible and hold a sense of authenticity. Using technology in a particular way provides uniqueness. Art becomes a tool, a machine, in which progression can occur and creativity and individuality can flourish. The pursuit of beauty in imperfection is the pursuit of beauty in impermanent, a concept that is associated with nature. The perception of beauty in nature and beauty in art are 'interdependent'.

t could also be said that beauty is not inherent in the object, or indeed in nature itself, it comes from the relationship we have with the art, as impermanent beings ourselves. In Impermanent art the beauty resides in an alternative space to the tradition idea of beauty. It isn't bound to an object as the object being observed transforms producing dynamic art.

This is true of wonder, the emotion that encourages our drive to gain knowledge and creates feelings of beauty and awe.

Technological progress is significant in aesthetical trends. This progress does two important things that lead to the appeal of impermanent art, especially within digital art. Firstly, technological progress leads to repetition in art. Secondly and subsequently, new technologies facilitate the need for new experience in contrast to the repetition.

> …years or even centuries of intellectual work must already have taken place in a certain direction before there can be a reality that is viewed as ordinary and unexpected. Only this makes possible the rare and privileged moment… Fisher [4.2]

In the development of digital art forms, repetition and familiarity begin to make way for the experience of the rare and imperfect moments found within impermanent art. As we become increasingly knowledgeable about our environment, we look for pleasure in what we don't understand. With impermanent art and the model of a framework, modern art is beginning to accommodate for the 'new' experience of Beauty.

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THE COMPUTER AS A DYNAMIC MEDIUM

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The space represented within the computer screen exists at one remove from physical reality but subsists within its own environment. The computer image is the dynamic result of a process, held in stasis at times but with the potential to be wholly altered without leaving any material record.

INTRODUCTION

Essential to any definition of "Computer Art" is some recognition of the inherent malleability of the virtual space and the computer interface, which makes it difficult to term the computer a "medium". As the artist Lillian Schwartz describes, the computer can be regarded as a polymorph of tools: "an unlimited supply of brushes, colors, textures rules of perspectives and three dimensional geometry."[1] The word "medium" has artistic connotations of surface and material, and also refers to channels of communication.

All previous art media shared the artist's own physical environment to some degree, even film and video which existed physically as footage and tape. Prior to the 20th century, all visual artists operated with physical materials, whether inscribing images on a surface, sculpting objects or capturing the imprint of light on film. Each of these physical media had certain inherent characteristics that conveyed a particular visual quality.

Physical media imposed no restriction on artistic style, but their physical limitations were a factor the artist had to work with – or against – to achieve the desired effect. Moreover, these qualities were irreducible since they were part of the medium's very structure. Such physical characteristics lent each medium its artistic appeal, even in the case of prints, posters and other mass-produced items.

All art media could be classified as surfaces, structures or materials, including transient ones like light, gases and water. Because they share physical space with the artist, these media cannot be manipulated below the level of their constituent parts, nor could their characteristics be manipulated outside a certain range. Even at the extremes, this is true. When IBM used a tunnelling electron microscope to arrange individual carbon 88 atoms into the letters "IBM", they were still operating on the smallest constituent parts of the medium.

The computer is simultaneously tool, interface, surface and material; in this it is quite unlike any previous art medium. The relation of artist to the physical interface is bound up with these characteristics. They also inform other issues which are unique to digital art, such as the difficulties of physically realising computer images, the lack of a digital "original" and the relation of artistic process to computational processes. Because all these questions relate back to the underlying digital structure of all Computer artwork, this may prove to be the computer's signal contribution to the arts.

With respect to its modes of operation, its specific requirements and the skills needed to master it, the computer should qualify as a medium. However, since its digital basis makes it fundamentally different to previous physical media, I believe the term is not strictly correct, if "medium" refers to an artistic or a communications medium. However Edward Lias holds that any environment of the human mind is a medium, in the sense that it can embody human thoughts and instructions. Building on this environmental approach, he suggests:

> The media provide an all-encompassing environment for the mind, just as physical surroundings provide an all-encompassing environment for the body.[2]

In this sense at least, the computer as a whole is a new medium. Yet only in some of its functions could it be seen as a medium for the visual arts; when functioning as a word processor or a spreadsheet the visual aspect is not engaged to any great extent. Lias's definition is too broad for pinning down the specific nature of the computer's status as a material or surface for visual art.

The concept of a sole computer medium is too restricting because it is drawn from the lexicon of traditional art terms. It takes for granted the idea that a physical medium has a range of defining characteristics; for reasons laid out above, the computer's visual characteristics cannot be easily summarised. The space created by computer software and the conceptual operation of the artist's thoughts could be described as a graphical environment in which a range of artistic actions might take place, inspired by J.J. Gibson's concept of environmental perception. Alternatively, the properties of the digital image might qualify as a new *substance* with very different characteristics from any physical material.

Theorist Tim Binkley is dismissive of the notion that the computer functions as a "medium". He considers that computer imagery relates back to existing art media, drawing on different aspects depending on the type of image, even when the content is generated in wholly new ways. He adds "although interactivity epitomizes the unique capabilities of computers, it does not invent a new medium".[3]

Artist Jean-Pierre Hébert frames a similar idea slightly differently: "[In] Computer Art the real medium is software art, the computer is only a mere thing."[4] Robert Mallary developed this point, saying that the computer has a variety of functions as an artistic tool, some extending the hand, others extending the artist's concept. The latter functions – "brain-like" – should be distinguished from the "output instrumentalities" where the image is realised, such as film or on paper. For this reason Mallary did not regard the computer as a medium per se. Rather, he said, "the role of the computer is that of a key cybernetic component in a host medium, art form, or art-generating system."[5]

For Binkley, art-making with a computer involves modifying the symbolic content of the program rather than the physical processes that constitute it: "electrons shuttling through logic gates or magnetic fields billowing over thin layers of iron oxide."[6] The material makes little difference so long as it can store and process the code. In this sense, Binkley denies the possibility that the computer qualifies as a medium in the singular, because its visual effects are not bound to its physical components.

THE COMPUTER AS A META-MEDIUM

William Mitchell considers that each level of the digital image might qualify as a different "medium" in some sense.[7] By this, he means that an image may be operated on at the visual level or at the level of its code; both acts are inherent in its digital structure and each may be regarded as a "medium" in terms of its parameters and operation. Binkley's denial of the computer as a medium does not allow for this possibility, nor for the way that digital images operate in an entirely different "space" to the artist.

It was the first recognised computer artist, Ben Laposky, who realised the nature of the immaterial space he was working with. In the 1950s Laposky was experimenting with an analogue computer – essentially an oscilloscope screen fed by sine waves to achieve specific shapes that Laposky termed 'oscillons' – and he recognised that the space shown on the screen had intriguing non-material properties. Laposky considered the twin factors of movement over time, and the impression of 3D imagery on a 2D surface conveyed "an almost sculptural quality" on the oscillons - "luminescent moving masses ... suspended in space" as he put it. [8]

For these reasons, the computer in art could be what Alan Kay (quoted by Larry Cuba) considers to be a *meta-medium* because of its power to simulate other media. For instance, in Cuba's work as an abstract animator, he programs the computer for his animations but has decided not to use it as a display medium, or employ any form of interactivity for the viewer. His films run as linear sequences on video formats. Thus Cuba works *on* the computer rather than working *in* it. [From my interview with Larry Cuba, July 2001, Los Angeles]

Craig Hickman realised that differentiating a wholly new field of Computer Art from the computer's extension of existing areas is important. Even if the computer merely recreated the situations and standards of preceding art media, it would still produce valid art. These recreations of existing media derive from the methods and expectations of their precursors, though they subsist in digital form. They are not judged by standards derived from their computational origins, so much as the visual and experiential connections with older media.[9]

At some point, the line between recreated medium and the products of that medium blurs sufficiently that the computer adds few new facets or results to what has come before. This is a useful dividing point between "Computer Art" and " computer-mediated art". The latter draws on a previous art-medium, transplanting its standards and expectations to the computer, and if the recreation is close enough the computer's role in the resulting artwork is minimal. Even so, the fact that multiple environments and expectations can exist simultaneously on one machine demonstrates its status as a meta-medium.

When computer images are created and displayed, the computer also functions as an intermediary for the artist and viewer to see its visual content. The artist can only interact with computational processes by treating them as program elements – directing their operation and outcomes – or by using physical devices to move proxies around the screen. The artist cannot enter the digital environment itself, but they can influence it from the outside. The viewer, meanwhile, can only see these results displayed on the screen, unless they are printed or recorded on film. In this sense, the computer becomes an "intermedium" – a quasi-physical digital substrate which enables interaction or viewing.

To properly understand the artist's relation to the computer, one must consider the nature of the interaction between the human and the software via this digital intermediary, or image space. Because it is dynamic and often fully three-dimensional, this space is quite different from that of the static surface of a painting, or even the linear sequence of a film. It might be considered an image environment, a space with its own laws and results that (as John Whitney realised) is not subject to the rules of the physical universe. Stephen R. Ellis considers an environment to be "the theater of human activity" which consists of a *content*, a *geometry* and *dynamics*:

> The content consists of both the actors and the objects with which they interact. The geometry is a description of the properties of the stage of action. The dynamics describes the rules of interaction between the actors and the objects. […] [10]

This definition may be usefully adapted to the computer in an artistic context. Here the *content* is provided by the artist and their interaction with the computer, including the alterations and developments its usage engenders. The *geometry* comes from the structure of the interface, the type of software, the artist's knowledge and their comprehension of the computer as instrument. Finally, the *dynamics* stems from the properties of the software or programming skills they are using: it provides the parameters within which they work.

Describing the computer as an environment, including its physical devices (keyboard, mouse etc.) and its dynamic non-physical aspects, is closer to its role in art than calling it a "medium". Rudolf Arnheim notes the comment of computer artist Christopher William Tyler that contemporary artists tend to operate by "selecting from an environment entities that have significance to the artist rather than creating from scratch on a tabula rasa". By this he means that artists have picked up tools to utilise from foreign contexts and made them part of the artistic process. Tyler believes that such selected instruments "become part of the environment in which the art is produced", informing its production and extending its possibilities. This prompted Arnheim to note that this situation goes beyond an artist standing in relation to his tools; rather, it is the relation of the mind's conceptions to the opportunities and constraints presented by the environment.[11]

In the computational environment, the image and its associated tools exist at a higher level than the data: they are the *form* but not the *matter*. The matter – instructions in code – is fundamentally linked to the form and provides its substructure, but it has no direct visual correlation. In this sense, it exists in a different space from the artist and for this reason can be wholly manipulated and altered in a way impossible for physical materials which share the artist's space.

If computer images can be said to have certain qualities, they are structural characteristics rather than visual ones. They can be freely deleted, rearranged, transformed and returned to their original state, provided that the software allows all these steps. In many programs, the component parts of the image can be edited without affecting the whole, or freely grouped and combined to form new pictorial elements.

The image the artist sees is comprised of an utterly different substance from material reality because it is built up from the first as a visual object and not a physical mass. All computer-generated objects are "hollow", comprising hierarchical groups of instructions rather than densely-packed physical structures. These model visual appearance and dimensions in the first instance, and physical characteristics from the point of view of their visual interactions.

The peculiarity of computer image space is that not only the tools but the space itself can change its characteristics. This is due to its origins as a sequence of coordinates. Also, specific properties of its organisation (such as layers in *Photoshop*) only apply within a particular program; at other times, the image is completely inert, held in potential in the data.

It prompts the somewhat flippant question: Do all computers running the same program and using the same data set partake of the same image space? Or is it only re-created every time it is displayed?

Every re-running of the image code (especially a 3D image) in different software and hardware environments seemingly shows the viewer the same segment of reality. Users of Internet-based 3D chat rooms experience the "same" 3D space from different viewpoints, though their machines may be running quite different software on entirely separate hardware. In the same way, a 3D CAD plan may be experienced simultaneously on office intranets and modified by group collaboration across the network. Is the image seen at every workstation the same image, or simply the same environment displayed in slightly different ways?

The question does not arise for TV or video footage because it is recorded as an image and thus every iteration is a duplicate. By contrast, the computer re-creates the image every time the code is processed. When objects are moving and the scenes depicted from slightly different viewpoints (as with online games such as *World of Warcraft*), players might be said to be participating in the same space, whilst viewing an iteration of it.

The pioneering computer artist John Whitney Sr considered that this dynamic space only existed "by virtue of the abstract forms that move in it".[12] For this reason, Timothy Binkley sees the computer's role not as an inert medium, a resistive surface or material, but rather as conceptual space:

> It appears that its function is much closer to the *conceptual contribution of the artist* than to the physical contribution of the medium.[13] [italics mine]

Binkley argues that the computer, functioning simultaneously as the image space, the tools for executing the design and the display medium, contributes to the conceptual creation of the artwork rather than simply providing the means for its reification. After all, until the image is printed or publicly displayed, it may be endlessly edited and modified. In this context, the artist may construe the "tools" either as those constructed within the program, or external hardware interfaces which affect the digital image. Only in the most general sense can the computer be said to be a tool *in itself*.

The computer moves images away from physical materials towards a data structure that can only be interpreted by devices, not directly by the viewer. As Levy describes it in the ACM Transactions on Digital Libraries 1998:

> Digital documents are split between an intangible digital object (which is ineffective outside of a complex, technical context) and a set of perceptible but transient manifestations.[14]

It is important that this "intangible digital" visual form cannot be manifested without the computer. Unless it is printed or otherwise materialised, at which point it ceases to be digital, it remains tied to the computer. Nevertheless, this space may correspond with physical space and materials; indeed, much Computer Art has a necessary physical component. Though it is mediated through and by the computer, the artist still remains the decisive factor in its creation and thus in its definition as "art". In addition, the art's non-physical existence enables it to be modified, transmitted, displayed and erased in ways that circumvent the limitations of physical materials.

The computer medium can only be penetrated with instruments and worked on at one remove; but insofar as it works to our expectations of scenes and objects beyond our immediate tactile range, it is effective and affective.

JJ GIBSON'S ECOLOGICAL PERCEPTION

The idea of the graphical computer as a reciprocal environment entered by the artist was elucidated for me by the theories of human perception put forward by the psychologist J.J. Gibson. Although his views on pictorial communication were questioned by Ernst Gombrich in *Leonardo,* (Vol. 4, 1971), I found his theories of environmental perception to be useful metaphors when working out the relation of the artist to computer graphics. Certain aspects of Gibson's psychology had already been noted by pioneers of Virtual Reality such as Michael McGreevy and Jaron Lanier, in relation to tool use. [15]

The word "medium" has artistic connotations of surface and material, and also refers to channels of communication. In a computer context it is instructive to consider JJ

Gibson's usage of "medium" when describing how perception might take place within an environment:

> If we understand the notion of medium, I suggest, we come to an entirely new way of thinking about perceptions and behavior. The medium in which animals can move about (and in which objects can *be* moved about) is at the same time the medium for light, sound, and odor coming from sources in the environment. An enclosed medium can be "filled" with light, with sound, and even with odor.[16]

If the computer is a "discrete" or "closed" environment, one that can only be experienced by proxy, it is still comprehended by perceptual mechanisms developed to deal with the physical world, hence the use of metaphors in interfaces. In this sense, the digital medium is both more comprehensive yet more constrained compared to its physical predecessors. As computer artist Aaron Marcus points out, computer graphics "effectively interfaces with man via light. The images have no mass, no physical substance in a sense, but they are perceivable and meaningful to the viewer."[17]

Thomas J. Lombardo noted that Gibson's concept of "ecological vision" meant that vision was understood as part of an ecosystem, as a component of the whole: "The term *ecological* signifies animal-environment reciprocity."[18] In seeking to understand how each environment shaped its inhabitants, Gibson considered the role played by certain substances that demark one medium from another. Water, for instance, functions as a medium for the fish swimming in it, but is a substance for humans who cannot enter the fish's world without breathing apparatus. The artist's position outside the computer's graphical environment parallels Gibson's reflections on the land-dweller's relation to water.

This consideration of substance versus medium is an important one. An artist using the computer can see *into* another medium, and by using interfaces they can operate and affect this medium, even to the extent of being able to feel sensations that correspond to the surfaces and masses of objects therein. But they can never enter this medium, there can never be direct physical contact or immersion in this space, because the medium they inhabit is wholly different. This is the greatest limitation on Virtual Reality, no matter what apparatus is used – even direct signals into the cortex.

The best the artist can ever hope for is a vicarious experience of their visual relations and interactions. They cannot enter their universe except visually; they cannot enter his except through visual displays or being physically rendered into inert objects, at which point they lose their digital basis and are transmuted into chunks of solid matter. Just as one can only work underwater with diving equipment or submarines – another "interface" – so one can only penetrate the digital environment by proxy.

This brings to mind Char Davies's installation *OSMOSE*, which uses breathing as an interface to permit the viewer/user to move within it: the installation is based on "on the intuitive, instinctual, visceral processes of breathing and balance. Through breath, the immersant is able to rise and fall in space with subtlety and precision." This novel interaction places the viewer within the digital domain as if suspended in an ocean; indeed, Davies says it was inspired by her experience of scuba diving. Yet even the most immersive digital artwork can never fully engage the viewer with the non-physical substance within which digital art subsists.[19]

Certainly, the space represented by the graphic display exists in an odd state: it may be flat like the screen that shows it, or have depth as well, and allow for movement in all axes. Meanwhile the artist navigates around using a two-dimensional mouse; three-dimensional pointers like the Polhemus are very rare. For the purposes of making an image, actions in this notional space have observable results that leave a trace on it. Yet the area is itself non-physical; there is no material on which such movements can have an impact, except that which the program simulates. The environment displayed on the screen recalls a description of "space" that attempts to address its special properties:

> [Space] so conceived is a very strange kind of thing. It seems to be part of the physical world, since it is not mental or spiritual, and since it is presupposed by physics. However, all objects treated by physics are, it seems, material […] But if space is something separate, "in which" such objects exist, then it appears that space itself cannot be a material object: if it were, then it could not be the container of all matter, for what would contain it?[…] space seems to be a physical object, *but unlike all other physical objects, it seems not to be material*. [Italics mine] [20]

Likewise, the computer screen is comprehended by GUI-using artists as if it was part of their physical surroundings and had a material basis. Insofar as their actions affect it, it seems to be "there" in front of them; it has an external existence which we would attribute to objects. Yet in other respects its immaterial nature is manifested in its transience and its distance, in the sense that it cannot be touched. In this respect, the computer image is closer to the mental concepts of the visual imagination. Also, its receptiveness to change is complemented by its non-linearity: an image may be endlessly altered and yet returned to its original state. Thus it exists not merely outside our space, but outside our time as well.

Our experience of physical reality is primarily visual (secondarily auditory) and predicated on visual properties: the inference of mass, inertia, speed, etc, from the observable characteristics and relations of objects. They only enter our immediate and physical environment when they get close enough to touch, i.e. when they enter the area bounded by the maximum extension of our limbs and skin surface, which is the extent of our capabilities for direct physical interaction. Beyond this, the physicality of the world can only be *inferred* from its visual and auditory properties, though we have to assume its physicality because it shares the same space as we do. Mirages and other environmental illusions such as rainbows are examples that defeat such expectations.

We can affect objects at great distances by remote control, or firing projectiles, or using extensions for our limbs; but beyond our immediate physical sphere these interactions too are at one remove and thus indirect. So the environment – even "medium" – in which we exist can also be only partially experienced at first hand.

Overall, the factor of "distance" plays a part in the willing suspension of disbelief which is such a factor in our interactions not only with computer graphics, but with slide projections, film and television.

Trompe l'oeil painting is most instructive in this regard, because it brings the illusion up short, so to speak. At the exhibition "Deceptions and Illusions: Five Centuries of Trompe l'Oeil Painting" at the National Gallery in 2002-3, normally tangible objects were depicted in a highly realistic and almost three-dimensional fashion. But close inspection destroyed the illusion to such an extent that they no longer appeared "real", no matter how hard one tried to deceive oneself. By contrast, a *trompe l'oeil* ceiling depicting heavenly apparitions remains effective no matter how much one assures oneself that it is painted – not because it is impervious to closer examination, but because the depiction itself is of something we expect to be beyond our normal physical interactions and can thus remain *intangible*.

The computer medium can only be penetrated with instruments and worked on at one remove; but insofar as it works to our expectations of scenes and objects beyond our immediate tactile range, it is an environment which is effective and affective. This environment can be entered either through hardware that converts movement into equivalent motions, or by directly rewriting its properties. Because everything is done at one remove, by proxy and instruction, it is an environment the user never enters themselves, but because of this can see "around" and "through" it. It certainly functions as an environment of the human mind, as Lias would have it.

Whether or not the reconstruction of an image space grants you access to the "same" or "different" space, Gibson's consideration of *medium* versus *space* is still useful:

> As the observer moves from point to point, the optical information, the acoustic information, and the chemical information change accordingly. Each potential point of observation in the medium is unique in this respect. The notion of a medium, therefore, is not the same as the concept of space inasmuch as *the points in space are not unique but equivalent to one another.* [Italics mine] [21]

In one sense, the computer space is only perceptible through a fixed window, whether 2D or 3D. But the view is ever-changing and even the window or host computer may change – though not necessarily affecting the image itself. The only constants are the menus and tools of the GUI. As for the senses through which computer images are perceived, these are primarily vision, sound and touch. All three can be modelled mathematically and reproduced electrically; smell and taste are much harder because they are molecular sensations. Gibson leaves touch out of his list of stimuli, but I suspect he is looking for sensations that can be transmitted rather than those which are tied to particular surfaces. He sums up the characteristics of an environmental medium as the following:

> […]that it affords respiration or breathing; it permits locomotion; it can be filled with illumination so as to permit vision; it allows detection of vibrations and detection of diffusing emanations; it is homogeneous; and finally, it has an absolute axis of reference, up and down. [Italics mine] [22]

The computer environment affords movement and the infinite extension of the screen area; it allows one to zoom in and out of a scene; it enables the animation of objects within the environment; it is homogenous insofar as the particular piece of software is concerned – images can be displayed on other computers and platforms; and its absolute axes are determined by the conventions of the screen. In short, it provides the equivalent of an environment even though it is heavily circumscribed by the limitations of the computer hardware.

This is quite different from a "medium" as understood in artistic terms. Although the connections with 3D graphics are obvious, it would seem to me that even 2D abstract images also share in these characteristics. For instance, the generation of algorithmic "environments" is essential to the creation of Jean-Pierre Hébert's images.

The artist can therefore exercise considerable power over the computational environment. Because the user is outside this environment, they are not subsumed by it and thus can control its every aspect – if they so wish. Decisions to only make use of a limited subset of tools rest entirely with the artist. The advantage of disconnection (or disembodiment) is omniscience.

ACKNOWLEDGEMENTS

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THE IMMERSIVE ARTISTIC EXPERIENCE AND THE EXPLOITATION OF SPACE

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Over the past fifty years, artists have explored the computer's potential to create both virtual and physical art forms that embrace the concept of space. Through the use of immersion, interaction, and manipulation of both virtual and physical space, computer artists have created powerful aesthetic environments that enable audiences to experience alternative realities. Immersive installations that respond the human body and online multi-user virtual environments such as Second Life satisfy the viewer's inherent desire to escape physical reality and become part of the art experience itself.

INTRODUCTION

We often think of physical space as a three dimensional entity that exists between objects. Although this entity may contain "nothing" but air, we conceive of it as physically definable, malleable, and constructible. We experience sensations in space and define our perception of the world by our relationship to space. This notion of "nothingness" attributed to space poses some interesting questions. Is space actually an entity, a relationship between our senses and physical objects, or an abstract concept? Can we define, create, and manipulate space to create aesthetic experiences?

Since the early 1950s, artists have explored the computer's potential to create both virtual and physical art forms that embraced the concept of space. [3] Because the technical complexities and limitations of digital technology inhibited the full realization of many ambitious concepts, a number of early innovative ideas' destiny was to remain "concept-only" in seminal papers and high-tech lab experiments. In 1968, Ivan Sutherland created a virtual reality system that gave the user the ability to occupy the same "space" as a computer generated wire-frame object. Through the use of a head-mounted display, the user was able to interact with and manipulate the object. [13]

This revolutionary experiment paved the way for artists, such as Myron Krueger, who developed a series of art installations that strived to embrace and mimic real world interaction. Krueger coined the term "Artificial Reality" to describe a new genre of work in which the user's physical body influenced the unfolding of meaning in the work of art. From his earliest interactive artworks, "Glowflow" and "Videoplace" in 1969, to his experiments in the 90's with hand-gesture interfaces, Krueger strove to create responsive environments that used computer-mediated physical space to construct the aesthetic experience. [7] According to Noah Wardrip-Fruin, the art community at first rejected Krueger's work, possibly because it focused on "response" rather than the creation of aesthetic objects. During this same period, however, Allan Kaprow, an artist already accepted as a member of the fine art community received applause for his rejection of the physical object. [15]

MIMICING THE REAL

Both Krueger and Sutherland attempted to fabricate a "virtual" space that facilitated unique experiences unrealizable in the real world without computer assistance. Although this concept is often associated with Star Trek's holodeck, (first aired in *Star Trek, The Animated Series* from 1973-74), [10] science fiction writer Ray Bradbury first defined the potential of such a simulated space in *The Veldt*, a short story included in the *The Illustrated Man*, written in 1951. Set in a futuristic world where children live out their fantasies by imagining environments and events in the "nursery", this perfect world falls apart when the virtual becomes real. The story concludes when the parents are eaten by lions that the over-privileged, vengeful children conjure up in the nursery. [2] The division between fiction and reality is blurred creating the ultimate virtual world where anything is possible.

Fascination with constructed reality appears to be inherent in the human psyche. From the beginning of recorded history, humans have engaged in storytelling. Cave paintings, petroglyphs, ancient artifacts and rituals mirror our contemporary obsession with worlds that extend beyond our concrete physical environment. An inherent desire to experience that which transcends our physical confinement to limited environments, has resulted in the popularity of books, movies, television, video games, theatre, and other forms of escapism. When coupled with the ability to directly affect the outcome of the experience by utilizing our bodies as an interface, the constructed world comes closer to mimicking the real world. If one of early computer art's goals was to create worlds such as the nursery and holodeck, fifty years later we have still completely missed the mark. Although there are research projects and artistic endeavours that still seek to create virtual spaces indistinguishable from physically real spaces, new directions have emerged, spurred on by technical and philosophical issues resulting from past attempts to create such spaces.

SENSORY IMMERSION

Through their nascent efforts to create intelligent, holodeck-like spaces, artists and computer scientists have discovered that human perception of reality relies on a large, complex combination of factors. In the past fifty years, many of these factors were employed in a variety of ways to create aesthetic experiences that differ markedly from original attempts at virtual realism. The sensation of "being there" depends heavily upon sensory absorption within the environment. One must feel immersed in the space and physically a part of it. Sensory immersion is fundamental to our relationship with the natural environment.

Capitalizing on the psychological power of immersion, contemporary artists have created immersive spaces that enable the audience to escape to other realms and experience genuine emotional responses. The power of artistic illusion, as well as the human desire to create realities within realities, enables us to suspend our belief in our physically situated world and accept artificial constructs. Our obsession with video games, short stories and films demonstrates our desire to enter symbolic space and actively engage with alternate realities. In *The Metaphysics of Virtual Reality*, Michael Heim asks, “Are not all worlds symbolic? Including the one we naively refer to as the real world, which we read off with our physical senses?” [6]

ENCUMBERED EXPERIENCES

When discussing immersive worlds, we typically divide the experience into two categories: encumbered and non-encumbered. Although the initial concept of holodeck-like virtual reality involved the ability to fully interact with the space, and all entities within it, using our body and mind as primary input devices, computer scientists and artists still cannot technically implement such an ambitious ideal. Early technological developments such as Sutherland’s head-mounted display in the 1960s, M.I.T.’s Aspen Movie Map in the 1970s (Fig. 1), NASA Ames’ Virtual Environment Workstation Project which included auditory, speech and gesture interaction and VPL’s Dataglove in the 1980s, all paved the way for artists to begin to explore creative uses of computer-simulated spaces that transcended the desire to perfectly replicate realistic sensory environments. [5] Aesthetic concerns that focused on the involvement of the participant and creative exploration of concepts became key in the development a series of seminal works. In 1995, at the Ricco-Maresca Gallery in New York, Char Davies exhibited *Osmose* (Fig. 2) as part of the Code exhibition (a seminal exhibition of innovative computer art). Participants were outfitted with a head-mounted display and motion/breath sensitive vest that enabled them to enter a world unlike any they had experienced before. Abandoning realistic visuals and interaction in favour of abstraction and sensory body involvement, Davies’ work facilitated a unique “perception of consciousness: a feeling of disembodiment and embodiment at same time”. [4]

Fig. 1. The Aspen Moviemap, Architecture Machine Group, MIT, 1980

Fig. 2. Tree Pond, Osmose, Char Davies, Virtual Reality Installation, 1995.

Interactions with virtual spaces now lean towards an abandonment of encumbered experiences that depend upon awkward and expensive devises such as head-mounted displays and datagloves in favour of natural unencumbered interactions. Inspired by the knowledge that truthful psychological responses to virtual space are not dependent on realistic visuals and interaction, artists and computer scientists have explored alternate means of interaction. Although computer art such as web-art and online virtual worlds still depend on keyboard and mouse as primary input devices, artists have also capitalized on the technological development of inexpensive input/output circuit boards, sensors, switches, intuitive programming languages, and software applications. Before discussing computer art immersive spaces, it is important to reflect upon the changes in the traditional art that were taking place during this period.

EARLY INSTALLATION ART

While computer scientists and artists sought to create virtual spaces using the computer, traditional artists were abandoning the sterile white walls and rectangular pedestals of the gallery in favour of an activation of the space between the walls. Although experimental theatrical design works such as Kurt Schwitters' *Merzbau* (Fig. 3), which were constructed throughout his home in the 1920s through 1930s, received immediate recognition as the realization of a *Gesamtkunstwerk*, today we might look back and label the effort early installation artwork. [1] In the 1950s, artists such as Pollock, Allan Kaprow, James Rosenquist, and Claes Oldenburg began to obscure the line between the art object and its context, thus utilizing the space the work inhabits to enhance meaning. *Poème Électronique,* (Fig. 4) a collaborative work between Edgard Varèse, Le Corbusier, and Iannis Xenakis was exhibited at the 1958 Brussels World Fair and consisted of 400 loudspeakers, projected film, colored lights, and architecture. This seminal work was the first fully immersive environment that combined electronic music, projections, and architecture for the purpose of creating a total work of art. [14]

Fig. 3. Kurt Schwitters, Merzbau, 1924-37

Fig. 4. The Philips Pavilion and Poème Électronique, Brussels World's Fair, 1958.

Since the 1960s, a new wave of artists have been transforming space into physical environments that defy realistic representation of recognizable environments. The physical space that these installation artworks inhabit often carries as much significance as the individual art object itself. The installation artist takes into account the viewer's entire sensory experience. The objects in an installation art space take on new meaning and the context of the elements defines the interpretation of the piece. Installation art often reflects and responds to the world we live in, thereby creating an interesting fusion of art and life. We must remember that the elements in the installation space are not art objects in themselves; the participant's experience is the work of art. Ronald J. Onorato in the book, *Blurring the Boundaries: Installation Art 1969-1996,* states, "The aesthetic power of installation art does not reside in a singular, commodified object but in an ability to become, rather than merely represent, the continuum of real experience by responding to specific situations." [8]

Not surprisingly, by the 1970s we began to see installation artworks that seek to explore and satisfy the human desire to experience constructed realities. Artists incorporated film, video, performance, sound, objects, and architectural space to create complex aesthetic statements. In *Organic Honey's Visual Telepathy*, (Fig. 5) created in 1972, Joan Jonas created a virtual space using video and performance that visually represented the artist's alter ego (aptly named Organic Honey)'s imagination. [9] Video artists such as Nam June Paik created works such as *TV Garden* in 1974 (Fig. 6), that seamlessly integrated contemporary technology into an actual space populated with live plants. The convergence of the "real" (the plants) with the "virtual" (the illusionary space within the television screen) forced the viewer to accept these two decisively opposing forces as one unified element – the real and the virtual converge and become real in the end.

Fig. 5. Joan Jonas, Organic Honey's Visual Telepathy, Video Still from Performance, 1972

Fig. 6. Nam June Paik, TV Garden, 1974, Guggenheim Museum.

CONVERGENCE

As installation artists began incorporating digital technology into their work and computer artists began exploring the potential of physical environments united with virtual space, the goal of creating holodeck-type environments became superseded by desires to create spaces that capitalized on the best of both worlds. Electronic sensors, computer programming, digital audio, electronic moving and still images, and physical objects served as the basic building blocks enabling artists to create innovative works of art that used the human body as the interface. To create a convincing sense of immersion, a number of factors were considered. Participants entered into the space itself rather than view it from afar. The elements in the art environment filled the participant's peripheral vision creating the sensation of physical presence. Visual elements in the environment offered depth clues and moved accordingly. Multi-channel or ambisonic (three-dimensional) sound enabled participants to hear spatial relationships between themselves and the elements in the environment. The viewer often had a degree of interactive control over the unfolding of meaning in these innovative pieces.

VIRTUAL PRESENCE

In 1992, Bonnie Mitchell explored the psychological effect of immersion in an installation entitled *Virtual Presence*, exhibited at the University of Oregon's Museum of Art. Viewers were invited into an enclosed semicircular room and were surrounded by computer monitors, each displaying a set of realistic eyes and a nose. The eyes blinked and rhythmic audio of breathing emanated from the computer. A Polaroid sonar sensor detected the distance of the viewer and responded by increasing the rate of breathing and visually altering the computer's face. Viewers in the environment were disturbed by the premise that the computers were living entities. Many viewers expressed the unpleasant sensation that they were being watched. This early immersive environment inspired a series of further installation works by the author.

EXPERIENTIAL EXTREMISM

In collaboration with electroacoustic composer, Elainie Lillios, Mitchell created an audio-visual interactive immersive installation artwork in 2005 for the International Computer Music Association Commission Award. *Experiential Extremism* (Fig. 7) explored the concept of extremism by focusing on enticements that cause people to gravitate toward thrill seeking and the emotional responses that occur before, during, and after extreme activities. By developing and manipulating abstract elements, they created an environment that evoked emotional and psychological responses similar to those that cause, maintain, or cease adrenaline rushes.

Fig. 7. Bonnie Mitchell & Elainie Lillios, Experiential Extremism, 2005.

This immersive, interactive installation was divided into three physical areas, each representing one aspect of an extreme experience. Phase One, the "psych up" phase, mimicked psychological and emotional states of being prior to engaging in an extreme event. Phase Two, the "event" phase, abstractly portrayed the event itself. Phase Three, the "cool down" phase, represented post-experience reflection. Each phase evolved over time, and created a unique, individualized experience with each participant's visit. As an immersive installation, *Experiential Extremism* challenged and changed participants' perception of time and space, and provided an integrated, networked environment that transcended expectations of time-based, spatial art and sound.

ENCOUNTER(S)

In 2007, Lillios and Mitchell created *Encounter(s)*, an interactive-immersive audio/visual environment (Fig. 8) that focused on the concepts of introspection, tranquillity and transformation. Each participant entered an immersive abstract sonic, animated world, and was enticed to sit in a centrally located seat. When the participant sat down, they triggered the emergence of a distant, abstracted ethereal figure that slowly moved towards the participant. When the figure arrived in front of the participant, it asked an introspective question. After a moment of contemplation, the figure retreated into the distance and transformed into a tree-like form that metaphorically represented self-actualization and growth.

Fig. 8. Bonnie Mitchell & Elainie Lillios, Encounter(s), 2007.

Eight loudspeakers and four subwoofers were arranged to create a full spherical (periphonic) listening environment using Ambisonics, a three-dimensional audio encoding/decoding system. Custom-designed, fabric walls suspended from the ceiling, defined the installation's physical space. These fabric walls also echoed the animations on all sides of the participant, filling the peripheral vision.

SOCIAL INTERACTION

Although spectators were able to view the participant in the centre, *Encounter(s)* was designed as a solitary experience. Although *Experiential Extremism* facilitated up to 20 visitors at a time, neither installation encouraged nor facilitated group interaction. Because of the popularity of online multi-user games, Facebook, Twitter and other social networks, it is evident that human beings crave interaction with other human beings. Computer-facilitated communication often satisfies the desire to connect with others even though the experience is often not immersive and does not attempt to replicate realistic communicative environments. When spatial immersion and interaction is coupled with human-to-human interaction via avatars, voice, or text the level of active engagement increases substantially. Online virtual worlds such as World of Warcraft and Second Life boast over 11 million subscribers and 16 million accounts respectively. Second Life is entirely user-created and the environments are easily manipulated, therefore very conducive as an art medium.

ART IN SECOND LIFE

Second Life is a 'multi-user virtual environment' (MUVE) in which users of an online 3d space interact through avatars using voice and text chat. Also called 'Residents', users can explore, meet other Residents, socialize, participate in individual and group activities, as well as create and trade virtual items and services. Second Life offers artists an interactive online social environment that can be sculpted using computer programming and the construction of virtual 3d objects.

Aesthetic responses are typically enhanced by encoding experiences visually and sonically as well as adding a participatory component. Through the development of algorithms, environments can be created that respond to avatars and change over time. Artists such as Juria Yoshikawa and Dan Coyote as well as many others, have created art experiences that fully engage the senses through the marriage of sonic and visual effects coupled with immersion and social interaction.

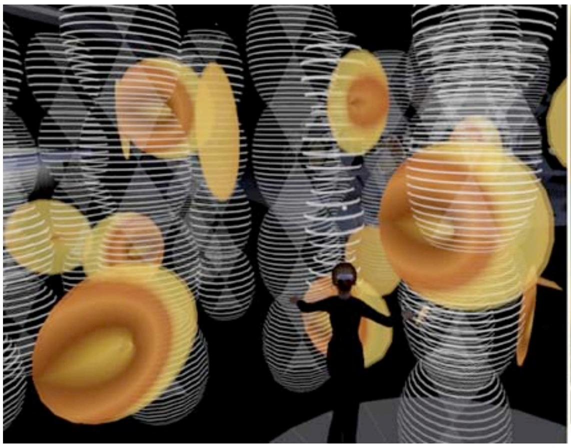

Fig. 9. Juria Yoshikawa,

Fig. 10. DanCoyote Antonelli.

Juria Yoshikawa, also known as Lance Shields in real-life, is interested in phenomenology in the virtual world, or the reflective study of the essence of consciousness as experienced from a first person point of view. Although Lance is a male artist living in Tokyo in the real world, the works in Second Life are all created by one of his alter egos, an avatar called Juria, a female. Juria uses the elements in Second Life and the Linden Scripting Language to create works that are impossible to make in the real world (Fig. 9). She mixes kinetic objects, animated textures, ambient noise and animations to create social experiences that are multi-sensory and immersive. The works are typically large in scale thus encouraging avatars to fly through and interact with the work in non-traditional ways. [11]

DanCoyote Antonelli, also known as DC Spensley in real life, has created a number of art works under the genre he calls *Hyperformalism*. The first generation of works he created was paintings and digital art uploaded into Second Life. The second generation was art made only from the Second Life default inventory materials (Fig. 10) and the third generation was a synthesis of the first two, combined with scripting in Second Life. *Hyperformalism* is described by Antonelli as "an aesthetic philosophical construct that may be employed to describe a late 20th century, early 21st century mass art phenomena consisting of scores of personal computer users generating abstract, often spatially unique artworks with software tools. These spatial realities have no analog in the physical world, and instead of making reference to physical reality, create a unique continuum of reference; a rearrangement of photons to illuminate alternate worlds of form, shape, color and space." [12] Although Second Life facilitates the development of artworks that can only be made in the virtual world, it is inhabited by avatars controlled by real people. Social interaction facilitated by the virtual environment as well as the layered fabric of identity inherent in avatar cultures, makes online experiences such as Second Life ripe with possibilities for artistic exploration.

CONCLUSION

Through the definition, creation, and manipulation of both virtual and physical space, computer artists have created powerful aesthetic environments that enable audiences to experience alternative realities. The original quest to create virtual spaces that mimic terrestrial space and real world interaction has not fallen to the wayside solely because of technical limitations. Encumbered artificial reality experiences have proven to be expensive, intrusive, and often interfere with natural sensory perception. Immersive installations that respond the human body and online multi-user virtual environments such as Second Life satisfy the viewer's inherent desire to escape physical reality and become part of the art experience itself. Technological advances and shifting art practices have expanded the palette of the computer artist over the past fifty years and promise to radically alter computer artist's exploitation of space in the future.

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REDEFINING SCULPTURE DIGITALLY

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Abstract: Between 1979 and 2009 the author has produced several series of digital sculptures, some of which have broken radically with existing concepts of sculpture. His first digital sculpture was a series of screen-based real-time interactive virtual sculptures produced between 1979 and 1981. He subsequently used the computer to compose and fabricate several series of sculptures, while also working in a variety of other artistic media. Since 2007, he has been using the computer to design and fabricate a series of large-scale sculpture installations that combine more traditional sculptural concepts with contemporary multimedia approaches.

INTERACTIVE VIRTUAL SCULPTURE, 1979 - 1981

First Exposure

Before encountering the computer, my earliest artwork was sculpture done in traditional media, including carved stone and wood, welded steel, cast concrete, and fired ceramics.

In 1978 I was exposed for the first time to computer graphics through a freelance job at the University of Pennsylvania for Professor Norman Badler. (1) Among the equipment at the University was a Vector General 3400, a real-time vector graphics device. At the same time that I was doing this work, I talked with the Sculpture Department at the university and learned that they were very open to me devising my own course of study. The next year, 1979, I began my M.F.A. studies at the University and immediately began my first virtual sculpture compositions.

Motivations

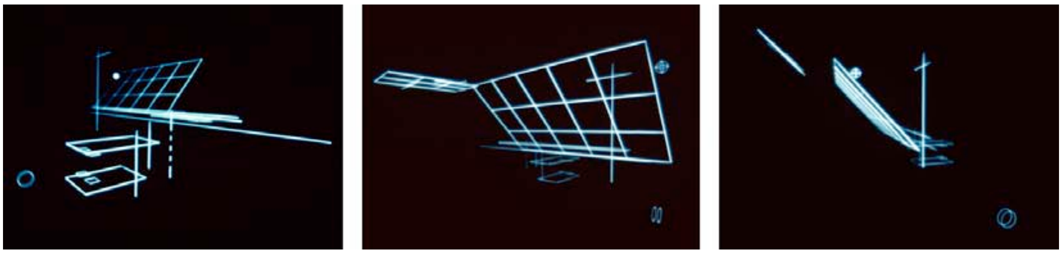
My interest in the possibilities of virtual sculpture grew out of my artistic interests as these had already developed prior to my exposure to the computer. While working in traditional media I had become increasingly interested in sculpting spaces, voids – what some call the "negative space". This approach, of course, was not original to me, but had been already well developed by a number of contemporary sculptors, notably Henry Moore and David Smith. I had also become interested in creating sculpture that functioned outside of gravity (perhaps because of the new prevalence of air travel and recent space exploration). Alexander Calder had gotten closer to this than anyone with his hanging mobiles. These almost – but not quite, because of the requirement that they be physically hung – defied gravity. Finally, I had become interested in kinetic sculpture, with George Rickey being that genre's best known practitioner.

Encountering the possibilities of real-time interactive vector graphics in the Vector General machine, I realized I could create sculptural compositions that could address all of these concerns, that could a) focus entirely on space rather than volume; b) operate completely outside of any considerations of gravity; and c) move in any number of ways.

Another fascinating possibility that I saw could clearly be addressed through virtual sculpture was interactivity. Though I was not yet aware in 1979 of the writings of what was just becoming known as post-modernism, I was very interested in allowing the viewer to give meaning to the artwork, to "complete" it, as post-modernists such as Roland Barthes had begun insisting was the case with all artwork anyway. (2) I did not want to reject the importance of formal composition, as some post-modernist artists were beginning to, but I did want to reject the notion of the self-contained, autonomous nature of the artwork. I wanted the viewer to be an integral part of the artwork. Indeed, I wanted the viewer's contribution to go beyond giving meaning to the artwork, and to include making changes to the actual composition of the artwork.

The Compositions

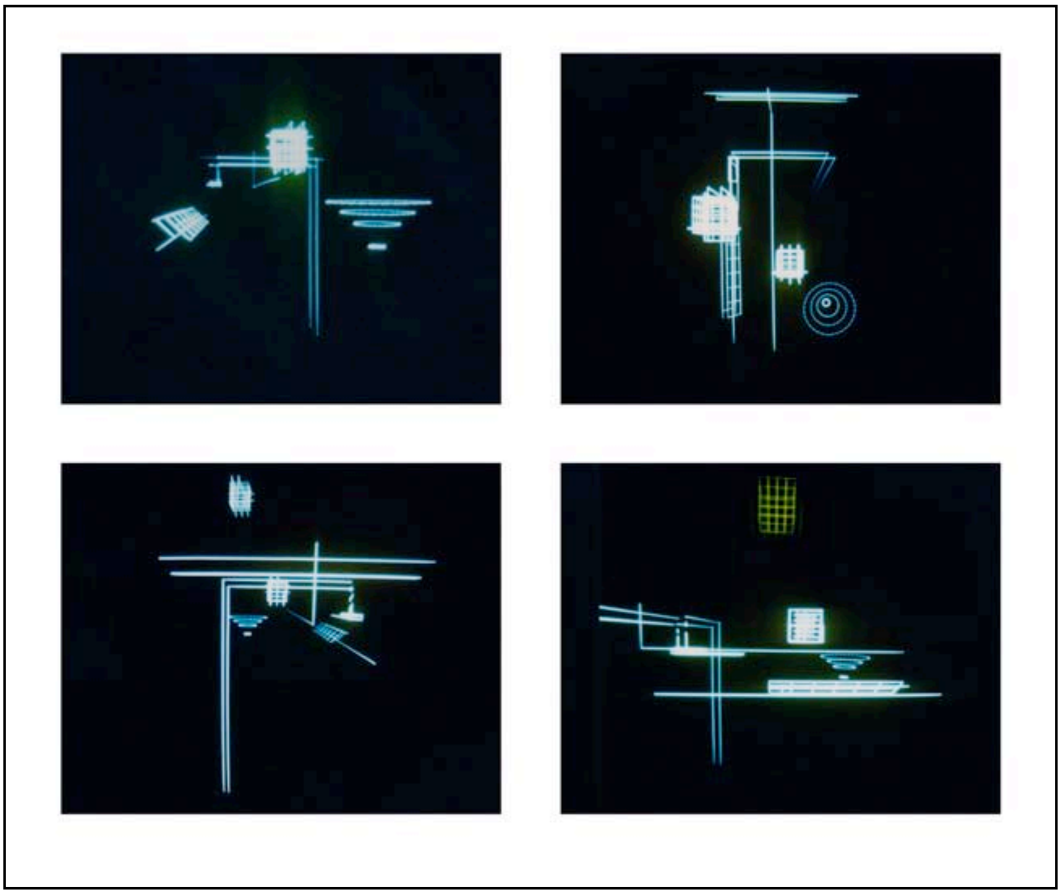
To create these compositions, I learned to program in Fortran. The programming was at a fairly low level, including telling the device where to draw each line, how bright the lines were to be, how to interpret movements of the 3-axis joystick, etc.. Over the course of three years, I produced approximately seven compositions. Each was defined as lines in three-dimensional space, with the viewer's point of view controlled by a 3-axis joystick. Using this joystick, one could "fly" through the space, looking at the composition from any vantage point, going through the composition and coming out the other side, looking at the composition from the inside out, etc. I deliberately programmed the joystick so that the viewer's movement was slow, ensuring that s/he would linger with the composition and really have a chance to see it.



1. s*oplane*, 1980. Interactive virtual sculpture.

Each composition also had at least one element that could be changed or repositioned by the viewer. Figure 1 shows three views (each a photograph taken from the screen) of one sculpture. In this piece, the large grid-like rectangle toward the left of the central image was the interactive element. By clicking a specific key on the keyboard, the viewer could cause this element to change to a different orientation – for example, to rotate 45 degrees about a certain axis. My goal was to give the viewer the option to change the composition, but to simultaneously restrict the options so that any choice would result in a visually interesting composition.

Ge-le was a later, and more complex, composition. The inspiration and title for this piece come from a tradition of the Mossi people of West Africa, among whom I lived for two years. To explain the sudden death of a healthy child during the night, they had the story of the "ge-le", a woman who, unbeknownst to herself or anyone else, was a sort of witch. The spirit of this witch would rise up out of the body of the woman at night, float through the air, and descend into the hut of another family, where it would eat the soul of a sleeping child. It would then return to the body of the ge-le woman. In the morning, the child would be found dead by its parents.



2. ge-le, 1981. Interactive virtual sculpture.

In this interactive virtual sculpture, a cube-like object hovers in one location. At the press of a button by the user, a duplicate of this object would rise up out of the original object. This duplicate (the "ge-le") would then float slowly through the air. The user could control its movement with a 3-axis joystick, but when s/he stopped doing so, the object would continue to drift of its own accord, beyond the control of the user.

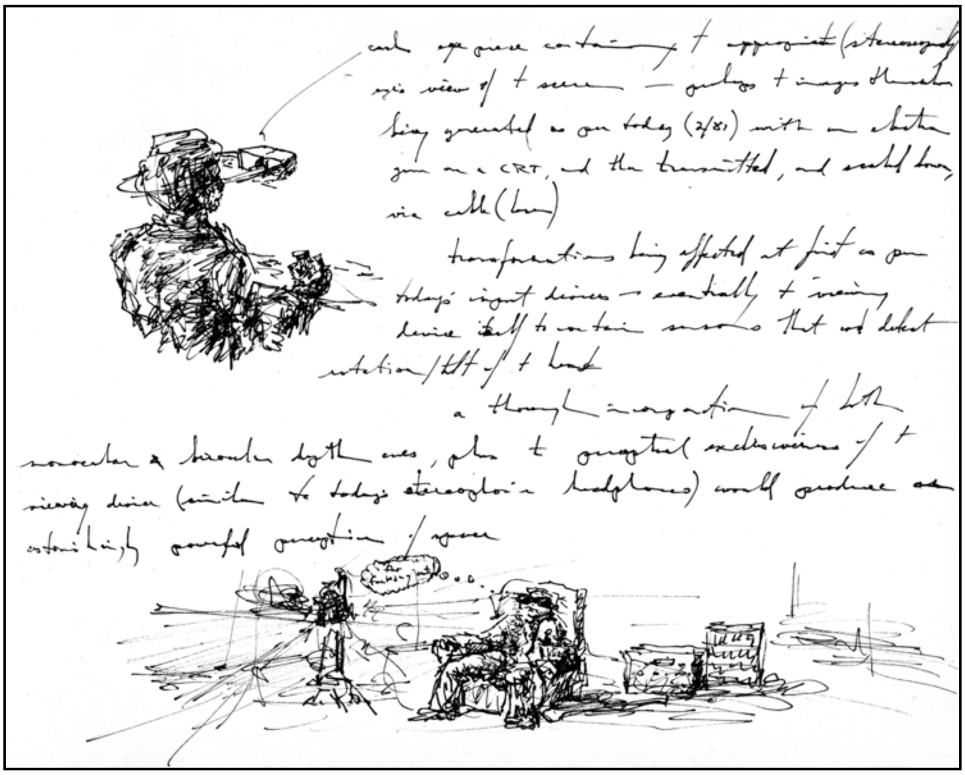
At any time, the user could resume controlling the object. But at a random moment and without any warning or input from the user, the ge-le object would suddenly disappear from its current location, reappear momentarily on top of the original object, glow briefly, and then extinguish itself. The user could elect to hit the button again to restart the process. As with all the sculptures, the user could also, with another joystick, move through the space of the whole composition.

The Reality of the Virtual

Despite the compositions being composed entirely of lines and displayed on a flat screen, there was an uncanny sense of real three-dimensional space to them. The blue-ish lines were depth-cued in several ways. First, all elements were rendered with perspective, nearer objects appearing larger and more distant objects appearing smaller. This perspective applied also to the thickness of each line – that portion of the line nearer your eye was thicker than a distant portion. There was also color depth cueing, with closer elements rendered very white and more distant elements an increasingly blue tint, effectively applying the atmospheric perspective technique of the Italian Renaissance to these contemporary compositions. Finally, as mentioned, the viewer was able to gently move his point of view in, around and through the space of the composition in real time by means of a 3-axis joystick.

A painter friend of mine, who had heard me describe this work a number of times but had never seen it, insisted that it was really two-dimensional, really just pictures on a screen. In an important sense, of course, she was right, and no matter how I described it verbally, I could not convince her it was “really” three-dimensional. Finally, I took her to the machine. As she sat at the computer and manipulated the joystick, she muttered to herself, “...Let me bring it a little closer....” Aha! I exclaimed. See! You are reacting to it as three-dimensional! It *was* three-dimensional, and the perceptual cues were such that one quickly saw it as three-dimensional and forgot the two-dimensionality of the screen, effectively looking through the screen into the space of the composition.

During the years I worked on these compositions, I became aware of some of the technical experiments in real-time virtuality being done elsewhere – Ivan Sutherland's head-mounted displays at MIT (3); and A. Michael Knowle's work with virtual tactility at Bell Laboratories (4). I realized the potential of the technology for creating and representing space. Figure 3 shows a page from my 1981 sketchbook outlining some of my thoughts on this.



3. Page from a sketchbook, February 1981. Here I muse on future possibilities of virtual sculpture, in terms of display, perception, and effect. The text reads: "each eye piece containing the appropriate (stereoscopically) eye's view of the scene – perhaps the images themselves being generated as per today (2/81) with an electron gun on a CRT, and then transmitted, and scaled down, via cable (laser). transformations being effected at first as per today's input devices – eventually the viewing device itself to contain sensors that would detect rotation/tilt of the head. a thorough incorporation of both monocular & binocular depth cues, plus the perceptual exclusiveness of the viewing device (similar to today's stereophonic headphones) would produce an astonishingly powerful perception of space. 'far fuckin' out!' ".

Throughout my work on these sculptures, I referred to them as “virtual sculptures”, first using that term in publication in a 1985 paper for the SIGGRAPH conference. In that paper, I spoke of some philosophical implications of these virtual sculptures and what I anticipated as their successors. Once again, though I was not aware of this, my ideas coincided with some post-moderist ideas being simultaneously developed by others. Jean Baudrillard's 1981 book, *Simulacra and Simulation* is especially relevant here. (5) I close this section by quoting from my 1985 paper.

> At what point, as we add and refine perceptual cues, do we cease to think of the object as being “virtual” and just think of it as real? If we can see a single view of what appears to be a three dimensional object, is it a “real” object? No, we say, because we can't walk around it. If we can “walk around it” by using a joystick to control our point of view, is it then real? Suppose the image is displayed to us not on a stationary monitor set on a table, but in a tiny head-mounted monitor that reads our body movements and updates the image accordingly, so that we can *physically* walk around it. Is it then “real”? And if there are two images – a left eye view and a right eye view – so that we see the object in stereo, as our eyes normally do? Suppose we program into the object virtual tangibility, so that we can “feel” the object – perhaps with a set of electronic gloves that would be to our sense of tactility as CRT monitors now are to our sense of vision. And if we add sound? And scent?
>
> How many, and which, characteristics must the object have before we consider it real? Or before we become incapable of distinguishing between what is real and what is not? Or before we cease to care about the distinction? (6)

Extinction

Before I had finished my MFA degree at the University of Pennsylvania where I'd been doing this work, the Vector General machine I'd been working on broke. By the time funds were available to repair the machine, the Vector General company had gone out of business. The machine on which my virtual sculptures had been composed, resided, and were visible was forever defunct. My virtual sculptures were extinct. It was no longer possible, and would never again be possible, to view or interact with these sculptures.

Within several more years, the first real-time raster-image devices began to appear. The demise of vector-based machines and their replacement by raster-image devices with their emphasis on surfaces made it much harder to pursue the line of purely spatial sculptural investigation I had started here.

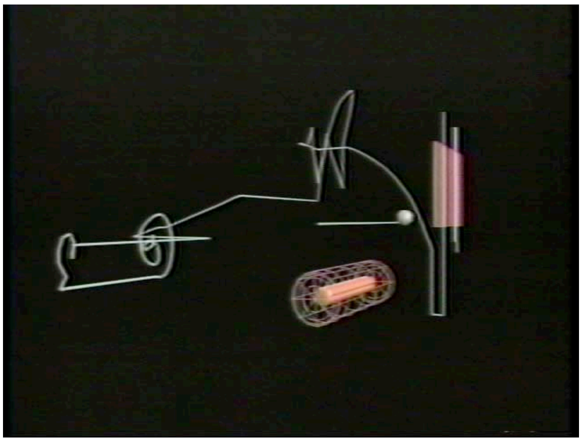
The only visual record that remained of these virtual sculptures was a set of photographs I had taken from the screen of some of the sculptures. Those sculptures I had not yet photographed had no visual record at all. The photographs taken from the screen in 1981 and 1982 have since deteriorated. Today the sole visual record of this work is the digital files – of the scans – of the photographs – of the screens – of some – of the sculptures.

And, somewhere in my cellar, printouts of the Fortran code for each sculpture.

IN BETWEEN (1982 - 2007)

Animation

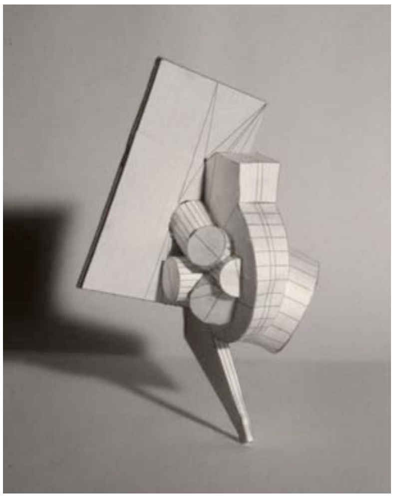
In the early 1980's while at the New York Institute of Technology (NYIT) Computer Graphics Laboratory, I produced a number of computer animations of abstract sculptural forms. (Figure 4) These continued my interest in defining space in the absence of volumetric forms, but now included some forms and surfaces, as made possible and suggested by the raster nature of the technologies involved. As with the virtual sculptures, they also included some moving elements.



4. faciebat, 1983. Computer animation of digital sculpture.

Polygon Unfolding

In the mid 1980s I also used the computer to design and fabricate physical sculpture. A series of paper and aluminum maquettes (7, 8) used a polygon unfolding technique originally developed by Ron Resch at the University of Utah (9), and customized for me by his former student and my office mate at NYIT, Robert McDermott. Additional software for this work was written by Pat Hanrahan and Jacques Stroweis. One of the sculptures in this series is illustrated in Figure 4.



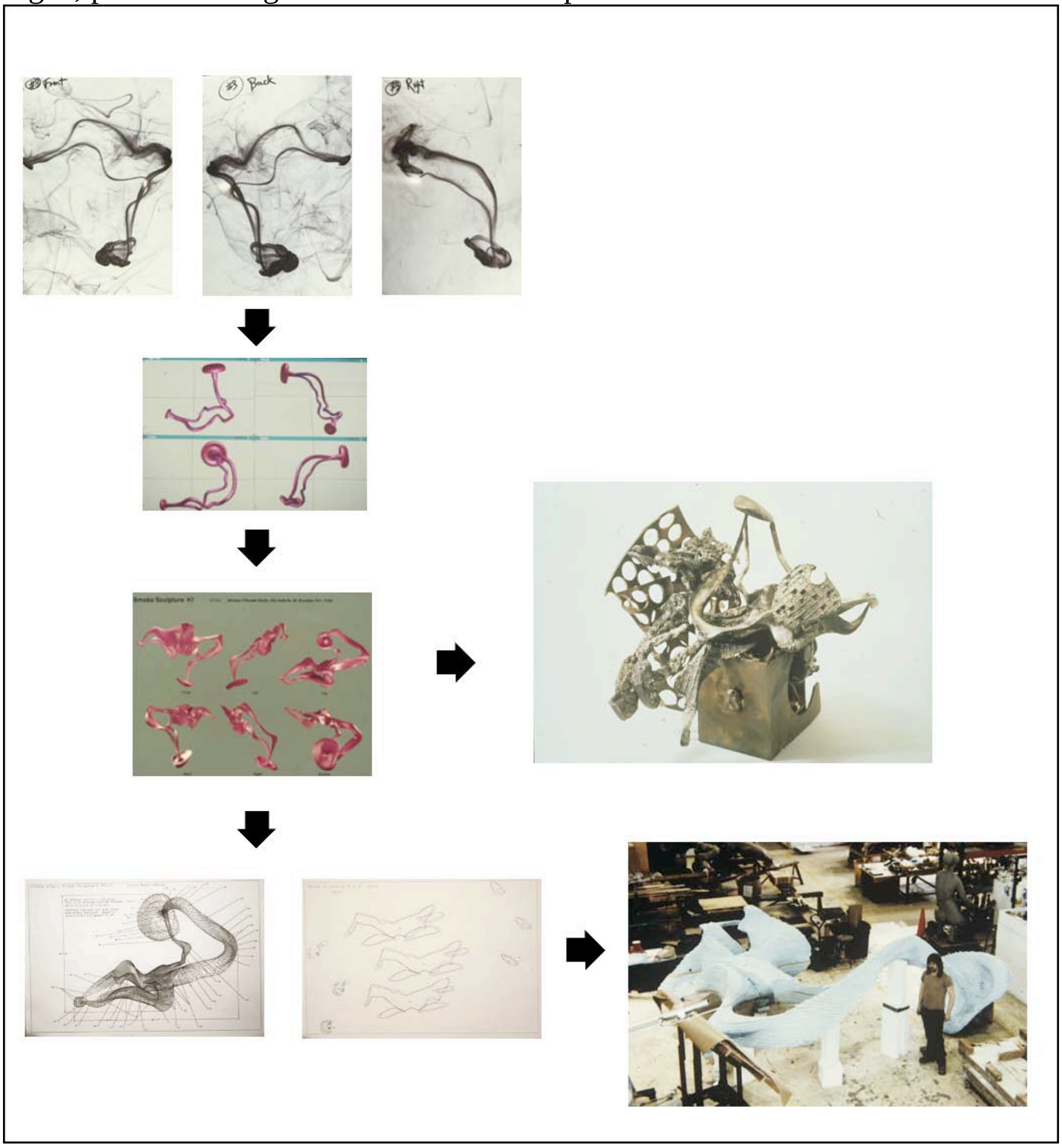
5. *vdelta*, 1985, paper. Digitally produced maquette for sculpture

This approach to designing and fabricating sculpture was extremely promising for several reasons. First, it allowed me to model forms that would have been impossible or nearly impossible to develop with traditional, physically based sculptural techniques – for example, the complex nest of intersecting cylinders in the center of the *vdelta* composition. Another was its extensibility: once the forms were designed and the flat patterns calculated and unfolded, they could be fabricated in any flat-surface material – paper, aluminum, steel, etc. – and at any scale.

Unfortunately, the software I used for this sculpture was proprietary to the NYIT research laboratory where I worked, and when I left there in 1988 I no longer had access to it. Nor, as far as I was able to determine, was similar software commercially available anywhere. It was not until years later that it became so. In the last section of this paper I describe current work with such software that extended this unfolding technique in very fruitful and sculpturally innovative ways.

Stereolithography – Smoke Sculpture

Several years later, I produced a series of "smoke" sculptures for the artist Frank Stella. (10) This work began with Stella's desire to model forms similar to the configurations of floating smoke. Based on photographs of smoke, I digitally modeled very fluid looking forms – forms that floated in space and wove through that space, approaching in certain respects my spatial-minus-volumetric virtual sculptures of 1980. Once digitally modeled, I produced small-scale sterelithographic plastic models of the forms. These were cast into various metals. I also produced cross-sectional drawings that, when enlarged, permitted large-scale cast metal sculptures.



6. An overview of the modeling and fabrication process for Frank Stella's “smoke” sculptures. 1990 – 1991.

The sculptural forms I modeled and built with this approach had a wispy, almost a-physical quality that I felt had hitherto been seen only in the welded steel “drawings-in-space” sculptures of people like David Smith. Unlike his work, however, where the shapes were clearly a result of – and limited by – the welding process, my “wisps” could be shaped in any way I wished. The digital modeling process was extraordinarily robust.

Unfortunately, the sterelithographic process was extremely expensive, and impractical for all but the very affluent. Today, almost twenty years later, stereolithography is commonplace, and in fact is frequently called “3d printing” in a marketing effort to convey its accessibility. The sort of extremely spatial, wispy forms I modeled in 1990 are therefore readily possible now. Nonetheless, the great preponderance of sculptural work done with 3d printers today remains primarily, and more traditionally, volumetric.

Interactive Multimedia Murals

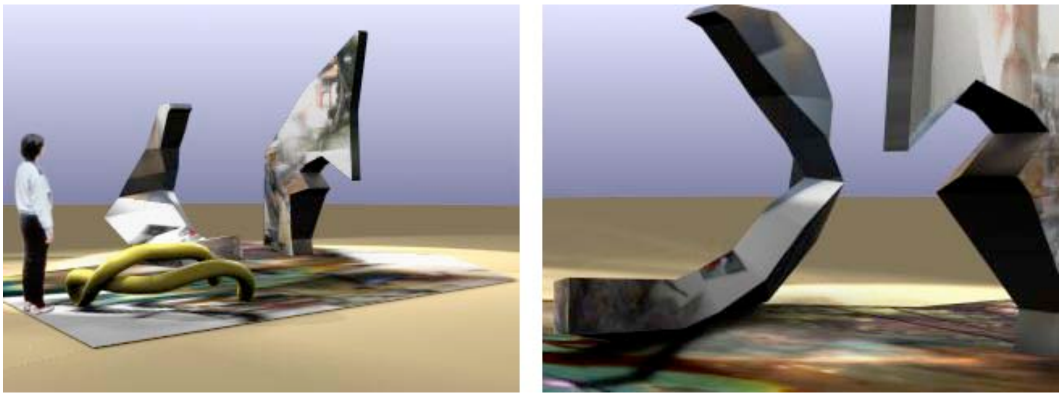
Beginning in the mid-1990s, my artwork diverged from sculpture and focused on digital prints and interactive multimedia murals. (11) From the point of view of sculptural concerns, several aspects of this work became significant to my later sculpture. The scale, the two-dimensional imagery, the use of photography, and the introduction of interactive imagery all became key to the sculptural work I am currently doing. Figure 7 illustrates the sort of imagery that I subsequently applied to my current sculpture.

7. Picnic. 2003-2004, 7' x 45.5'. Printed tiles, real-time processed video, prerecorded video, and prerecorded sound.

MONUMENTS, 2008 -2009

Two years ago, I began composing a series of sculptures entitled *Monuments* in which the insights, skills, and approaches I'd developed over the previous twenty years congealed. These large-scale interactive multimedia sculpture installations, all of which are still in various stages of development, combine three-dimensional forms, two-dimensional imagery, moving imagery, interaction, and sound. The interactive portions are being developed by my collaborator and colleague at Pratt Institute, Liubo Borissov, using the Max/MSP language.

For each sculpture, large forms and imagery combine to define a three-dimensional space. The forms are covered with printed imagery as well as, in some cases, moving projected imagery. As viewers walk into the space, hidden cameras capture their movements, and this information is used to modify the projected imagery. In some compositions, ambient sounds are captured and re-emanate through the walls of the sculpture. (Figure 8)



8. Monument #2. Digital model for a large-scale sculpture. Live video is projected onto a portion of the larger form. Sound emanates from the tubular form.

The conceptual challenge posed by each sculpture is initiated by its title, which prods the viewer to ask: "Monument to what?", but declines to answer that question. The root of the word "monument" is the Latin *monere*, to remind. The sculpture records and reacts to viewers' movements and voices. In some cases the presence of past viewers continues to affect the sculpture. The sculpture itself becomes a form of memory, reminding us of others, of ourselves, or our connection to others.

Our comprehension of the whole composition requires another exercise of memory, since the totality of the forms and their imagery cannot be seen from any one point of view. We must walk into and around the sculpture, remembering what we saw earlier from some other angle, in order to piece together an understanding of the composition. At the same time, our very presence is (like Heisenberg's) altering the composition, making it impossible to ever fully and surely "know" the sculpture.

The development of each *Monument* composition begins with sketches and notes and proceeds to digital modeling of a virtual version of the forms. At the same time, two-dimensional imagery (known technically as "textures") is developed and positioned digitally on the forms.

The polygonal data of the sculpture is then digitally unfolded into flat patterns, using an approach very similar to my 1985 work, but now with inexpensive commercially available software. These flat patterns are printed, complete with the appropriate texture imagery, and the prints transferred to lightweight foam boards, which are cut and assembled into the whole.

Figure 8 shows a realized version of *Monument #3.* The white projected lines in b) derive from the linear patterns of the form's edges and are programmed with a dynamic system of springs and forces such that the movement of viewers causes the lines to drift and form new patterns. In c), the projection includes these lines plus some of the same imagery that is printed on the forms. The composition becomes a merging of sculpture, performance, interaction, and print.

a *b* *c*

9. *Monument #3*. 2009, Interactive multimedia sculpture. Printed imagery on board, projected interactive imagery.

CONCLUSION

Sculpture can be physical or virtual, static or interactive, monochrome or teeming with imagery. The possibilities cannot be exhausted and are explored by each generation. Digital technologies can help, and have helped, us find new ways to extend the definition of this art form and to make the viewer's experience of sculpture emotionally and intellectually meaningful. Like any technology, however, digital technologies limit at the same time they liberate. It is our task, as thinking human beings, as artists, to understand and take advantage of the technology's capabilities, at the same time that we see past its limitations.

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THE NEW RAVENSBOURNE

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A BUILDING WRAPPED ROUND AN IDEA

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Let's create a Higher Education College that looks outward, a place that will make a major contribution to the development of the digital age. A place to develop ideas and to bring those ideas to life. The idea of a College comes of age in a building designed for flow and integration. We're creating a place where skills and talents merge and mingle, where expertise is a bridge not a boundary.

At the new Ravenbourne we will remove the walls between departments - literally. We will create landings and lobbies, wide-open spaces and quiet corners. Social spaces, galleries, workshops and technology hubs. We will install design studios and production suites, resourced with state of the art kit, run as a professional facilities houses, open all day, every day, used by project teams rather than owned by departments. A digital destination for creative thinkers, for craftspeople, for designers, for broadcasters, for researchers, for commentators, for business people. For individuals who want to explore the potential of the digital world, for industry professionals who want to preview the future.

A building that is big, bold and utterly beguiling. A fluid, supple space where new ideas will emerge through meeting and mixing, engaging and connecting. As graphic designers work alongside programme makers, who talk to fashion designers, who collaborate with photographers, who connect with designers, who experiment with sound engineers, who team up with businesses, who build partnerships with industry until - well, you get the idea.

LEARNING SPACES @ GREENWICH

While classrooms and studios can still be regarded as our core learning spaces, it is obvious that a host of new factors and opportunities has dramatically changed this landscape. We are forced to use a broader term to describe these new possibilities. One compelling reason that the concept is expanding and evolving is that of new learning and teaching technologies are available. As their functionality expands new learning activities become possible. The traditional face-to-face classroom or studio is diminishing in usefulness with the rapid evolution and adoption of technology. Wireless networking for example makes real-time or synchronous interaction among students and between students and staffs a very real possibility.

More and more learning is taking place outside the traditional classroom than ever before. With an increased emphasis on mobile computing such as the use of laptops and hand held devices, making possible a variety of collaborative and group projects.

Another compelling reason for this shift is because of the new learning technologies, we can think of virtual spaces as well as physical spaces. Unlike real spaces, virtual spaces can come and go. They can be spontaneous as well as deliberate. They can be asynchronous as well as synchronous. Participants and their relationship in virtual space can shift rapidly. Participants can also multitask, inhabiting more than one virtual space at once, unlike physical space. With the increased functionality of technology virtual spaces will play an increasing role in all aspects of Higher Education.

No one ever said that designing exceptional learning environments was going to be easy and that building an appropriate, engaging, challenging, ambitious and effective, world-class digital learning environment is highly complex. That complexity is neither well understood nor well documented; it is thus not well implemented either. We therefore have few models to work from.

It is clear that in planning our new facility at Greenwich we need to recognise these changes and we must adopt a much broader frame of reference than just our traditional concept of space.

COMPUTER ART & OUTPUT
THE IMPASSIVE LINE.

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This paper considers the issue of digital output in the light of the author's early experience of observing plotter drawings at the Slade School of Art in the mid 1970's. The paper proceeds to discuss the author's own work in terms of a range of outputs and their implications in forming a relationship between old and new technologies. Other artists referenced in this paper include Michael Craig-Martin and Kathy Prendergast. The paper draws on research from the AHRC funded project, The Personalised Surface within Fine Art Digital Printmaking.

THE IMPASSIVE LINE

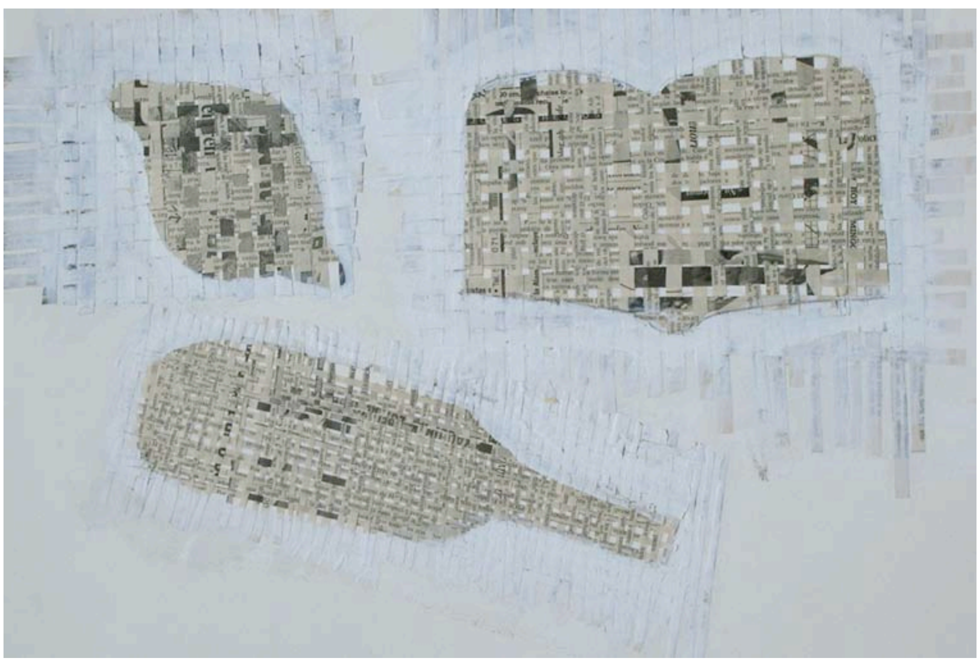
In Digital Culture, Charlie Gere argues that ' the artist who has had the most profound influence on our current digital culture is the composer John Cage. Through his pioneering artistic practice in the 50's and 60's and through his influence on other practitioners and groups, he fostered interest in a set of concerns that would later become central to the development of digital media and digital art' [1]

Gere then goes on to describe the fact that Cage's early work didn't involve computers at all but suggests that in the 1950's Cage was 'responding to a similar set of issues and ideas to those that were beginning to be rehearsed in relation to computers.'

As a young artist I was excited by the possibilities of Cage's work well before I had any idea of its relationship to the computer. Ideas take time to filter through and sometimes longer for an artist to become conscious of the root of their ideas. This has certainly been the case in my own work in particular in relationship to the change from a language of drawing as an expression of an individual signature, through to a more impassive line, a line that seeks its quality from its clarity and detachment. Gere's assertion also suggests the way in which ideas lead technology and that in many cases, new technology can provide an artist with a solution to a problem already being tested through older technologies. But before going into more detail about my own work, I wanted to describe the circumstances under which I first encountered the computer as a tool within art practice.

I was a postgraduate student in Printmaking at the Slade School of Art in the mid 1970's, The Slade at this time was composed of many different fractions, life drawing under the tutelage of Euan Uglow and Patrick George who perpetuated the Coldsteam approach of measurement and restraint, printmaking under dos Santos and Stanley Jones looked to Goya and Pirenasi and the School of Paris while the painting department under Malcolm Hughes was committed to an exploration of systems, Into this strange mix was also what was referred to as *the experimental department*, a hybrid space under Hughes, where the use of the computer within art was being explored.

Whilst there was limited interaction between the various departments, there was a sense throughout the Slade that drawing underpinned practice and along side this, a questioning of what drawing might be. In this respect John Cage and Marcel Duchamp were significant influences, providing evidence of an approach to art in which ideas took president over gesture and emotion and where the mark could be seen as a consequence of predetermined decisions.



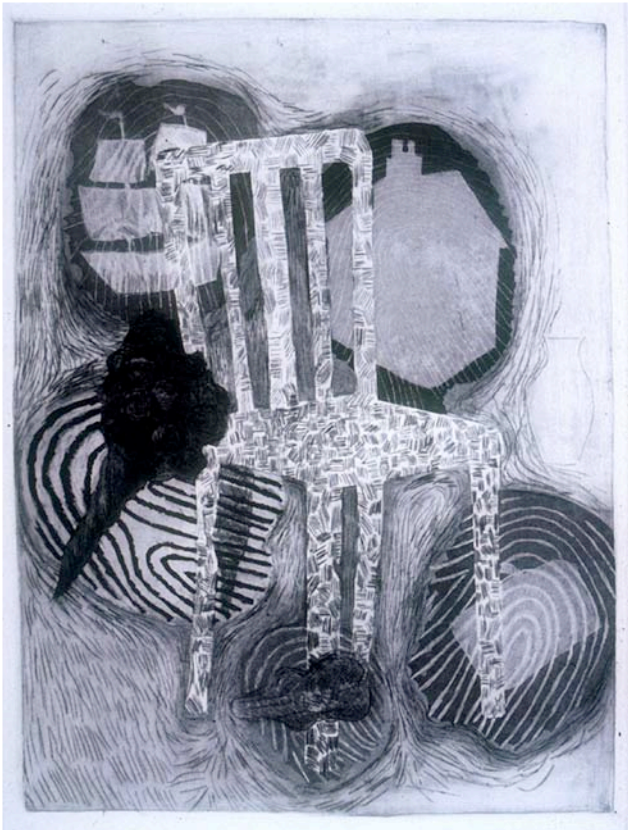
1. P.Coldwell -Drawing-mixed media on paper

While at the Slade, although not personally involved with the experimental department, I was aware of the work of Chris Briscoe, Julian Sullivan and Darrel Viner, and their attempts to get output from their computers. For the most part this took the form of printouts using a flatbed ink plotter. For me there were two distinct reasons against getting involved with this technology. Firstly that at that time a knowledge of programming was essential and secondly that it seem immensely time consuming and that drawings I naively felt could have been done in a few minutes with a ruler and pen, took sometimes days to output.

The plotter drawings were also challenging to me as a printmaker. It was unclear if these were to be seen as drawings or prints, either way they had the quality of office documents rather than fine art. They seemed far removed from the emphasis on handmade paper and rich physical qualities that as printmakers we took as pre requisites. However the then research assistant in printmaking, Chris Crabtree, himself well versed in programming had begun to be involved in the experimental department and was developing computer drawings that would then be realised through photo etching or lithography.

This early encounter, combined with other ideas ‘in the air’ has shaped my approach towards the computer, steering my work away from what I could describe as ‘painterly concerns’ to ideas that were more centred on drawing. I was moving away from a gestural language towards a more objective approach and on reflection my thinking was being shaped and reformed by amongst other things this observation of the computer as a tool.

In printmaking there is a very natural separation between action and result. Working in intaglio for example there is the obvious mirror reversal of image as well as the fact that the etched line is drawn as a bright line in a dark ground which, when etched, becomes a black line against the white of the paper. Likewise in lithography and screen-print, where original marks are translated into ink on paper, its colour independent of the original drawing. So from this perspective, the idea of translation, from the image developed on computer screen to a physical output is part of the natural thinking within the discipline of printmaking.



2.P.Coldwell –Chair, Etching & Aquatint

Barbara Nierhoff_Wielk identifies this connection between printmaking and the computer, seeing is as both part of that history but also a radical departure.

> 'Is the computer then a new tool like pen and pencil in former times, or is computer graphics a new printing technique like lithography, for example, in the 19th c, or serigraph in the mid 20th c ? It is far more than that- the computer may well also be a new tool, and computer graphics also a new printing technique, but it is first and foremost the expression of a new conception of an image'… even if plotter drawings look like hand drawings at first, they are nevertheless pictures that have been drawn neither by the hand of an artist, nor printed from an artist's hand made template. Instead, they have been calculated by a computer according to a specific programme and drawn by a plotter.'[2]

While it would be 20 years before I would begin to use the computer as part of my practice, I had begun to experiment with ways of creating a more detached line. I traced, reduced drawings through multiple photocopying, played with drawing tools to enlarge or reduce and used printmaking as an intentionally intermediary process.

In a recent conversation with Michael Craig-Martin at the V&A, he spoke with great insight about his experience of discovering the computer. We had discussed how his recent work developed from his wall drawings from the Rowan Gallery in 1978 which were hand drawn, photographed, then projected onto walls and redrawn using tape.

> ' …and suddenly I realised, *cut and paste*, that's what I had been doing with these drawings. So I scanned all the template drawings and got them in the computer. They were very crude pixalated images but it was like a dream come true, as if someone in heaven had thought, what does Michael need, he needs a computer that does cut and paste. And suddenly all those things I couldn't do before, I could do. I could suddenly make the drawings 1% or 200% bigger, I could flip them over, I could do anything with these images and I could see it instantly. I could save it, do another, it was as though I had spent ten to fifteen years waiting for the computer.'[3]

Craig-Martin confirms that view that ideas lead technology and certainly this was the case when I first began using the computer.

My memory of the early pioneers had fixed in my mind something about the space that I would explore when I came to making works through the computer myself. In those drawings they had explored a flat space personified by the flat bed plotter itself, a space in which lines can be directed to go up, down or across, a space referencing Paul Klee's maxim of taking a line for a walk.

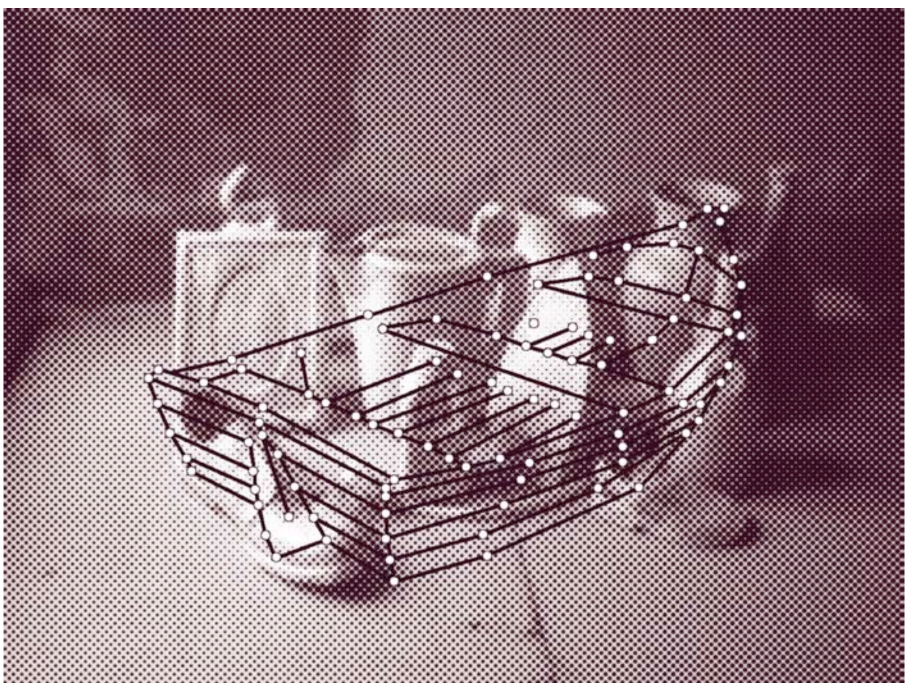
3. P.Coldwell- My Father’s Coat. Etching from Digital File.

My first attempts with the computer were in 1995 when I was invited by Tristan Humphries to join a small research project between Camberwell College of Arts and Chelsea College of Art & Design, which was looking at the potential of the computer in relationship to for printmaking.

Whilst by this stage, software such as illustrator and Photoshop enabled artists like myself with no programming skills to work independently with the computer, I was greatly helped by the assistance of George Whale, whose patience and troubleshooting proved invaluable. There were issues however that had to be taken into account. The choice of paper was limited, either a thin matt cartridge or else a high gloss for more photographic work and most importantly, the inks themselves were fugitive, being at that stage dye based. There was also considerable delay between action and result; there was a delay in drawing a line and seeing it manifested on screen and also there was the continuous requirement to save since the machine would regularly crash. Together these made me aware that working on the computer was a very different activity to simply drawing. It required planning, patience and I also began to understand that it might require a different way of working emotionally.

These early works of mine where fully developed on screen and then transferred to photo etching. This enabled me to have the benefit of the fluidity of developing the drawing within the computer and then the use of my craft skills in realising them as finished works in print. I could etch each line according to its particular need and in some cases, etch the whole plate to a sufficient depth that I could print it as if it were relief. What I was particularly excited by was the fact that the final output didn't have to reveal the complexity of their making. Whereas in my previous prints, the etching plate for example would be a record of all my actions, using the computer I was able to edit out all the preparatory work. I could also redraw elements whilst still keeping the original as both a reference and alternative option. In addition I also became more aware of was the kind of space I wanted to deal with. I wasn't interested in trying to construct a deep space; I was interested in marks across the surface.

When drawing in the computer, I have always used the mouse as my preferred tool. This is to signal to myself that drawing in the computer has little resemblance to drawing with pencil or other drawing tools. I hold the mouse with my whole hand, and I draw by either sliding it across the mat or else, by clicking, fix points. This also reinforces the fact that the space I am dealing with is a flat space and whilst I use layers, I know that these are virtual rather than real.



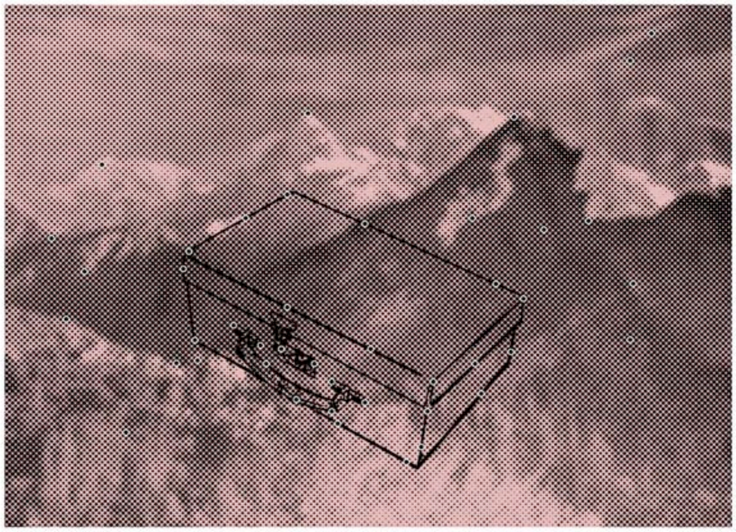
4. P.Coldwell- Constellations. Inkjet

A further aspect for me in using the computer has been the rather obvious fact that drawing and photography can be brought into the same space. A photograph once imported, becomes malleable.

> Digital reproduction makes manifest what we always knew about the suspect nature of photography's claim to objectivity, by promising to reunite photographic reproduction with painting"[4]

When I use the photograph in my work is to be seen as a graphic device. The image is invariably half toned, a reference to the means through which a photograph is transformed from chemical to graphic representation, but also so it is apparent that the information, like the drawing is to be read across the surface. This had led to works which play between the two languages of drawing and photography within a space where each is equally subject to change, the drawing literally linking points across the surface of the photograph. I have also in manner cases treated the photograph as a drawing, manipulating each half tone dot, enlarging or reducing, to literally redraw the photograph.

While for the early pioneers, the means of achieving output was somewhat limited; the contemporary artist is now presented with an almost infinite choice. There are perhaps two distinct categories, the first in which the image remains within the digital environment, i.e. the computer driving a plotter, printer or cutter to produce an image that has literally been untouched by human hand as in Tim Head's Dust Flowers (inkjets) or Marlene Oliver's digitally engraved acrylic Exhausted Figure 2007. This approach can also include works which are conceived specifically for the monitor or plasma screen as with Craig-Martin's Becoming 2003, where using bespoke software, a continually changing set of relationships is played out. The second category is where digital output is used to engage with older technologies for example in plate making or forming the positives for screen prints as with Julian Opie, Watching Suzanne 2006, (screen-print on acrylic sheets), or laser cutting the woodblocks as with Terry Winters, the blocks then printed using a conventional press. Increasingly there is an understanding that the digital does not have to operate within its own vacuum but can be seen within the wider context of printmaking.



5.P.Coldwell-Sites of Memory:Suitcase. Screenprint

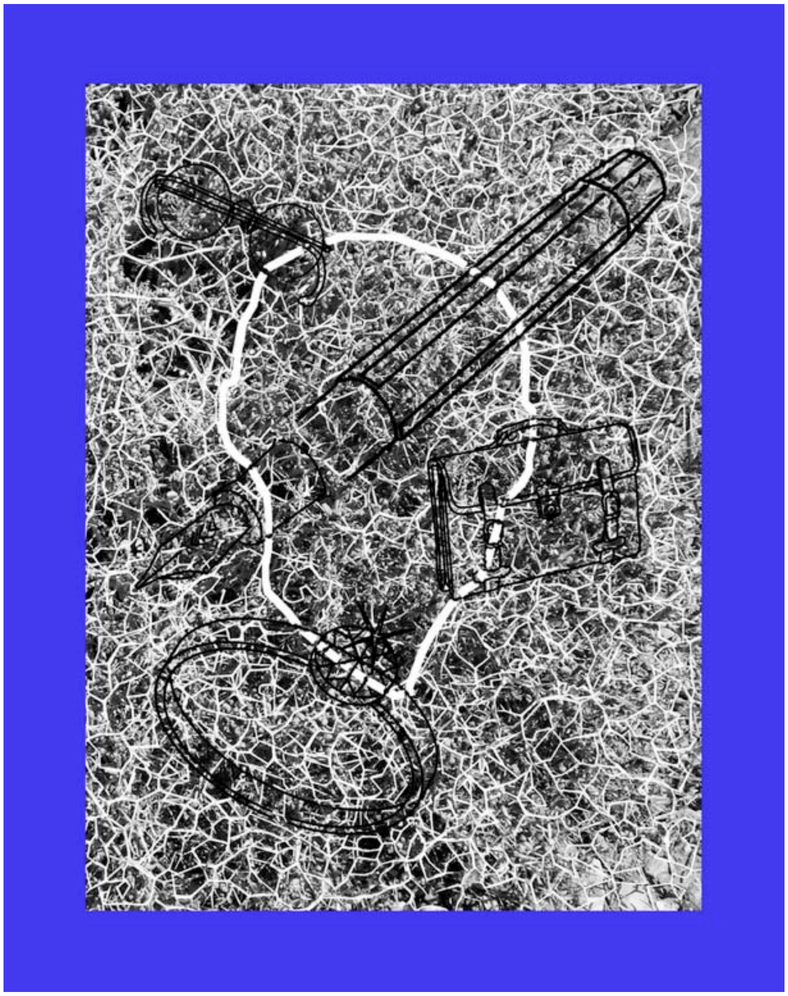
In terms of output, as mentioned my earlier digital work used photo etching as means to print out, and I have subsequently used lithography, screen-print as well as images conceived and executed through inkjet. In addition I have begum to combine inkjet with polymer plates and lino cut to introduce areas of relief printing to the inkjet image.

The inkjet print is now a far cry from the first four colour Encad prints. The new range of large format printers not only print to the highest photographic standard but also are also capable of outputting onto a range of substrates, from heavy fine art papers through to plastics and material. However there is uniformity, perfection about this technology that doesn’t always sit with artist’s intentions and needs. In a recent research project, The Personalised Surface within Fine Art Digital Printmaking, this question of output was addressed through artist’s case studies and interviews.

One of the artists involved in the project was Kathy Prendergast, an artist who we first worked with in 1999. Then she developed, with the research assistant George Whale, the print Lost Map in which she took the data of a map of North America and stripped it of all its place names. Then she systematically reinstated all those names with the suffix lost placing them according to their coordinates. This was an intriguing project working on many levels, which while on one level utilises the computer as a tool for detached manipulation of data, on another level resulting in an artwork with great depths of emotional feeling. Prendergasts’s map reveals an emotional seam within America’s geography and history, places of loss and unfulfilled dreams. In addition, it reveals those places that are too small to be registered on a broad map of America, a reminder of the manner in which a continent is populated by individuals. This further connects to her own Irish background and that history of emigration in the search for a better life. Prendergast's sculpture work and drawing is characterised by an intense physical engagement, which here she substitutes for a manipulation of data.

> PC It could seem from what you have said…that there could be a contradiction for you in using digital technology. You don't have the direct correlation between your hand and the mark.
> KP Well I agree. It's a completely alien process for me, there's a distance there. The first project I did with this technology was Lost map and it could only be done through the technology. I looked up emotional place names and tried to hand draw the maps but it didn't work, so when you invited me to work with the project it was an opportunity to use this technology and I realised how important it could be for artists.
> PC … you digitally unraveling the surface of the map.
> KP It was deleting, not drawing, an act of destruction removing all the other place names. It was the opposite of drawing.[5]

Working with her again, this time supported by Jonathan Kearney, she took a contour map of Mt Fuji and gradually interwove an image of cherry blossom, reinforcing the reference to Japanese ukoyo prints. Here her process was to output through inkjet, draw onto the proofs, scan, reprint, re draw until the image reached a conclusion. Here the output is both serving as proofing to give a physical evidence of the image on screen as well as a substrate to receive more drawing. Prendergast's drawing occurred both on screen and on paper, a continuous dialogue between virtual and real.



6. P.Coldwell-Untitled, Inkjet & Linocut

This relationship between virtual and real offers exciting possibilities, especially in my view when this new technology is seen within a broader tradition of printmaking. New technology enables older technologies to be revisited and examined for untapped potential and as the hardware gets cheaper and more assessable, artists will have more opportunity to play. As a footnote, I am currently exploring ways of producing prints through laser cut, perhaps not so far away from the original plotter drawings that made such an impression on me in the mid 1970's.

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THE DIGITAL ATELIER: HOW SUBTRACTIVE TECHNOLOGIES CREATE NEW FORMS

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The Digital Atelier: For 50 years artists have been utilising the convergence and combination of different technologies to produce visually and intellectually challenging artworks. These artists create compelling artefacts that engage the pragmatics of technology and the free invention of art and bring them to a successful synthesis. A close examination of work from the past and present reveals how advanced digital design methods and subtractive fabrication processes have been used to make physical things from virtual data.

INTRODUCTION

The idea of a Digital Atelier comes from the French term for studio. Since the 1960s [1] the conceptual path of a small group of painters, printmakers and sculptors was considerably altered and redefined by the use of the computer. These artists began forging new forms utilising digital design systems and fabrication processes and have produced work that uses both subtractive and additive technologies. Their research encompasses the scientific exploration of materials, the development and use of new technologies, the cross-fertilisation of old and new technologies and the creation of new forms.

TECHNIQUES AND TECHNOLOGIES

The term solid freeform fabrication is applied to a range of techniques for manufacturing solid 3D objects directly from Computer Aided Design (CAD) data. To make sense of the many techniques and technologies used today we can divide them into either subtractive or additive processes.

Subtractive fabrication is the term given to any fabrication process where material is taken away or reduced from a solid in order to reveal a new shape. This subtraction can take place using any combination of tooling techniques such as drills, lathes, and grinders, and more recently lasers and high-pressure water jets. With additive fabrication, the machine reads data from a CAD drawing and lays down successive layers of liquid or powder and in this way builds up the model from a series of cross sections.

This paper will focus on artists using subtractive technologies. A second paper examining additive technologies will be delivered as part of Digital Continuities: From the History of Digital Art to Contemporary Transmedial Practices at the Association of Art Historians conference from 15th – 17th April 2010 at the University of Glasgow.

The following examples echo the forms of the past whilst utilising the latest technologies. Using the concept of 'Ideas before their time – Connecting the past and present in Computer Art' I am going to take a look at the work of two pioneering artists working with subtractive technologies: Robert Mallary and Richard Hamilton and how they have influenced the work of two specific contemporary artists; Bengtsson and Delvoye in the case of Mallary, and Grossman and Shafiei in the case of Hamilton.

MALLARY, BENGTSSON AND DELVOYE

Bengtsson and Delvoye laser cut a variety of sheet materials from plywood to corten steel to create their volumetric sculptural artworks. In 1968 the artist Robert Mallary began to experiment with computer sculpture, he manufactured Quad II and Quad III. To create these sculptures he developed his ideas on sequential contour projection and used them in the creation of sculptural computer forms [2]. The computer program he developed with his colleagues was called TRAN2, described in the following extract:

"TRAN2 is a computer graphics program with twenty sub-routines to generate sculpture. The program presupposes a means of compiling form description data for use by the computer. This is done by breaking down the solid into a regular series of parallel cross sections, or contour "slices," which are then graphed and digitized as X, Y and Z coordinates and transferred to punch cards. A sequence of mathematical transformation procedures is brought to bear on the contour sections whereby the computer, in effect, models and reshapes the contour sections into an original sculpture. The computer plotter reproduces a series of perspective views of the generated form together with a complete set of the transformed contour sections. These are used as patterns to complete the sculpture in some appropriate material."

Mallary considered the computer as an intelligence and information amplification device which could be linked synergistically with the unique, creative capacities of the human mind for creative activity, surpassing either human or machine capabilities functioning independently.

Figure 1. Quad II. 1968. Material: Plywood. Robert Mallary

The information for the contour slices in Fig. 2 was transferred to computer punch cards as described before. The plotter produced a series of perspective views which Mallary called 'Computer transformation templates'. These 2D slices were used as patterns for cutting the final sculpture from laminated wood veneer.

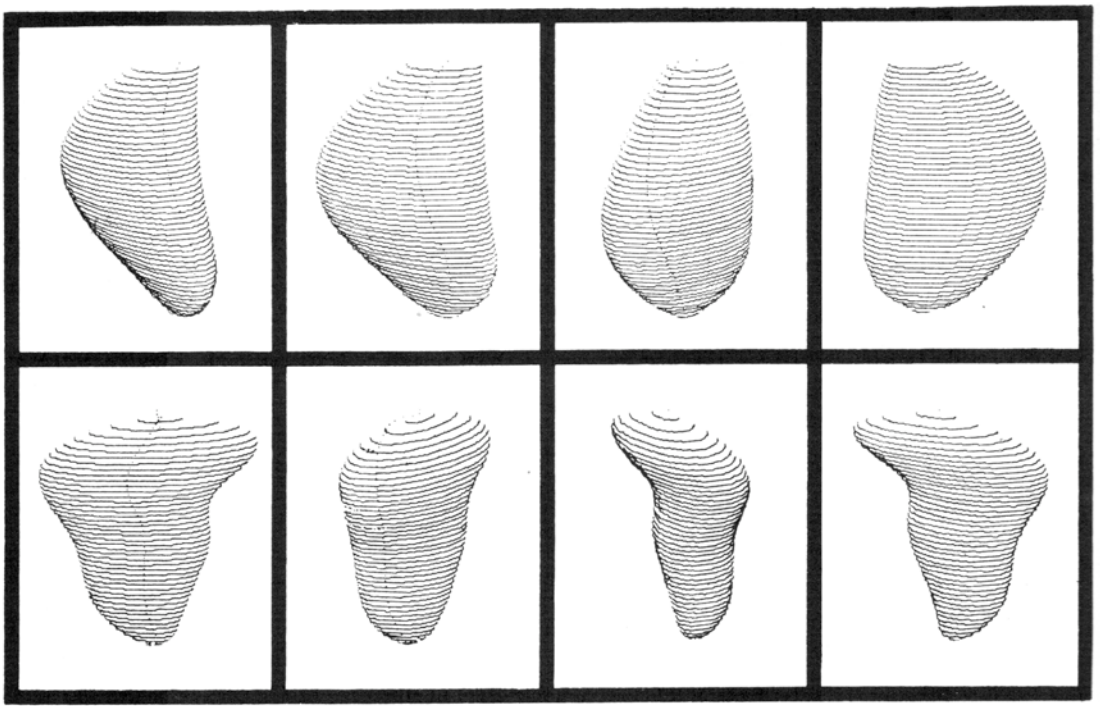

Figure 2. Computer transformation templates. 1968. Robert Mallary.

Mallary began using rapid prototyping for his sculptures in the 1960s and since that time increasing numbers of visual artists have used rapid prototyping, as prices of hardware and software have dropped and performance, user interface and output technology have improved dramatically.

The following contemporary artists employ lasers to cut the component parts of their work using paper, wood steel and plastics. A laser is an amplifier of light, focusing it into an intense beam that can burn, melt and evaporate the material it encounters and because the cutting tool is a beam of light it can move very quickly and makes cuts as fine as the focus of the beam.

Mathius Bengtsson uses materials that are both natural and manufactured, each material seems to be carefully chosen to highlight the sinuous quality of the final design. *'The Slice chair was constructed with the same adeptness an architect would employ to create a topological map of the landscape, evoking the illusion of a piece of furniture cut away from a cliff face and scaled to human proportions.'* Bradley Quinn, in Scandinavian Style [3]. First drawn by hand and later modelled in clay, the Slice chair combines organic shapes with cutting-edge technology. Slice is constructed as an assemblage of horizontal cross-sections that stack together into a uniquely lateral profile. Laser-cut to a thickness of only 3mm, each individual layer resembles a two-dimensional abstraction more than it does a hi-tech element. Although the process was inspired by rapid prototyping methods, Bengtsson worked with more traditional materials. His starting point was to create a new form by using clay, which he then sliced in horizontal layers and manipulated digitally. The result was a surprising shape that blurred the distinctions between armrests, backrest, legs and frame.

Figure 3. Slice Chair. Material: Plywood. 1999. Mathius Bengtsson

'It has such a strong aerodynamic feel that it could be an aircraft or a Formula One racing car.' Corinne Julius, in the Evening Standard

Conceived as a single, sweeping curve, the 'Slice chaise longe' comprises a contouring backrest that arcs forward to support the legs and feet. Crafted in ninety nine individual layers, regular spaces between each allows the eye to travel far beyond the chaise's structure. As with the aluminium Slice chair, Bengtsson used transparency as a device to deconstruct the conventional parts of a chaise longe. Bengtsson's technique makes every aspect of the chaise visible in a single glance, and breaks down the density of its complex surface area. The 'Slice chaise longe' echoes the form of Mallary's 'Quad I' and 'Quad II' but in the horizontal plane.

Figure 4. Slice Chaise. Material: Acrylic. 2000. Mathius Bengtsson

Wim Delvoye takes laser-cutting in steel to a new scale with his highly detailed sculptures in ornate patterns referencing the industrial revolution and gothic and Victorian architecture.

Figure 5. Wim Delvoye. Peggy Guggenheim Museum 2009.

Wim Delvoye’s artistic practice draws on the notion of the attraction of binary opposites: the past and the present, the triumph of ornamentation over functionality [4]. The Peggy Guggenheim collection presented Wim Delvoye’s latest creation, 'Torre': a corten steel tower, with ogival windows, tracery and turrets in the international gothic style, on the terrace of palazzo Venier dei Leoni, overlooking the grand canal in Venice in 2009.

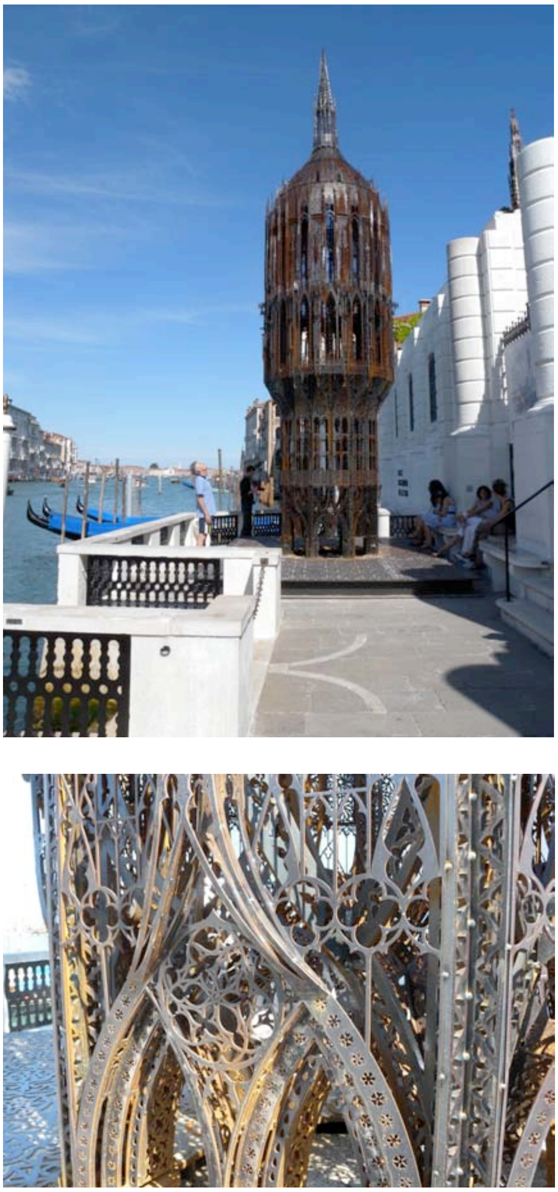

Figure 6. Torre. Corten steel. 2009. Wim Delvoye. Peggy Guggenheim Museum.

"I tried to integrate the tower with the building, but the architecture of the building is Neo-Classical. My project is another style completely. The way I designed it is also very unorthodox—from the top down rather than from the base to the peak.

I want every detail to be perfect. My design team has incorporated the Gothic style and Gothic Revival into the tower. These are architects who have worked with me for years and totally understand what I want. I've constructed other towers, but they were mere exercises in relation to this one. Last year I exhibited a couple of 6-meter-tall [20-foot] maquettes in Moscow and Basel, but the tower for the Peggy Guggenheim Collection is a scale model for a tower that I hope someday to build. It's one-to-four, a quarter of the size, which is still huge.

I've designed towers 80 meters [262 feet] high. One is 325 meters [1,066 feet] high to match the Eiffel Tower. They remain maquettes, but with the Venice tower I'm very motivated to push the design into reality because I'm satisfied with what we've done. It starts where Gothic stopped. We somehow ate it all, we assimilated it, and now we've done a Gothic style that has never been done. It's like we've continued a long tradition, but we are not just copying other people—we're inventing.

The tower is Cor-Ten steel, which is laser-cut, folded and welded. It's layered and very sculptural. The surface will be rusted, but we'll varnish it to keep it from bleeding into the stone of the historical building. By making it in this steel we can do things that the Gothic builders couldn't do. Some of those things are more beautiful in steel than in stone.

The designs are computer-generated. Since 2000 I've created 3-D images so I can see how my works might look in real life. We have several different programs and we play with their limitations. I'm always reminding my staff about the great cathedrals of Strasbourg, Cologne, Canterbury and Paris, which weren't built with computers, cameras and helicopters". Wim Delvoye

HAMILTON, GROSSMAN AND SHAFIEI

Richard Hamilton's interest in technology began with his reading Giedion's 'Mechanization takes Command'. The impact of technology was also the theme of Hamilton's exhibition 'Man, Machine and Motion', at the Hatton Gallery of Newcastle University and the ICA in 1955.

From 1951 to 1963 Hamilton made perspective drawings leading to the 1964 print,'Five Tyres Abandoned' In an issue of a magazine called Technique et Architecture published around 1951, there was an illustration of five tyres in a row. On the centre of each tread was an oval panel labelling it with a date – 1902, 1905 and so on to 1950.

"In 1963, I began to make a perspective drawing of the subject. I proposed to make a print; an embossed relief, printed blind, so that the effect would be of the varied treads of the five tyres pressing up from the back of the paper – but in perspective. After working for a good many weeks it became clear that to continue in the rigorously accurate manner that alone made the task worthwhile would require such an abundance of time that I would have to consider whether the result could possibly merit such devotion. It was then I regretfully decided not to complete the drawing, and 'Five tyres abandoned' became the title of the 1964 print." Richard Hamilton.

The project had been revived in 1970 when an American art dealer, Carl Solway, publisher of EYE Editions, offered to find a US computer programmer interested in plotting the perspective drawing with a computer. Sherill F. Martin, manager of computer animation at Kaye Instruments, organised the computer formulation of the perspective drawing using a general FORTRAN programme called CAPER (Computer Aided Perspective).

"The uses to which the computer has been put by artists most often develop out of properties peculiar to that device which enable it to use a set of instructions to effect transformations of a given image, or develop sequences of kinetic patterns. There is a tendency to ask it to perform what it most likes doing, or at least what it does most fluently, so we have to come to recognise a computer graphics style. [5] The use of a computer to make a conventional perspective projection puts no claim on its capabilities as an image creator – that is to say, the stylish qualities are not prompted by the tool. This kind of problem might have been posed by anyone since Piero della Francesca and its solution can be precisely forseen. What the computer provides is an inhuman speed which makes possible the formulation of a complex perspective image in its purest terms." Richard Hamilton

Figure 7. Five Tyres. 1972. Printed by Frank Kicherer, Stuttgart. The relief cast was made by Hartmut Freilinghaus of Hamburg. Richard Hamilton. V&A print room '3D for Print' symposium March 2009.

"Major computer programmes usually have wider applications than that of giving an answer to the specific problem in hand. CAPER (computer aided perspective), itself an extension of CALD (computer aided line drawing), by S E Anderson of Syracuse University, May 1967, is a general programme, written in FORTRAN. This offers the essential notions as to how instructions to the plotter may be stated, together with card – coded commands which provide the potential for the generation of any line- drawing. Sherill Martin received the data and proceeded to inform CAPER so that it would tell a plotter how to draw the required perspective. A series of encoded messages was then converted into a deck of punched cards. An IBM 36075 computer read the deck and generated signals on a magnetic tape to control the movements of a pen on a drafting machine. In this case a Calcomp 763 was used, which co-ordinates rotary movements of the paper with lateral movements of the pen along the axis of the cylinder to produce any figure.

At this stage the original idea of producing an embossed print on paper was modified to a proposal to cast the relief to the treads integrally with a sheet of cold-curing rubber. I filled in the linear drawing by hand with the intention of etching a metal plate to serve as a mould. Etching proved unsatisfactory, so the mould was mechanically engraved in a brass plate. Machine cutting permitted a variation of relief. To take advantage of this, a further drawing designated depth of cut in tenths of a millimetre. The 'print' is 'cast' by spreading on the plate a silicone elastomer (manufactured as a flexible mould material), then reinforcing with a non-woven Terylene cotton fabric". Richard Hamilton.

Today Grossman, a sculptor and Shafiei, an architect use CAD in different ways to realise their three dimensional hybrid forms. The sculptor Bathsheba Grossman uses a laser to cut her CAD drawings into crystal. The points created by a focused laser beam are tiny (.1mm) fractures. The conical beam, with a focal length of about 3", shines into the glass without damaging it except at the focal point. At that one point, concentrated energy heats the glass to the cracking point, causing a microfracture.

To draw more points, the laser is pulsed on and off. To make the beam move between points, it is reflected from a mirror that is repositioned between pulses. The mirror is moved by computer-controlled motors, so many points can be drawn with great speed and accuracy. A typical design might use several hundred thousand points, half a million is not unusual in a large block, each placed with .001" accuracy.

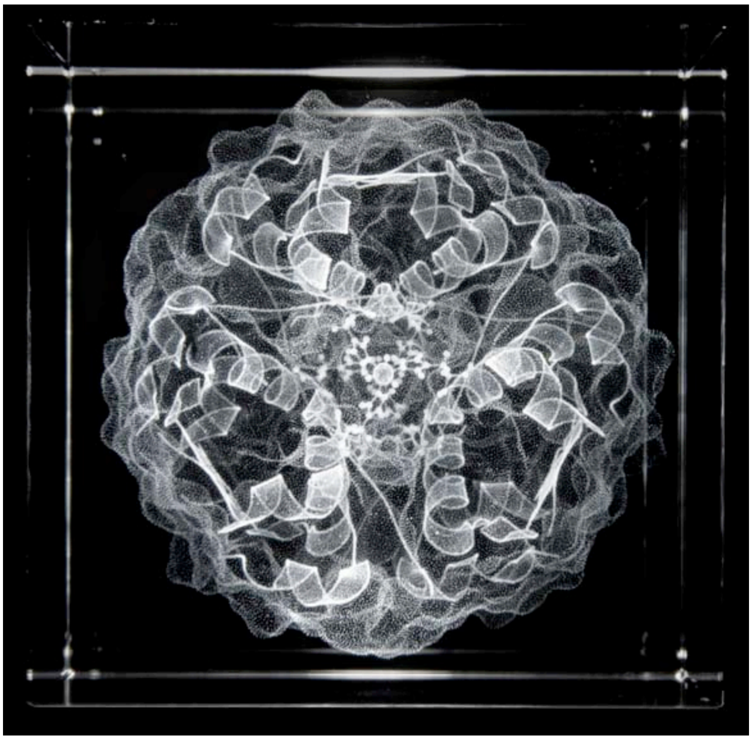

Figure 8. Insulin. Material: jLaser cut crystal block. 2007. Bathsheba Grossman.
The images are produced with different types of laser, and the results vary. Grossman uses a high-frequency laser, which draws points that are barely visible to the naked eye

using a Nd:YAG laser, named after its active medium: a yttrium-aluminum-garnet crystal doped with neodymium.

The glass itself must be clear optical crystal, since any ripples or bubbles would block or blur the laser. The process requires drawing in layers, moving from the rear to the front of the glass, so that previous points do not block the laser from drawing new ones.

The glass surface must be flat, or refraction will blur and redirect the beam; that is why it is difficult to work with spheres or other curved shapes. Refraction is also an issue in viewing curved glass: in a 60mm sphere only the central 20mm can be used, because optical magnification makes that area seem to fill the whole sphere. If anything is drawn closer to the surface than that, it will look very distorted.

The architect Sara Shafiei in her project 'Anamorphic Tectonics Theatre for Magicians' plays with the art of illusion, bending laser-cut card. The project is based on a site in the National Botanical Gardens in Rome, and proposes a dispersed magical illusion, with its central spectacle being a theatre for magicians. The building sits at the peak of the site overlooking the gardens. The use of text and cone anamorphosis along with other perspectival illusions, aid in the creation of a landscape of the imagination, which surround the theatre. The project attempts to portray how the foundations of magic and illusion can become an inherent part of an architectural design.

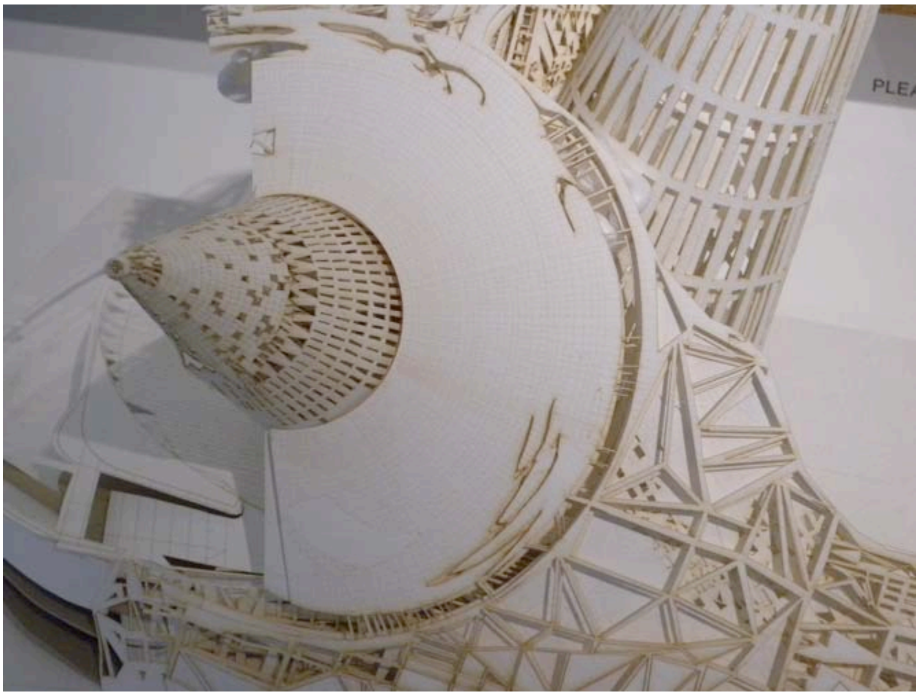

Figure 9. Anamorphic Tectonics: Theatre for Magicians. Laser cut paper, longitudinal section. 2007. Sara Shafiei.

Sara Shafiei explains: "Anamorphosis is a distorted projection or representation of an image on a plane or curved surface, which, when viewed from the correct vantage point, or as reflected space from a curved mirror or through a polyhedron, appears regular and in proportion. This technique takes the form of signs within my architectural proposal. It is used in order to allow the visitor to engage with the landscape and architecture and navigate their way through the site. The use of this technique will also allow the visitor to experience a slow progression of a landscape of illusions, from the onset of entering the site."

THE FUTURE

In 1985 Lisa Phillips, Associate Curator at the Whitney Museum in New York, made the following statement: "So many artists are exploring the computer that it cannot be ignored". But it wasn't until 2001, sixteen years later, that the Whitney Museum acknowledged this aesthetic by organising a major exhibition of Computer Art entitled 'Bitstreams'. Eight years on in 2009 the exhibitions 'Decode' and 'Digital Pioneers' were mounted at the V&A museum in London.

During the next decade digital craftsmanship will develop and new forms will emerge as solid freeform fabrication becomes more accessible and affordable and artists and designers investigate the many techniques that are available using subtractive and additive processes. This includes developmental research that explores new Rapid Prototyping techniques and processes, e.g. 3D scanning, CNC routing (3 and 5 axis), SLS (Selective Laser Sintering in Nylon), 3D printing and all the new and modified materials that are being developed.

The problems confronting these artists and designers will be the same that faced Mallary and Hamilton in the 1960s. How to consider specific items of technology in terms of what they can do and determine whether or not they are useful and whether or not they allow scope for an idea to be developed or communicated. Another challenge will be whether they can make the technology perform in a certain way even if this contravenes the intentions of its inventors.

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DIGITAL PHYSICALITY: PRINTMAKING

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This short paper revisits a few aspects of digital physicality in my experimentation with computer-aided printmaking during the 1980s and early 1990s. Topics include integration of hand-made and computer-generated, programmed and serendipitous, and output with a variety of traditional and digital printmaking techniques. My artwork in media other than printmaking is not addressed in this paper

INTRODUCTION

In 1980 I was a young artist fortunate enough to land a student internship in a computer graphics research lab at Columbia University in New York City. This allowed me to get close to computers at a time when they were bulky, unfriendly, and cumbersome. Up to that point I had been trained in the traditional and media arts, had experimented with animation and video, and had gained some recognition in the field of painting. I found computers intriguing, possibly because of my love for science fiction, and decided to learn how to use them. My ultimate and ideal goal was to somehow find a way to integrate computers into my artwork, even though the only reasonable way to output digital creations at the time was by using those noisy black and white dot matrix printers that are almost extinct today.

I decided to teach myself programming and that proved worthy, as I gained useful insights into the techniques and inner workings of the system. I also learned the process for sculpting virtual objects developed at that particular computer graphics research lab. The basic idea was to define 2D contours that were placed in 3D space and then reconstructed with software. The modelling process was laborious but it made use of a huge graphics tablet and that I liked. The process allowed the modelling of shape and surface irregularities and it did not follow the more common geometry-based approach. I liked that too. The particular computer system in use at the research lab was considered high-end, and consisted of a DEC VAX 11/780 with a 24-bit color frame buffer and an E&S PSII vector system. The modelling and rendering techniques that I used in the early 1980s are documented in [1].

Figure 1. Pyramid in Black and White Number Six, 1985, etching, 51 x 40 cm.

I experimented with a few ways to incorporate the images created with the computer system into my artistic vocabulary. I also wanted to continue working with some of the traditional techniques that I had been using until then, and that remained a guiding thought as I explored with the new digital technology. I particularly liked the procedural approach of working with computers, and incorporated that into my creative process. Cynthia Goodman, Program Director IBM Gallery of Science and Art at the time, said of my working process: “In spite of his intense involvement with computer-generated imagery, the realization of these images in traditional art forms is central to both his working process and his success. Through his skilful integration of images created on computers with others which have been either hand-drawn or painted, Kerlow has demonstrated how electronically-generated imagery offers not only an end product but also a point of departure for a creative mind” [2].

While at the computer lab I experimented with different ways of capturing the imagery that I was creating with the computer system. I tried all the imaging techniques available to me there, as I was interested in finding out about the different visual signatures and degrees of fidelity that were inherent to each. Dot matrix printers yielded a high-contrast black and white image that immediately made me think of the type of high-contrast imagery that I had previously used in graphic arts projects. Electrostatic printers delivered a sort of a black and white halftone printout that was detailed enough to preserve some of the pixels in the color computer-generated image. The software I was using at the time was not suitable for producing four-color separations but I created simple spot color separation techniques by manipulating the color look-up tables in the rendering software. I also took photographs directly off the screen by using a tripod and turning the ceiling lights off to minimize reflection and glare on the monitor. Through trial and error I became proficient at photographing the vector display on high-contrast film and the raster display on color transparency film. I obtained good quality film transparencies that I could further manipulate in the darkroom, as these were years before the release of the Photoshop software in 1990.

Figure 2. Maya in the Clouds, 1986, etching, 48 x 67 cm.

After a couple of years of experimentation in the computer lab and in my studio I decided to put together a series of prints where I could apply the techniques that I had developed. I was eager to get busy as I was not aware of anyone working with the same approach of integrating hand-made and computer-generated images. I started working on a series centered around pre-Columbian patterns, fantastic characters and natural elements. Pre-Columbian architecture has been a favorite interest of mine, and I was struck then by the similarity between the jagged edges of low-resolution computer displays and those of stone architectural ornaments found primarily in Mayan and Mixtec pyramids [3]. Through research and previous familiarity with the topic I also found interesting parallelisms between the colourful patterns of hand-made Maya textiles and the textures that I was able to create with the software at my disposal.

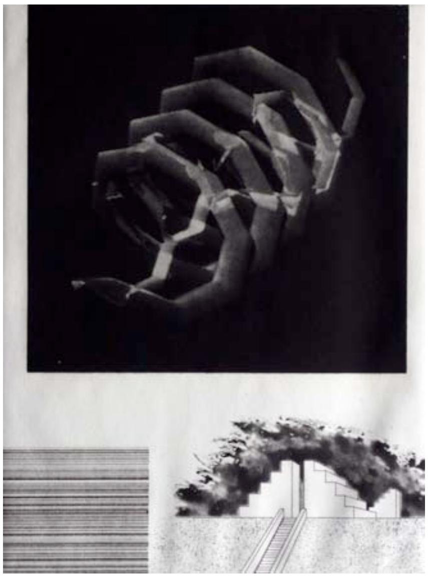

Figure 3. Pyramid in Black and White Number Five, 1985, etching, 51 x 40 cm.

TRANSFERRING THE COMPUTER IMAGES ONTO A PLATE

The image and archival quality of digital prints in the mid-1980s left a lot to be desired, so I focused my attention on ways to transfer the computer images onto traditional printmaking techniques. “There is a strong conceptual similarity between traditional printmaking and computer image generation. Both techniques are based on the idea of making multiple copies from a single matrix. Traditional printmaking techniques use one or several printing plates, and computers use the numerical description of an image as a matrix for producing multiple versions. It seemed natural to me to transfer the results of a numerical matrix onto a printmaking matrix for creating new versions of the same image” [4].

I decided to stay away from using graphic arts half-toning when transferring the computer images onto traditional printmaking techniques. After a couple of years of experimentation in the computer lab and in my studio I chose to use etching and aquatint techniques. “Pyramids in Black and White” is the seven-etching series that I completed in 1985 (Figs. 1 and 3) and printed on Rives Heavyweight paper. The transfer of the computer images onto the plate was done using photo-etching techniques, and I used the finest possible aquatint in order to obtain the richest black tones. Printing from such dense aquatints became a bit of a challenge while on the press but in the end I was very satisfied with the final quality. Soon thereafter I produced a few color etchings using spot color separation techniques. “Maya on the Clouds,” for example, features a high-contrast rendering of a morphed alphabet inspired by Mayan architecture floating on a two-color landscape of clouds (Fig. 2).

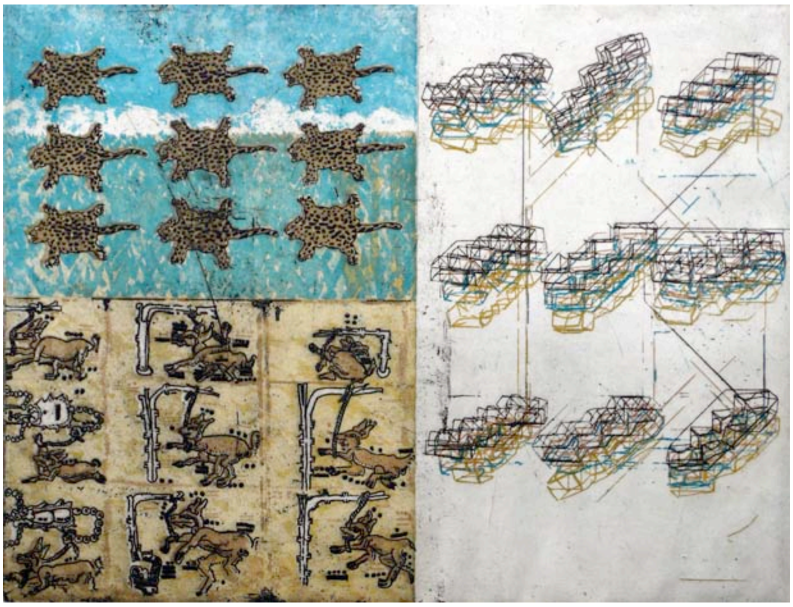

Figure 4. Freedom and Imprisonment, 1986, etching, 48 x 67 cm.

THE SECOND WAVE OF EXPERIMENTATION

Integrating digital and hand-made elements was at the heart of my experimentation with computer-aided printmaking. Cynthia Goodman and Juan Villoro observed about my integration approach. “Never content to use any medium in a straightforward manner, Kerlow’s collage-like intermingling of different media–the hand-drawn with the computer-plotted and the hand-painted with the computer synthesized–causes one to revise one’s opinion of each. Furthermore, some of his most sophisticated patterns were computer-generated and/or mechanically plotted and some of his most photographically precise images were either drawn or painted by hand” [2]. “What originates from a brush and what originates from a computer? To ask this is as absurd as trying to hear applause made with only one hand. A master of disguise, Kerlow makes the electric pencil act temperamentally and paints by hand with a precision that the inexperienced eye would attribute to the computer” [5].

Figure 5. The Big Spiral, 1986, silkscreen, 76 x 56 cm.

After producing a dozen prints I was quite comfortable with photo-etching techniques, and wanted to venture into non-photographic and more direct ways of transferring the computer-generated image onto the plate. I experimented with commercial computer-controlled engraving machines but was not satisfied with the results, so I modified a computer-controlled flatbed pen plotter with a steel needle instead of a pen. This allowed for the computer-generated image to be drawn directly on varnished metal plates, and be etched with an acid solution. The metal needle sometimes got stuck a bit on the metal plate and created a slightly wiggly line. I welcomed this technical imperfection as I missed some of the accidents that normally happen when working with traditional media. I wrote at the time "I am not attracted to the computer because of its capability of creating perfection or pure geometry. My interest in computers is to generate emotional works with a gestural unpolished quality to them" [4]. I also tried replicating the dry point technique with the needle plotter but the mechanism lacked the weight and power required to do it in a consistent and somewhat controllable way. "Freedom and Imprisonment" is a four-color etching where the right half of the work was plotted directly onto four cooper plates (Fig. 4). The work is loaded with poetical contradiction: the jaguar skins flying above the jungle are a metaphor for freedom yet the actual animals are dead in a real sense, while the deer below are trapped yet alive.

After the initial period of extreme attention to technical detail I explored simpler and more direct ways to transfer wireframe computer imagery onto etching plates smaller than the sizes that I was used to. I also worked with silkscreen techniques and produced a set of three technically ambitious and successful prints. These incorporated 2D and 3D computer-generated elements and hand-drawn images. They were printed on Arches 300 gr. paper, using transparent and opaque inks. During this time period I also continued to develop my artwork in the form of paintings inspired by or incorporating computer-generated imagery, and computer-based interactive installations [11]. My computer-aided printmaking methodology and techniques from this period are described in [6, 7 and 10] and reviewed in [8, 9 and 12].

Figure 6. Blue Pearl, 1998, digital print (inkjet), 28 x 34 cm.

In the early 1990s I started to use digital printers to edition my work. It was challenging at first due to the limited image and color resolutions, as well as the ultraviolet weakness of inks and pigments. But things improved with time and I ended up working extensively with dye sublimation and inkjet printers, although I am still interested in using traditional printmaking techniques. I editioned my entire “Broken Heart” project on a Kodak XL 7700 continuous tone digital printer on Ektatherm paper [13]. “Blue Pearl” is an inkjet digital print representative of my work from later that decade, the imagery depicts painted patterns distorted by a transparent virtual object (Fig. 6).

ACKNOWLEDGEMENTS

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MODELS, MAQUETTES AND ART OBJECTS: MAKING DATA PHYSICAL

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When I am involved in interdisciplinary collaborations with mathematicians and scientists, physical models and objects have proved to be powerful counterpoints to virtual models and data sets. I will discuss my use of rapid prototyping to make such objects, and contrast that to my earlier screen-based and online artworks. The use of rapid prototyping reconfirms the importance of the material properties of objects in my art practice, but accessing rapid prototyping machines is not easy. I will highlight some of the limitations of the rapid prototyping process and suggest reasons why fine art objects made with these processes are relatively rare.

THE JOURNEY FROM LIVE ART

I did my BA at Sheffield Polytechnic in the 1980s in Fine Art, Communication Arts, where I used video, film, and sound. Through working with my tutor, Fran Hegarty [1], a performance artist who uses video, I became interested in, and attentive to, the body in space. She helped me to train my thinking, and to pay attention to every thing placed in an installation, to be rigorous about what happened across time during a performance. Attention to detail was paramount. In light of this formative mentoring, I would describe my practice as being one that scrutinises structure and space, and makes a response to it. Sometimes that is literal, exploring the physical structures of a building or anatomical structures, but it may also be a social or cultural exploration of meaning. There can be an interesting overlap, or a kind of slippage, between how we relate to a physical structure, such as the heart or the English oak tree, as ‘out there’ and simultaneously as an icon, whose meaning is contested.

While at art school, I did not make many objects or models, focusing instead on performance and video. The nearest I got was as a first year student in Hull where we were expected to draw boats. Bored and bewildered by this assignment, I hung out in the local café with unemployed dockers who still went there every day because that was their routine, their structure. I got to know them a little and a couple of them guided me around huge, derelict, cut-up trawlers. During those walks I accumulated samples in plastic bags (flakes of rust, dried pigeon shit, dozens of discarded welders' gloves). For me, this was the true stuff of the docks, getting up close and personal in a way I could not do by sketching. I'd lay this accumulation of material out to make compositions, but it wasn't representational sketching. Now, when I work making art objects in my studio, I recognise a similarity to that gathering of impressions. I am not necessarily trying to represent something literally, I am trying to capture the essence of a structure, sometimes to allude to its ideal form (its 'model' version). The series of pieces that comprise Model Landscapes were made in this way. This is in contrast to the works I make with scientists, where the resulting object is in some way a literal representation of a data set (such as Heart).

Model Landscapes (2005). Two rapid prototyped tree forms generated from fractal data.
A video camera that sends the image to a small LCD screen.

GRAPPLING WITH DATA AND THE VIRTUAL

I did my Masters in Electronic Graphics in Coventry, an odd choice for a technophobe. I focused on making time-based work. It was incredibly frustrating, the relative fluency and sophistication of my live art seemed long gone, replaced by clunky, awful-looking animations. Like many of my cohorts I produced nothing in that 18 months that I liked. Subsequently, many of my so-called 'digital artworks' have a time-based element. In

TechnoSphere [2] the Alife creatures ‘perform’ their lives, in Cell [3] the simulation of time is essential to our modelling of stem cell behaviour. In that virtual space, the importance of every element we model cannot be underestimated because it impacts on the veracity of the stem cell simulation, and its resulting usefulness to our collaborator medical scientist. The concerns of much live art are still in the pieces, and ‘the devil is in the detail’.

During my MA I learnt, falteringly, to 3D model on a computer, which at that point meant typing in *x*, *y* and *z* coordinates, using DART™ software. I had a matchbox on my desk that I used to hold up as a stand-in for whatever I was modelling, as I struggled to visualise z space. It seems strange now, but screens really meant two dimensions to me then, and working with a third, virtual, dimension was hard. Nothing I modelled was of any interest, but visualising a 3D virtual space was pretty radical for me. The ‘z’ space was a non-space ‘in’ the computer. It was in data.

OBJECT FROM DATA WHICH WAS FROM A ‘REAL’ OBJECT

Years later I read about rapid prototyping in journals like *Scientific American*, and *New Scientist*. Most of the examples shown were three dimensional, but barely. It was rare to see any rapid prototyped object that looked organic or particularly irregular. I was intrigued, but struggled to relate fully to this process. My interest in rapid prototyping was not to make ‘the prototype for something’, but to make ‘the thing itself’ (what is now partly addressed through so-called rapid manufacturing). In essence, rapid prototyping makes real something that previously has been virtual, and that is what interested me. Previously the object has been in that ‘z’ space on the computer and I wondered ‘do you relate any differently to it, when you see it and can pick it up?’

Heart (2004) MRi data of healthy human heart reconstructed for rapid prototyping.Two angles of the resulting rapid prototype, silver plated.

I concentrated on ‘making real’ objects that had previously been virtual. The first object I made was from MRi data of the human heart. I worked as artist in residence with Francis Wells [4], a cardiothoracic surgeon. By working with him I became interested in the structure of the heart, especially how he saw a ‘model’ of a heart in his mind’s eye, alongside what he saw literally when he was operating. To operate, a surgeon accesses multiple simultaneous understandings, and three-dimensional ‘images’ of the heart structure. One understanding is based on what they see before their eyes and feel in their hands. Others are derived from conceptual models – the heart as a moving vascular structure. But the appearance of the complex vascular structure as shown in textbooks, is never seen in surgery (unless it is plastinated and preserved as a rigid immobile object). As soon as the chest cavity is opened and the heart lifted out, it is subject to gravity. The vascular structure, without the support of the surrounding tissues, collapses and hangs like a squid. The only time it is seen non-collapsed and ‘alive’, is mediated, in 3D MRi scans and echocardiograms. So, I made a heart on the rapid prototyping machine from MRi data as an experiment to see how the surgical team would react to it.

OBJECTS FROM DATA FROM VIRTUAL OBJECTS

After we made TechnoSphere, Gordon Selley and I wrote some plain English rules describing the way oak trees grow, and the way they look. We embedded these rules in algorithms, and used them to produce 2D images to make the digital photographic work, The Landscape Room, and the animation, Decoy. It was intriguing how many people suspended their disbelief and thought they were looking at ‘real’ trees when looking at The Landscape Room photographs, into which I had placed algorithmic trees. People believed they were seeing a real tree, even if it was a wire line (so largely transparent). Viewers said, “Oh! It can’t be real because that one is transparent. I don’t understand. Did you erase part of the photograph to make the lines?”

Decoy (2001). Still from one of the animated sequences.

For Model Landscapes some of these computer models were wrangled into a format that the rapid prototyping machine could use, to produce little 3D trees. Some of them were impossible trees (without collision detection some branches blended together). It was interesting watching people look at them. They looked at them from many angles, by moving their head around, in the same way the surgeons moved the heart or walked around the heart object. And the more angles they looked at the object from, the more they started to question whether it was real. Then they would have discussions amongst themselves about what 'real' meant. And that, for me, was really the whole point. What is it about a structure that makes us believe it is natural, organic, versus artificial, and does it matter? In relationship to model-making, how does the scale of an object or a model impact on our willingness to believe it is a real organic object?

MAQUETTES, RAPID PROTOTYPING AND SCALE

When I made Model Landscapes with the rapid prototyped trees, I never thought of them as a maquette. I thought of them as a model in the sense of being 'smaller than', and in the sense of them being an idealised tree. That was my motivation. I started to think about them as a maquette *after* I had made them. They came out of the machine and were exhibited almost immediately. When the work goes out into the world, my relationship to it changes. I am distanced from it. Seeing the trees as part of the Model Landscapes exhibition was like looking at those Gestalt images, when you see the wine glasses, and then suddenly you also see two profiled faces, and then you can only ever see both images of figure and ground, but beforehand you could have spent months only ever seeing one or the other. For months I had seen the rapid prototyped trees as an exploration of ideas about idealised landscapes, and been engaged with their relationship to mathematics, rules and the modelling of tree growth. Once I saw them as objects 'out there', I suddenly saw them as maquettes, which was disturbing.

I went back to the engineers at Bath University and said "Why is rapid prototyping used to make small things?" And the more important question, "What would happen if we scaled up rapid prototyping?" That was an important collision point for me. We had talked about approximation, and rapid prototyping being about intricate detail. One of rapid prototyping's selling points is that you can get within 0.1mm accuracy. But for me, what it does in terms of making virtual 3D data real is the cool thing. I asked Adrian Bowyer [5] at Bath University what would happen if you scaled up rapid prototyping, and he was willing to conduct a thought experiment with me. His first response was 'But of course it probably won't be very accurate.' I said 'No, okay, it won't be accurate, but if we made something that would rapid prototype something 40 feet high, do you not think somebody would find a use for it? We dreamt up giant cake icing type machines - robots that would pipe out expanding foam (or concrete) to extrude huge rapid prototyped objects, big and messy, not very accurate in relation to the computer file. For me, the making physical of something that is virtual is what is most interesting, and seeing the rapid prototype as a maquette rather than a model, made me think about wanting to scale up rapid prototyping, and that triggered off a huge number of problems, questions and ideas. These ideas have not been made real. Yet. [6]

THE TURN-OFF

Having a sketchbook with lots of ideas for rapid prototyped objects, does not mean any will get made. I am a determined, some say stubborn, artist, and many of the pieces I have made have been produced in a context where a lot of 'people who know' have told me a work is technically impossible, too expensive, or too big to produce. But I've made it anyway, somehow. So, it's notable that I've made so few rapid prototyped objects. The current lack of opportunity for artists to rapid prototype replicates the problems of early artist-adopters of other computing processes – 'who' makes and 'what' gets made is shaped by the context of the technology. A lot more designers use rapid prototyping than artists. Why is that? It uses a very uniform material, an ivory coloured plastic (a polymer) that is brittle, not that interesting. You can now rapid prototype with inkjet coloured plaster, but plaster is vulnerable. The inks are not archival inks. These are off-putting restrictions for sculptors, used to a range of materials that have a richness, different surface textures, strengths, durability. Currently, rapid prototyping materials do not have that variety. And it is also expensive. Every time I say that, industry people say 'Oh but you can buy one for £1500.' But unless you are going to use it a lot, £1500 is a lot of money for most artists to spend on trying something out. In summary, there is a dominant culture within which artists use this technology. This, and the institutional context (the places that have the equipment) impacts on take-up, on who is using it, and how are they using it.

This is not the whole story, there are plenty of artists that want to use the technology, despite its material imitations, and having to access it through a University or business. However, most have not done so. Why? What are the most significant limiting factors? Firstly, you need a particular skill-set to use rapid prototyping machines, if you are not scanning an existing 3D object from the real-world in order to generate virtual 3D data, then you have to model the object in virtual space. 3D computer modelling is complicated, time-consuming, and can be very boring. You do not make the virtual model with your hands, and the irony is that the people who would probably make the most fantastic objects using the technology are traditional sculptors, but to generate the computer file you cannot use those techniques. Then there is dealing with the seemingly archaic STL file format. The file formats that can be used on these machines need to be expanded, radically. Even though I worked with programmers, the STL file format was a serious barrier to creativity, and the only way to find out if a dataset was going to work was to run it through another piece of software. In summary, for a broader take-up, the technology needs to expand out of the specialised engineering and university workshop environment.

This is anecdotal, but when a straw poll of where the RP machine is located in the university system, and which staff control access to the machine, shows it is predominantly in engineering with technicians controlling the machine, or it is in design (and there is still a split between art and design). So, if you find a rapid prototyping machine you need to ask 'who has got access to it?' Design departments, where prototyping of all sorts is an established part of the design process, of have queues of students waiting to use the kit, there is little spare time to offer artists and art students. Some art departments shy away from buying and running these technologies and say "we really want this department to stay very traditional, we don't want laser cutters and rapid prototypers, we want to stay etching and doing litho and whatever". It seems strange to assume one would replace the other as opposed to them sitting side by side. As long as you have that kind of Luddite resistance from fine art departments, there are all sorts of objects that will not get made.

WHOSE ART GANG?

Rapid prototyping depends on a skillset more common amongst artists who have been identified as working with 'new media'. Elsewhere, I have spoken about what I see as the delights and dangers of the 'new media art ghetto', one of which is that new media art remains predominantly screen-based, maybe because it came from independent film, guerrilla video, guerrilla television, independent video, video art, scratch video, performance. It didn't come out of object-making. One of my personal hobbyhorses is that if you look at the new media art exhibition circuit, there is no place for 'the object' unless it is interactive. So, rapid prototyping is problematic for that art gang, because it is not seen as relevant due to the dominant ideology that priviledges interactivity and autonomy. Objects that respond, especially robots, *are* considered relevant. What is often engaging about a rapid prototyped object is the 'being of the object', the way the object 'is'. It doesn't have to 'do' anything. Its form, and how that form came into being, is what is engaging about it. I think that is completely at odds with the new media art network. This matters because funding and commissioning is greatly influence by these arbiters of taste. I have a feeling that my sketchbook of unmade rapid prototyped works will continue to get fatter, but I am determined to make more of them real [6].

ACKNOWLEDGEMENTS
I am grateful for insights gained during discussions with Nina Wakeford for the interview in the forthcoming, 'Revisualising Visual Culture' that formed the basis of this paper.

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[2] TECHNOSPHERE: An online digital environment launched on September 1, 1995. TechnoSphere, created by Jane Prophet and Gordon Selley, was a place where users from around the globe could create creatures and release them into the 3D environment, described by the creators as a "digital ecology." http://en.wikipedia.org/wiki/TechnoSphere

[3] CELL: A collaboration exploring the ways research into adult stem cells is having to re-address the complexity of human biology. As part of the collaboration, medical scientist Dr Neil Theise, a world leader into adult stem cell research, based in New York, worked with Jane Prophet, mathematician Mark d'Inverno, computer scientist Rob Saunders and curator Peter Ride, who instigated the project, from the University of Westminster. One aim was to find ways of visualising the new and contentious theories of stem cell behaviour, and to feed these visualisations back into the scientific research, as tools for use in the laboratory practice. Another has been to generate a range of artistic outcomes that are under-pinned by the emerging

understanding of cellular activity. http://www.janeprophet.com/cell.html

[4] FRANCIS WELLS, heart surgeon from Papworth Hospital, Cambridge and Leonardo da Vinci expert. http://news.bbc.co.uk/1/hi/health/4289204.stm

[5] ADRIAN BOWYER, Senior lecturer in the Department of Mechanical Engineering at the University of Bath working in the Biomimetics Research Group on the RepRap Project and the Bioaffinity Applications Laboratory. http://people.bath.ac.uk/ensab/

[6] UNMADE ARTWORKS
Small But Perfectly Formed http://www.janeprophet.com/small00.html
Big Plastic Tree http://www.janeprophet.com/plastic.html
Self Portrait of the Artist Meditating on Death: A Vanitas
My aim is to make a contemporary Vanitas piece using medical imaging to recreate my skull, face and brain (preferably also using MRi to show which part of the brain is active when one thinks about death) and recreate the Vanitas using my data, like a self portrait. The form of the sculpture would be similar to the form of the Wellcome piece – namely a head which is dissected to reveal the skull, and again to reveal the brain. The work would be made as a physical object using rapid prototyping so that it can be reproduced life-size. This would result in an off-white coloured polymer form that would then be silver plated or coloured

CURATING TECHNOCULTURES [2010]

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This paper sets out to discuss issues of curation of media arts and other emergent technologised practices (e.g. digital performance). Through examining a range of media art festivals, exhibitions and events from the 1990s to 2010, this paper will argue against the curation of media arts as practices that are divorced from the contemporary arts scene. I will suggest that this curatorial approach of positive discrimination can lead to: a) establishing emergent technologised practices as peripheral to other, often more popular or mainstream, (sub-)cultures (and thus markets) and, b) technological determinism (in this case, focus on the technologies at the expense of content, social impact and/or affect).

In 1998 I co-founded, with Manthos Santorineos (Associate Professor, Athens School of Fine Arts), the *1st Hellenic Art and Technology Festival* (*HATF*) in Athens, Greece. A year later the festival expanded to become international with a focus on the area of Southeast Europe and the Mediterranean, and was renamed *Medi@terra*. Its aim was to showcase the (at the time) emergent field of media arts. This was the first time a large-scale event in Greece had brought together arts and emergent technologies. The festival embraced a range of artistic practices, which, until that time, had no place within the Greek contemporary art scene. *HATF* did not have an overarching theme: it simply invited, through a call for projects, artistic practices that integrated digital technologies, and it/we commissioned works along the same lines.

The fields under which we invited works for submission were defined in relation to the different formats the projects could take, such as: interactive installations (for interactive projects which manifest themselves, in one way or another, as objects or environments within physical space), animation and video art (for screen-based works), net.art (for projects that exist solely online), CD-ROM art (for digital projects that exist off-line), digital photography and print (for digital imaging works) and sound art (for digital sound/music works). At the time several 'media/digital art' festivals were taking place, such as *Ars Electronica* (Linz, Austria), [1] *Inter-Society for Electronic Arts* (international organisation based in Canada, nomadic event), [2] *Transmediale* (Berlin, Germany), [3] *European Media Art Festival* (Osnabrueck, Germany), [4] *Dutch Electronic Arts Festival* (Rotterdam, Netherlands), [5] *VIPER* (Basel, Switzerland) [6] and *Multimedia Arts Asia Pacific* [7] among others. Several of these festivals, such as *Ars Electronica* and *Transmediale*, still thrive today (2009).

The approach favoured by the *1st HATF*, that is, inviting works on the basis of their format and media rather than content or subject-matter, was in accord with the international media arts community: all the above mentioned festivals also did (and still do) invite works on a similar basis, thus generating taxonomies within which the emergent artistic practices we were aiming to showcase could be 'neatly' categorised. Throughout the (brief) history of the genre, these taxonomies have primarily focused on the format of the work, the way the work manifests itself within the physical domain, and the technologies employed, rather than the qualitative issues of concept, content, and dramaturgy (in relation to interactive artworks which are performative in their nature). Such taxonomies were, I think, strengthened when Christiane Paul's book *Digital Art* was published in 2003. In this, Paul argues:

> It is problematic to claim that all digital artworks can be neatly categorized according to different forms: most of the time, these works combine various elements (…) and defy a purely formal classification. Nevertheless, it is important to be aware of the formal aspects upon which the art is based. Ultimately, every object –even the virtual one– is about its own materiality, which informs the ways in which it creates meaning. Among the forms that a digital artwork can take are installation; film, video, and animation; Internet art and software art; and virtual reality and musical environments. [8]

The forms that Paul identifies are not identical to the ones identified by the *1st HATF*. Indeed, such discrepancies have been common across the field, as formal categories are subject to constant change, updating and revisiting (following new practices but also signifying differing curatorial approaches). For example, the *1st HATF* did not include 'film' as a form in its call: we considered film to be an older medium that was already being showcased elsewhere. It did not include virtual reality environments either, but this was due to the technical requirements of such artworks: in order to showcase a virtual reality environment we would have needed to acquire and install a VR system (such as a CAVE, for example).

These were particularly costly at the time, and people with the technical knowledge and expertise required to install and operate this technology were few and far between (Medi@terra 2000 did include VR works in the Call, as we were able to use the Hellenic Institute's newly installed CAVE system). Despite discrepancies in formal categories, one thing was consistent across the international community of media arts festivals: they all invited works invested in emergent technologies –other, non-technologised types of artworks did not normally have a place within these contexts–

and they mostly did so through categorising the works on the basis of formal rather than conceptual, aesthetic, social or other criteria (I should point out that this approach of positive discrimination was possibly justified at the time, as media arts were rarely represented within more mainstream contemporary art contexts).

In 2002 Sergey Teterin (director), Olga Goriunova (curator) and Alexei Shulgin (consultant, curator) launched in Moscow (Russia) the *read_me festival 1.2* on software art and software art games. *Read_me 1.2* was the first festival "dedicated to the artistic contemplation of software: its creation, modification and deconstruction." [9] The organisers of *read_me 1.2 festival* went on to develop *Runme.org*: an open, moderated database where people were invited to submit software art projects. [10] The next edition of the festival, *read_me 2.3*, took place the following year (2003) in Helsinki, based on the *Runme.org* database. [11] At the time I found *Runme.org* and *read_me 2.3* striking due to their exceptional structure: *Runme.org* was structured both "taxonomically/rationally (category list) and intuitively (keyword cloud)". [12]

The category list was more expansive than most and ran as follows (these are only the main categories; each category featured several sub-categories; numbers in parenthesis indicate the amount of projects submitted under each category):

algorithmic appreciation (2)

appropriation and plagiarism (5)

artificial intelligence (10)

artistic tool (39)

bots and agents (15)

browser art (19)

code art (21)

conceptual software (31)

data transformation (34)

digital aesthetics r&d (9)

digital folk and artisanship (18)

existing software manipulations (7)

games (15)

generative art (48)

hardware transformation (7)

installation-based (6)

institutional critique (7)

performance-based (10)

political and activist software (25)

social software (5)

software cultures - links (15)

system dysfunctionality (10)

text - software art related (47)

text manipulation (36) [13]

Read_me was targeting works of a very specific genre, that is, works that could be approached as artistic software. Nonetheless, what this list of categories makes clear is that taxonomies, though 'rational', were generated on the basis of not only formalist but also conceptual criteria: for example, the categories 'political and activist software' and 'social software' taxonomise works in relation to their social and political agendas and impact, rather than the technologies employed or the way projects manifest themselves in space. Even more intriguing to me at the time was the intuitive approach (word cloud), which existed side by side with the taxonomical one. This was as follows:

1960s	collaboration	film	junk	open_source	psychiatric	surreal
1980s	collaborative	flash	knitting	outsource	python	surveillance
1990s	community	folk	labor	P2P	radio	symbiosis
1996	conceptual	lawyer_resistant	paranoid	random	symmetry	formalist
1997	consciousness	found_object	lingo	parodyware	realtime	synesthesia
3d	constraints	fractal	linux	pascal	realworld	system
abstract	copyright	fragile	lisp	passionate	relaxing	talking
abuse	corruption	free_software	literary	patterns	religious	taskbar
active	countercultural	friendly	live	performance	remix	telematic

aesthetics	crash	frustrated	live_coding	performative	representation	templates
algorithmic	criticism	gadgety	love	perl	robot	terrorism
amiga	cute	generative	lowtech	philosophical	RSS	text_
anachronistic	cyborg	genetic	mac	photography	sampling	trash
anti_information	dada	glitch	manifesto	PHP	scary	trivial
anthropomorphic	dangerous	goofy	Mapping	pixel	scientific	turing
apocalyptic	database	Google	market	plagiaristic	screensaver	tv
archetype	death	hackerly	marxist	playing	semantic	typing
archive	debate	hardware	mathematical	pocket_pc	seminal	unix
ascii	deconstructive	HCI	meme	poetry	serendipitous	unnoticeable
atari	decorative	historical	messaging	political	serial	useless
audiovisual	design	hoax	metaphorical	pop_culture	sexy	utility
authorship	desktop	html	metaphysical	porn	sharing	vectorial
automata	dhtml	identity	MIDI	positive	simulation	video
automation	disturbing	illegal	mindware	posix	sinclair	violence
backwards	dos	illustration	minimalistic	post dotcom	sing	virtual
BBS	drugs	imagery	mobile	postscript	smiley	virus
beos	dysfunctional	information	modal	power	social	visual
binary	eccentric	installation	montage	pragmatic	sound	voice
blog	ecological	instructive	multiuser	presence	spam	voyeur
body		educational	interactive	musical	privacy	speech
c	efficient	interface	network	probability	stimulation	windows
c64	email	intuitive	neural_net	process	storytelling	xxxxx
capitalism	error	irc	news	productivity	stream	
chaos	evangelist	ironic	noisy	programming	subjectivity	
chat	feedback	iterative	nude	propaganda	subversive	
code	feminist	java	obfuscated	provocative	supernatural	
coding	filesharing	javascript	on line	psychedelic	superstitious	

[14]

I consider *Runme/read_me*, from a curatorial perspective, as revolutionary in its approach: it constituted the first attempt to question rigid formal categories in media arts and challenge the way curators and, possibly, artists thought about their works; at the same time, the festival did acknowledge the necessity and functionality of taxonomic systems and the near impossibility of abandoning them completely. *Runme/read_me*'s approach is a playful and pertinent criticism of the long-standing attempts of curators and event organisers to neatly classify and formally categorise emergent fields of practice. The festival's intuitive structure succeeded in exposing the rigidity (and often absurdity) of such formal categories as well as the lack of engagement with issues of content, social value and affect in the way festivals and showcases invited works for submission or commissioned new work.

Despite its attempt to question and unsettle formal categories for studying and presenting media arts, *Runme/read_me* remained firmly rooted within the tradition of presenting this emergent field of practice as independent from (peripheral to?) more mainstream contemporary art practices. As a result, although formal categories within the field were imaginatively challenged, the festival itself remains classified as a media arts festival, without any attempt to shake this (formalist) distinction (I do not intend this as a judgment on the cultural value and success of the event). I will go on to examine *Read_me/Runme.org*'s heritage today in relation to the curation of media arts and other emergent, technologised, practices.

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NETWORKS OF FREEDOM: NETWORKS OF CONTROL

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In 1996 the usually sober minded political scientist Manuel Castells, wrote about the revolution in popular networked computing in momentous terms. “We are witnessing”, he declared “the formation of a hypertext and a meta-language which for the first time in history, integrate into the same system the written, oral and audio-visual modalities of human communication The human spirit reunites its dimensions in a new interaction between the two sides of the brain, machines and social contexts. For all the science fiction ideology and commercial hype surrounding the so-called information superhighway we can hardly underestimate its significance”. 1

However inflationary this rhetoric now sounds, for some of us the significance went even further into the realm of the political. In the 90’s I and many other radical media artists felt ourselves to be part of a utopian moment, a moment characterised by what became known as the ‘hacker’ ethic in which it was believed that challenging the domains of forbidden knowledge would lead to a new kind of society based on participatory communications. Historical context played its role in fuelling these dreams. The power some of us attributed to this ‘new media politics’ was influenced by role that all forms of media appeared to have played in contributing to the collapse of the Soviet Union. It seemed as though old style armed insurrection had been superseded by digital dissent and media revolutions. It came to be believed that top down power had lost its edge. As late as 1999 in his Reith lecture, Anthony Giddens could still confidently assert that ‘The information monopoly upon which the Soviet system was based had no future in an intrinsically open framework of global communications’.

The myth of a triumphant computer mediated popular democracy continues in the newly minted lexicon of web 0.2, crowd sourcing and all the other high tech means for harvesting so called ‘user generated content’. From Wikipedia to The X Factor, the basic premise remains stubbornly intact, with its claim that technology has ushered in a new era of participatory freedom. The purpose of this paper is not only to critique these assumptions by examining some of their founding myths but also to ask what if anything can be recuperated from the hacker ethic and its utopian origins.

My way of addressing this question is to interrogate one of the core assumptions, which drive these cultures, the assumption that the emergence of new forms of human freedom based on openness or transparency are the result of the decentralised structure of the technologies of the network society.

The continued dominance of this supposition is in part the result of the persistence of one of the most powerful myths of the information age; the myth that knowledge that will set you free. This founding narrative of techno-culture visible from Ted Nelson 'Computer Lib'2 onwards, upgrades for the technological era the age old proposition that knowledge and freedom are not only connected but may actually entail one another.

The fact that a belief in the necessary relationship between knowledge and freedom has gone largely unquestioned is based in part on the depth of its lineage, 'ancient stoics and most modern rationalists are at one with Christian teaching on this issue'. And 'ye shall know the truth and the truth shall make you free'. As Isaiah Berlin pointed out in 1968, 'This proposition is not self evidently true, if only on empirical grounds.' It is, he asserted, 'one of the least plausible beliefs ever entertained by profound and influential thinkers.'3 The accompanying rhetoric of transparency, freedom, access, participation, has come to constitute the ideological foundation of our era.

TOOLS OF CONTROL

Whatever counter evidence is presented there is something stubbornly persistent idea that freedom (and by association democracy) has been transformed ever since its fate became associated with the Internet. And creative computing, has in its turn, been reconfigured with the installation of freedom at its core'. The influence has gone in both directions: our ideas of what constitutes freedom change and these changes in turn influence the design of subsequent generations of new media objects, systems and tools.

I understand how naïve these arguments, or indeed how any continued belief in connections between new forms of liberty and the internet, can sound in the light of just how entwined networked technology has become in the formation of the 'control society'. It can be argued that the architecture of the net, far from being intrinsically supportive of autonomous networks of creativity and dissent is in effect the most powerful tool yet created for control and suppression. We can in fact go even further and argue as Alex Galloway has persuasively done in his book *Protocol* – subtitled *How Control Exists after Decentralisation* – 4 that the founding principal of the net has never been freedom but rather a new mode of control that is entirely native to networks. And that this controlling power lies not merely in an upgrade of the Benthamite Panopticon, but rather it is the technical protocols in and of themselves. They exercise control simply by virtue of the fact that they make the network connections (and critically the disconnections) possible. The equation is simple, no controlling technical protocol, no Internet. Power here is expressed through exclusion rather than exploitation or even surveillance. The signature application for the exercise of power in the control society is not CCTV camera but the *password*.

The implication of this argument is that it is not in the obvious cases such as the ease with which the totalitiarian regimes have gained control of the net, which should make us sceptical. Rather we must face the fact that concept of the net, as a space of freedom was always an illusion. The foundational modality of the net was never freedom but was, from the outset, a new and profound type of control. And the most sophisticated applications of this control are not to be found in the crude methods totalitarian states such as China, Iran or Belarus but in the so called 'open societies' of the west where the net is experienced as an open and seamless spatial continuity. To theorise the space constituted by the network society as the social scientist Manuel Castell's has done as a 'space of flows' is perhaps the biggest delusion of all and the most important narrative for artists and radical theorists of the net to confront and to explode.

We must question the idea that any meaningful democratic participation can be constituted simply though joining 'the big conversation' by becoming 'bloggers' or 'citizen journalists'. To do this may simply to become victims of what media theorist Jodie Dean describes as " communicative capitalism's perfect lure" in which "subjects feel themselves to be active, even as their every action reinforces the status quo.'… One needs look no further than the politics of scandal that surrounds Berlusconi to realise "that any revelation can be allowed, even celebrated and furthered, because its results remain ineffectual."5

WHAT CAN BE SAVED

So can anything be recuperated from the utopian belief in freedom through openness? I believe it can if we look at the examples where the principles of free creative computing, are being applied in the grass roots and back alleys of radical new media culture.

Some years ago I put some of the arguments elucidated above for repudiating belief in the 'hacker ethic' of open media to an impressive group of pirate media activists in Brazil (Autolabs) 6, who work in the Favelas as educators creating computer networks and pirate radio channels out of re-cycled materials. They did not buy into my pessimistic narrative. "No!" they objected "for us technology and media are a vital battlefield particularly in Latin America where monopolistic media giants like Brazil's Globo pump out an endless narcotic diet of soaps, game shows and football that help to keep poor people passive" For these activists there is no imaginable political strategy that does not involve the expressive dimension 'language' (language in the widest sense) to articulate alternative futures. For these Brazilian activists the dichotomy between control and freedom I had presented was a false dichotomy. They argued that some important and radical definitions of freedom depend as much upon on control (often in the form of self governance) as they do upon absence of boundary or constraint.

We can, they claimed, meaningfully connect freedom to democracy, not because we seek to dissolve all boundaries but because we seek the means to participate in determining where these boundaries (including laws and customs) might lie. Many of my discussions in recent years lead me to go further. I would claim that the identification, interrogation and re-articulation of boundaries, as a way of testing the limits of human freedom, has become the core subject of all advanced contemporary art, with or without computers.

FREEDOM'S PLURALITY

In 1958 in his justly famous inaugural lecture "Two Concepts of Liberty" the philosopher Isaiah Berlin made the crucial distinction between two concepts of liberty 7 – the positive and negative.

Alongside a basic negative freedom "the wish to be left alone to get on with my own life in my own way without being interfered with or coerced by others", Berlin described a quite different second concept of "positive liberty".

The idea of positive or self-directed freedom is founded on the principal of self-governance, the perceived wish of everyone to be their own master: 'I wish my life and decisions to depend on myself, not on external forces of what ever kind. I wish to be the instrument of my own, not of other men's acts of will'. From the perspective of 'positive liberty' structures, disciplines, systems and even bureaucracies should not automatically be seen as the antithesis of freedom.

Like language itself, a structure such as TCP/IP, DNS, and HTML, the protocols that make the Internet operational, do not only constrain, they also enable, by providing common framework. The proposition is as simple as it is paradoxical: no structure no freedom.

Despite the power of the radical critiques outlined in the opening paragraphs of this paper, the hacker ethic, with its ideal of freedom through 'openness' cannot, in the end, simply be dismissed as ideology. The foundation of these claims are at root epistemological. The ideal of openness represents an approach to knowing based on freedom to doubt based on an awareness of the provisional nature of all human knowledge. From this perspective discovery can only ever be about knowing more and more about what we do not know. Behind the ideal of openness is the drive to create a space not only for assertion but also for doubt and a degree of humility. Avoidance of the totalitarian disasters of the early 20th century depend on the continuous awareness that knowledge is only ever partial and no verification is final. Zizek famously makes the distinction between 'knowing' and 'believing'. But neither knowing nor believing is enough. Assertions whether in contemporary art, politics or science have to be tested, every day, day after day, again and again. These are the constraints we must negotiate as we seek to re-imagine what constitutes creative freedom in conditions of pluralism.

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THE CHANGING NATURE OF ARTISTS' PRACTICE

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'Digital Art' practice often suggests an over emphasis upon applications rather than objects, reproduction over authenticity. Can 'New Media' be considered within a fine-art framework, or should it be considered as a separate discipline? The cultural shift this represents may blur, remove, or even reinforce boundaries commonly associated with the activity of fine art.

1. INTRODUCTION

In this paper I hope to identify how there is a shifting nature of artistic practice that has developed from the late 1960's until this present day, with the increasing growth of digital technologies. I will particularly identify this through my own on going research and visual art practice.

2. BACKGROUND

In the mid sixties I studied painting at Coventry University, then known as Lancaster Polytechnic, where the atmosphere there – in the mid-1960s – was one of extreme rigor: every decision, every mark one made, had to be justified. One way of responding to that context was the theoretical exploration which Terry Atkinson, Mike Baldwin and others were involved in, which emerged as the conceptual art group *Art & Language*, which was derived from their journal, which existed as a work in conversation as early as 1966. Throughout the 1970s, Art & Language dealt with questions surrounding art production, and attempted a shift from the conventional "non-Linguistic" forms of art such as painting and sculpture to more theoretically based works.

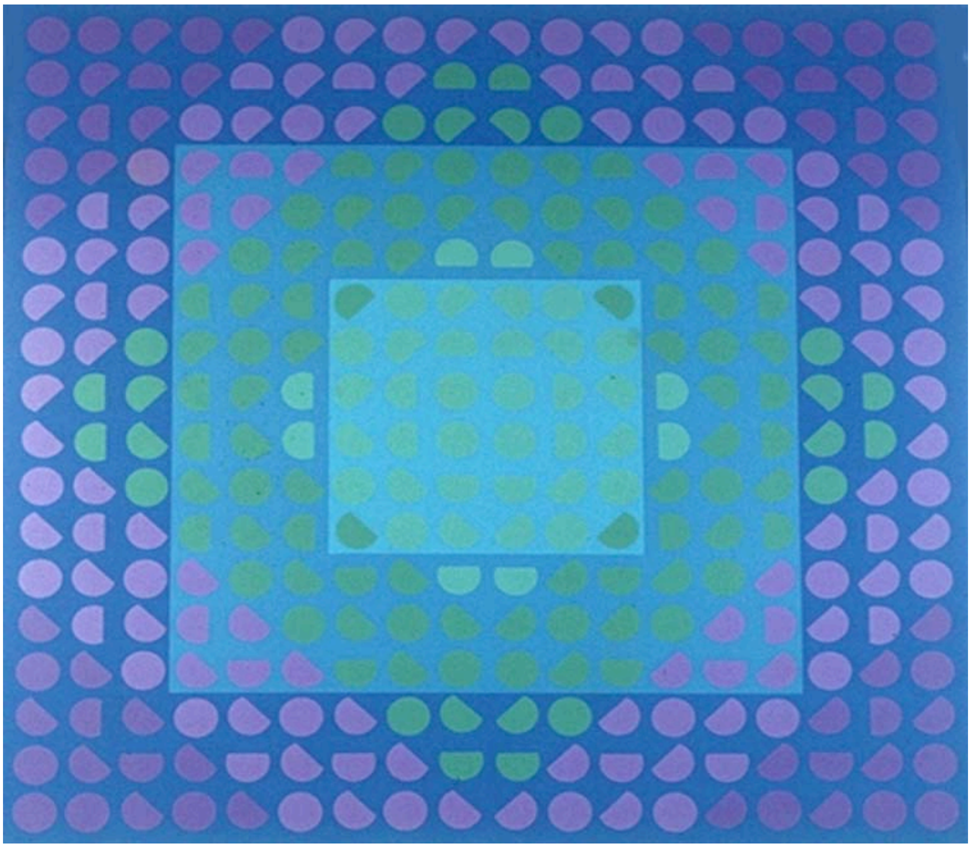
I was not particularly interested in that route. I suppose I was more pragmatic, more concerned with making things: in my case, six-foot square paintings. I was working in collaboration with another student. We thought it was important to discard a number of assumptions that seemed to condition the making of art objects: the idea of the individual maker, the expressive gesture, and so on. The work itself seemed to be more important than who made it. I used screen-printing at that time as a research base of for rehearsing the colour combinations in the paintings. But as a process it also opened up a unique opportunity to produce mechanised perfection and to incorporate photographically derived images. At that time collectors and curators still could not convince themselves that screen-printing could be seen as fine art printmaking process, which had traditionally always depended on the artist's hand. These same arguments are still being applied to computer-generated imagery today.

However historically *Prints* have always had an important role to play in society and are of unique social significance.

Quote from William Ivins, Jr. (1969) *Prints and visual Communication*

> 'This means that, far from being merely minor works of art, prints are among the most important and powerful tools of modern life and thought. Certainly we cannot hope to realize their actual role unless we get away from the snobbery of modern print collecting notions and definitions and begin to think of them as exactly repeatable pictorial statements or communications, without regard to the accident of rarity or what for the moment we regard as aesthetic merit. We must look at them from the point of view of general ideas and particular functions and especially we must think about the limitations which their techniques have imposed upon them as conveyors of information and on us as receivers of that information.'[1]

My work during this period could be defined as *Minimalist,* which emerged as an abstract art movement (with roots in geometric abstraction via Malevich, the Bauhaus and Mondrian). We argued that extreme simplicity could capture all of the sublime representation needed in art. I was using mathematical principles to form the work from the '60s on. I was also heavily influenced by Victor Vasarely, Jesus-Rafael Soto, and the so-called 'kinetic' 'Op'artists: Yvaral, and the Groupe de Recherche d'Art Visuel.



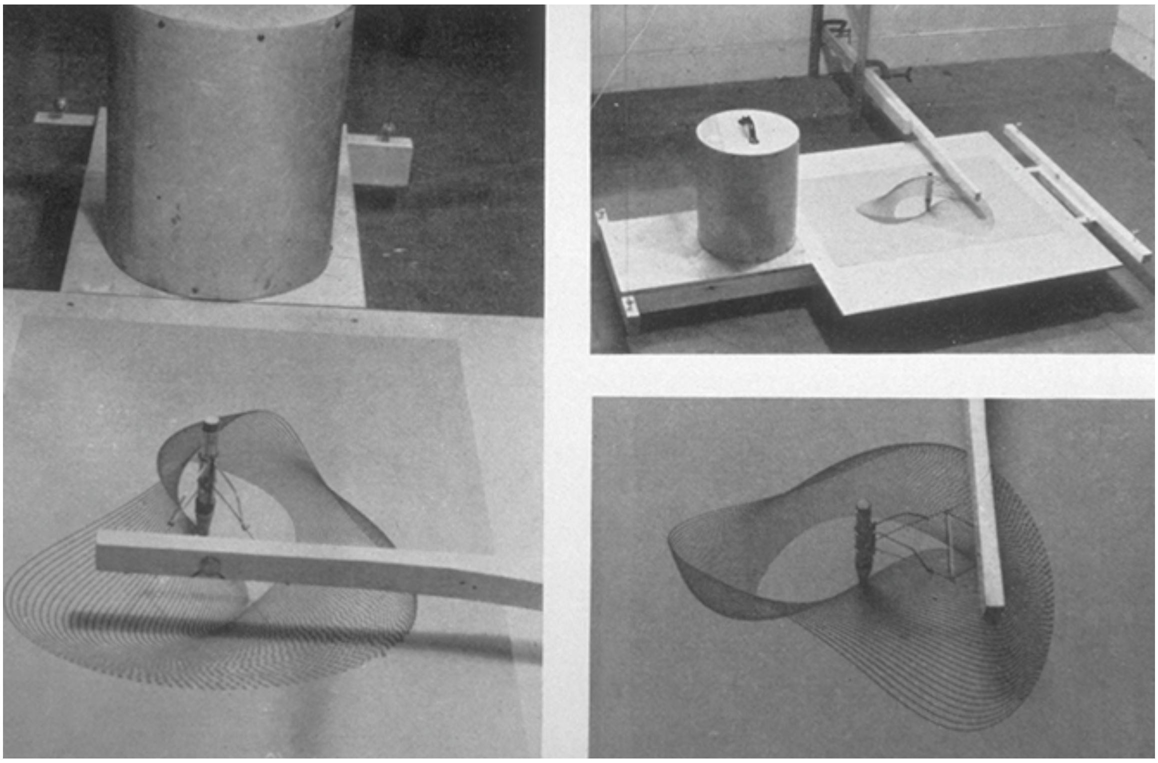
1. GOLLIFER, Screenprint (1969)

3. ON THE SCREEN

In 1968 Jasia Reichardt curated an important show that was held at the Institute of Contemporary Arts in London. *Cybernetic Serendipity* explored and developed the relationship between technology and creativity.

Quote from Jasia Reichardt, (1971) *The Computer in Art*

> 'The computer is only a tool which at the moment, still seems far removed from those polemic preoccupation's which concern art. However, even now seen with all the prejudices of tradition and time, one cannot deny that the computer demonstrates a radical extension in art media and techniques. The possibilities inherent in the computer as a creative tool will do little to change those idioms of art which rely primarily on the dialogue between artist, his ideas and the canvas. They will, however, increases the scope of art and contribute to its diversity'[2]



2. Cybernetic Serendipity at the ICA 1968

This proved to be a very significant and pioneering exhibition, enabling artists to see the potential that computers had for producing and generating images.

Some of the artists in the I.C.A. exhibition demonstrated, for the first time, algorithmic computer-generated art works. Their still images, produced on a computer, were rarely intended to be *viewed* on a computer. It is only in recent years, with the advent of high-resolution monitors, plasma screens and the distribution of images 'virtually' by the Internet, and more specifically using the World Wide Web, that output from a computer has not been an enormous hurdle. Obtaining adequate printed output has been a problem for which solutions have been developed over a considerable time. Initially, they could be made with a computer-driven graphic plotter, a pen moving along a horizontal rod, drawing onto the paper, which was rolled on a vertically moving drum. Each line was composed of very small steps: each step corresponded to a specific instruction conveyed to the plotter from the magnetic tape. Next, there were many types of printers, which could produce patterns composed of letters and other type symbols. Briefly, artists used a cathode ray tube display or television screen on which to draw with fleeting patterns of light, which could be preserved photographically; Later developments included dot-matrix inkjet, thermal wax transfer, electrostatic pigment transfer, dye sublimation and laser-printed photography. These devices emerged in parallel with the development of bit-mapped graphics, for which the pixel is the basic component

I was very much inspired by the *Cybernetic Serendipity* show, but when I tried to get involved and have access to computers, there always seemed to be a series of obstacles. Few artists in the Sixties had access to such computer or output equipment, or were trained in the specialised programming needed at the time to gain control over the machine. So I decided to turn myself into a computer, doing the calculations and measurements the hard way.

It was only in the 1980s, with the introduction of the personal computer and interactive graphics - paint/draw applications - that artist-printmakers were able to see the full potential use of the computer as a creative tool. When I finally had access to a personal computer, in the ‘80s, the calculations, which once occupied hours, and involved painstaking measurement with ruler and compass, could be completed with greater accuracy in seconds, leaving more time for the purely artistic judgments. In fact, the work I do now, entirely with computers, looks far less ‘computer-generated’ than the work I used to do entirely by hand: it has to do with being liberated from the tiresome tasks, and being able to concentrate on the images and colours.

In 1990, I was seconded as an Academic Researcher to the *Rediffusion Simulation Research Centre,* which subsequently became the *Centre for Computers and Creative Work (CCCW*). My early research was into the link between the use of new technology and the traditional Fine Art practice of Printmaking. The application of computer technology is particularly suited to the art of printmaking. The use of computers affords the artist-printmaker both an unprecedented variety of techniques, approaches, and working methods – a new repertoire of media and processes – and a variety of ways in which the production and decision stages can be made more efficient and more effective. However the integration of computer-generated imagery with more traditional printmaking processes, through the media of screenprint, lithography, relief printing, letterpress or etching, creates opportunities for further developments, such as enhanced colour stability and an emphasis on physicality, allowing for mediation, recording and conversion.

To develop this research further I had the opportunity of curating *ArCade*, the First UK Open International Exhibition of Digital Fine Art Prints, as part of the first *Computers in Art and Design Education (CADE*) conference held at the University of Brighton in 1995. The initial intention behind the exhibition was an opportunity to demonstrate visually my research practice - *a new print medium and a hybrid link between both old and new technologies, to create a convergence of ideas, disciplines and practices*.

Subsequently I went on to curate *ArCade's* - II (1998), III (2001), & IV (2003- 5), V (2007), BitStream (2002), & GAMUT (1998 & 2007).

What lessons if any can be drawn/learnt from any of these exhibitions, particularly *ArCade*; did I achieve any of my original intentions and objectives?

Quote from Sue Gollifer *ArCade*

> 'Since I have been curating the ArCade exhibitions, questions such as the of longevity and the light-fast properties of the inks have now broadly been resolved, and digital prints are now entering museum collections. In addition, the cost of high-resolution printers has been dramatically reduced, making this form of printing available to students and artists alike. Furthermore, the new generation of printers allow for a wide range of substrates to be used, from hand made paper through to plastics. I hope the Arcade IV exhibition demonstrates how digital fine art prints, offers the possibility of generating 'radically new' physical; aesthetic and conceptual frameworks.'[3]

3. **ArCade IV, the Novosibirsk State Art Museum, Siberia (2004)**

4. BEYOND THE SCREEN

The use of digital imaging makes this an exciting, challenging, and innovative time to be an artist investigating new potentials. It also encouraged a major revaluation of fine art processes in general, raising the issues of authenticity and ownership. These are current issues within contemporary art practice.

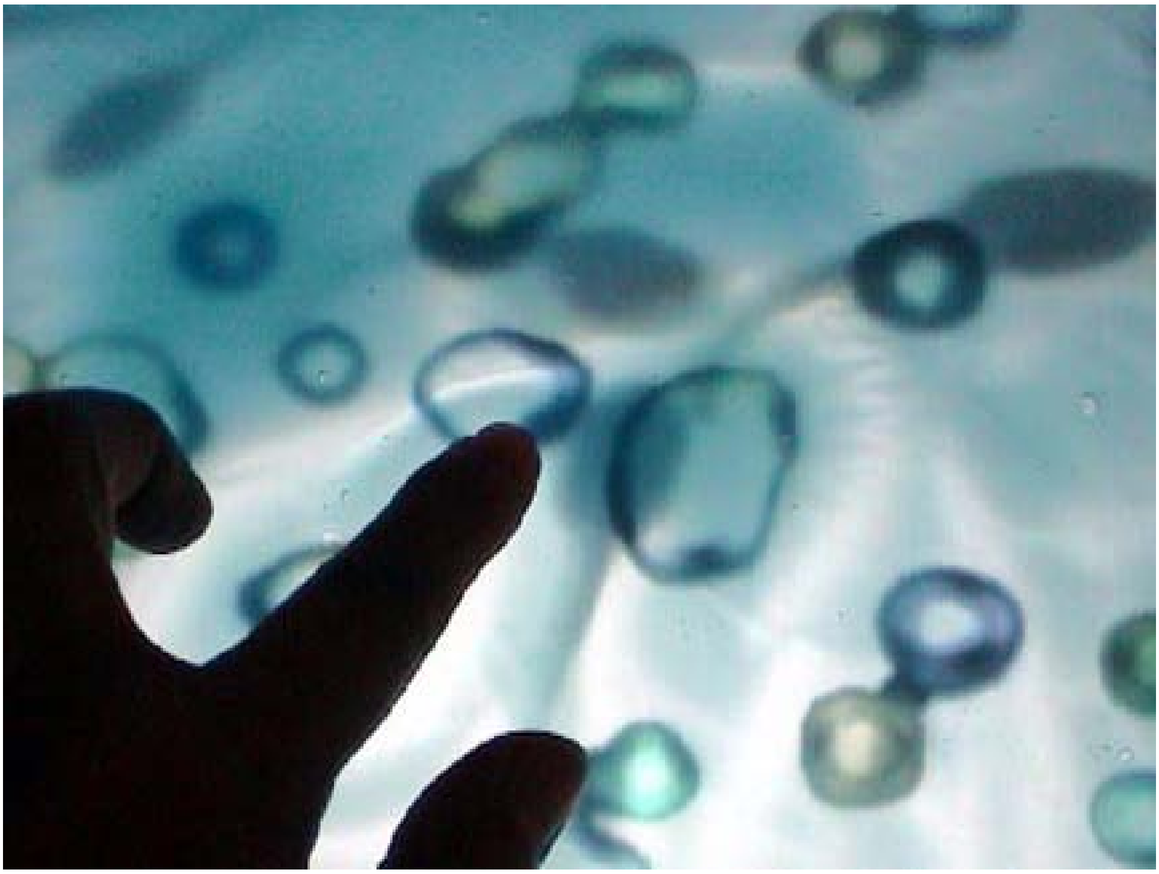
Quote Lev Manovich (2001) The Language of New Media

> The Computer revolution affects all stages of communication, including acquisition, manipulation, storage and distribution; it also affects all types of media-texts, still images, moving images, sound and spatial constructions. How shall we begin to map out the effects of this fundamental shift? What are the ways in which the use of computers to record, store, create, and distribute media makes it "new?"[4]

An example of new opportunities to exhibit and display work was shown in the SIGGRAPH Art Gallery Show *Synaesthesia,* which I curated in August 2004, as Art Gallery Chair.

Quote from Gollifer (2004) SIGGRAPH- Art Gallery Synaesthesia

> 'This year's theme Synaesthesia demonstrates how artists can excite and stimulate the senses using technology to create art that ranges from low-tech digital plotters to high-end computer graphics and animation.'[5]



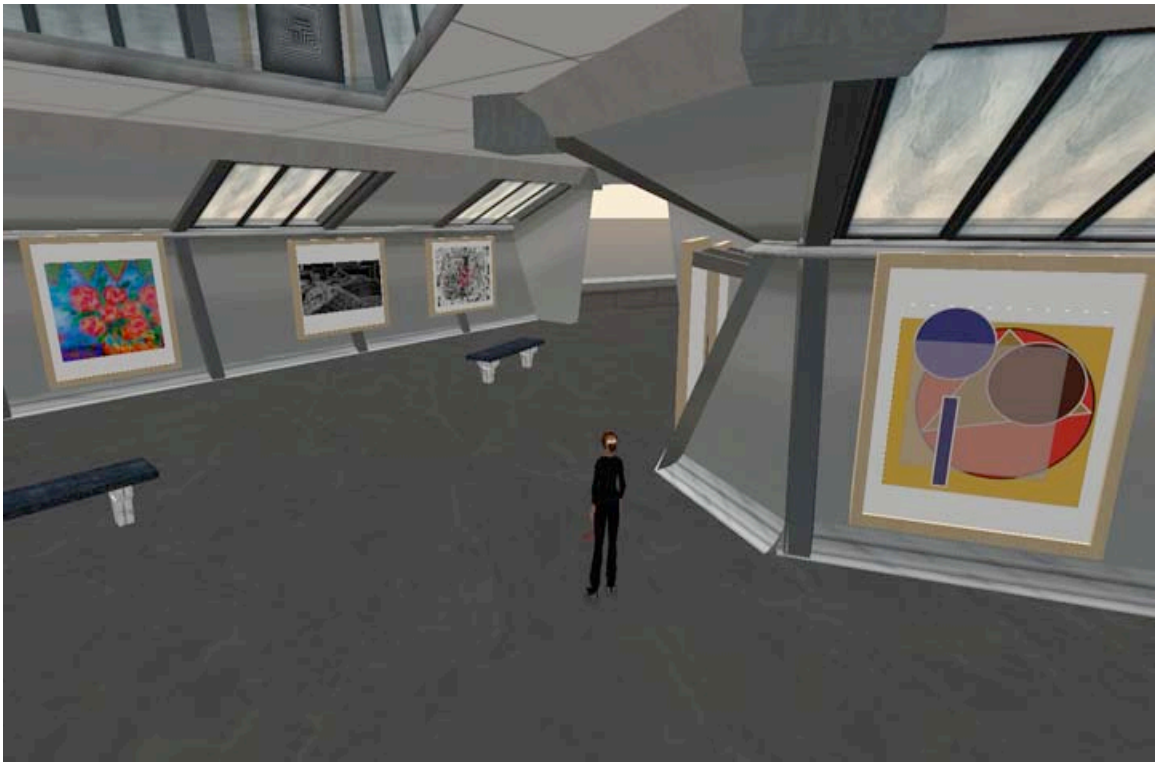
5. **SIGGRAPH Art Gallery'05 Synaesthesia - Touch the Drop *by Kushiyama***

The exhibition showed work by visionary artists in all areas of digital art that stimulated the senses, including 2D, 3D, interactive techniques, installations, multimedia, telecommunications, screen-based work, and computer animation. The viewers to the Art Gallery were encouraged to see, hear, and touch the art. New ways of experiencing art and an opportunity to be engaged interact with the artwork itself both physically and virtually, and blurring the distinction between 'original' and 'reproduction'.

Quote from Margot Lovejoy (1997)

> ‘Photomechanical reproduction raised questions about the ‘uniqueness’ of copies as art, thus undermining the existing function of art not only because it could provide visual reportage, but because it threatened the aura of the handmade object which relied on the specialised skills of the artists.’[6]

This also raises one of the crucial issues in the field of computer-generated art: the intangibility of the artwork. The work is essentially a freely available signal, rather than a visual artefact, which can be packaged, marketed and sold. Another issue is that of authenticity: who 'owns' it- does it even exist? Computer-aided art in its purest form is not concerned with artefact but with communication and interaction (New Media). Thus raising issues concerned with the ontology of the art object and the identity of the artist in relation to the work.



6. ArCade V in Second Life (2007)

A broader definition of its possibilities of digital art in all its hybrid forms. Creating a synergy between processes old and new and opening up new areas of freedom and diversity, establishing a unique repertoire of aesthetic tools be they instant transmissive digital images in the social networking spaces and the endless identical reproduction open to revision, evolution, collaborative manipulation and cross-disciplinary utilization via the Internet in a vastly expanded creative domain.

IN CONCLUSION.

So ‘Digital Art’ or ‘New Media Art’ now exists in a multiple of contexts, and in a myriad of forms and covers a broad range of artistic practices, which can not be described in terms of one form of aesthetics or as one form of art practice. It exists within the new conceptual spaces, through virtual worlds and distributed networks; thus allowing for mediation and transactions, and offering the possibility of generating ‘radically new’ physical and aesthetic frameworks.

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Electronic Resources
Inter Society of Electronic Art (ISEA)
http://www.isea-web.org/
DIGITAL ART MUSEUM (DAM)
http://dam.org/
SIGGRAPH Art Gallery’04
http://www.siggraph.org/artdesign/gallery/S04/

CREATING CONTINUITY BETWEEN COMPUTER ART HISTORY AND CONTEMPORARY ART

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Computer art was started by a small group of pioneering artists who had the vision to see what digital tools and technology could bring to the creative process. The technology at the time was primitive, compared to what we have today, and these artists faced resistance from the traditional art establishment. Several organizations, such as the New York Digital Salon, were started to promote digital creativity through exhibitions, publications and websites. This paper will explore how to create continuity between computer art history and a new generation of artists that does not see making art with computers as unusual and views it as contemporary art.

INTRODUCTION

The origins of computer art trace back over fifty years as artists began to experiment and create artwork with new technologies. Even before computers were invented, photography, radio, film and television opened up new creative territories. Many people point to the photographs of abstract images taken of an oscilloscope screen that Ben Laposky called *Oscillons* as some of the first electronic art images, which foreshadowed the development of computer art. While the system he used was essentially analog, the way in which the images were created was through mathematics and electronic circuitry. Another artist working at that time was Herbert Franke, and as the author of *Computer Graphics – Computer Art*, originally published in 1971, and followed in 1985 by an expanded second edition, he began to document the history of computer art and the artists who were involved. One of the first computer art competitions was begun in 1963 by the periodical *Computers and Automation.* A. Michael Noll created *Computer Composition with Lines* and won the prize in 1965, followed by Frieder Nake with *Composition in Squares* in 1966. The year 1965 also marked two seminal computer art exhibitions held at the Technische Hochschule in Stuttgart, Germany and the Howard Wise Gallery in New York City. These exhibitions were instrumental in fostering an increased interest in the aesthetic use of computing.

In 1966, *9 Evenings: Theatre and Engineering* was held in New York City. This event was collaboration among artists, computer scientists and engineers. It was also a key event to bring public awareness of new creative approaches to making art. Organized by Billy Kluver, Experiments in Art and Technology (E.A.T.) continued for many years to encourage this type of collaboration. The archives of E.A.T. now reside at La fondation Daniel Langlois in Montreal, Canada.

A few years later in 1968, the landmark exhibition *Cybernetic Serendipity*, organized by Jasia Reichardt, took place at the Institute for Contemporary Arts in London. Computer artists included in the exhibition were Charles Csuri, Frieder Nake, A. Michael Noll and John Whitney, among others. Other contemporary artists who worked with technology, sound art, music, and film included Nam June Paik, James Seawright, John Cage, Iannis Xenakis, Kenneth Knowlton and Nicholas Negroponte. The exhibition had three major components: 1) computer generated work, 2) cybernetic devices, robots and painting machines, 3) machines demonstrating the use of computers and the history of cybernetics [1].

Another exhibition the same year was *The Machine as Seen at the End of the Mechanical Age* at the Museum of Modern Art in New York City. It included the work of over a hundred artists and explored the relationship between art and technology. The establishment of the British Computer Arts Society and the publication of the first issue of the *Leonardo* journal by Frank J. Malina happened in the same year.

As one can see, 1968 stands out as a pivotal year in the development and international recognition of digital art. While this year was a highlight, and the interest in computer art did continue throughout the 1970s, Herbert Franke commented in 1985 that, “the expansive period of computer art is considered to have been finished by 1970 – the year of the first presentation of computer-generated graphics at the Biennale in Venice. The subsequent years were characterized among others by a different attitude towards the computer – its use for artistic purposes was no longer regarded as a provocation” [2]. While this may not have been ultimately been the case, the responsibility for the development, support and archiving of this art form at that time, and until now, has fallen primarily to visionary computer art organizations and galleries.

COMPUTER ART ORGANIZATIONS AND DIGITAL ARCHIVES

As computer art developed, it faced resistance from the traditional art establishment. Computer art failed to fit into any standard traditional art category, such as drawing, painting or sculpture. Much of the work was non-archival, printed on plotters with inexpensive papers and inks and the technology used to make the artworks rapidly became obsolete. While these were a few of the valid concerns from the art world, it did not stop the pioneering artists from continuing to develop and experiment with this emerging art form. However, many of the museum shows during the 1970s and 1980s created far less excitement than computer art exhibitions generated in the late 1960s As a result, several organizations and festivals that supported and believed in making art with technology began to emerge.

The first Ars Electronica Festival was held in Linz, Austria in 1979. It continues to this day, and recently an online Festival Documentation and Catalogue Archive was created that chronicles the thirty year history of the festival with all programs and catalogue texts published since 1979, the Archive of Prix Ars Elecronica from 1987, and links to all festival websites since 1995. Starting with only 20 artists in 1979, Prix Ars Electronica grew to near five hundred artists in 2008.

In Germany, the ZKM Center for Art and Media was founded in 1980, was established as a government foundation in 1988, and has been a leader in the development of new media art since. Professor Peter Weibel took the helm in 1999 and expanded ZKM to include research in new media theory and practice, and the establishment and expansion of such resources as the

Museum of Contemporary Art, the Media Museum, Institute for Visual Media, Institute for Music and Acoustics and the Institute for Media, Education and Economics.

V2_ in the Netherlands was founded in 1981 as an artist collective. Began as a center for multimedia performances and experimental media, it also included an exhibition space. The interest in these new art forms propelled V2_ to evolve into a center for art and media in the mid-1980s. It published a *Manifesto for Unstable Media* in 1987, which laid the foundation for future development. Since 1994, it has focused on networked media art, and other forms of creative expression using digital media. The V2_Lab was established in 1998 and extended their mission to artistic practice, research and the development of an online archive of creative work.

Started in 1988 as an International Symposium on Electronic Art, the Inter-Society for the Electronic Arts (ISEA) was founded in 1990 in the Netherlands. The goal of ISEA is to support an international awareness of the electronic arts. It has held both annual and biennial symposia at various locations around the world. In addition to the symposia, the archives of ISEA are maintained at the La fondation Daniel Langlois in Montreal, Canada and a more comprehensive archive website is currently under construction.

In the United States, ACM SIGGRPAH began their art exhibitions with the *Computer Culture Art* show in 1981. The works in the exhibition were a selection of digital prints taken from the *High Art Technology* show, which was exhibited at the Library of Congress in April of that same year. It included works by David Em, Herbert Franke, Ken Knowlton, Ruth Levitt, Lillian Schwartz, Joan Truckenbrod and Edward Zajec, among others. The SIGGRAPH Conference and Art Gallery continues to this day. The online archive of the Art Show currently includes the exhibitions from 1994-2007. In 2009, SIGGRAPH began an annual Distinguished Artist Award, which was given to Lynn Hershman Leeson and Roman Verostko.

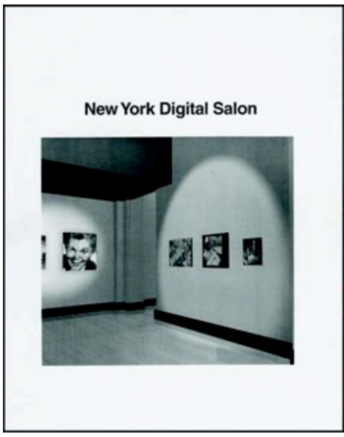
NEW YORK DIGITAL SALON

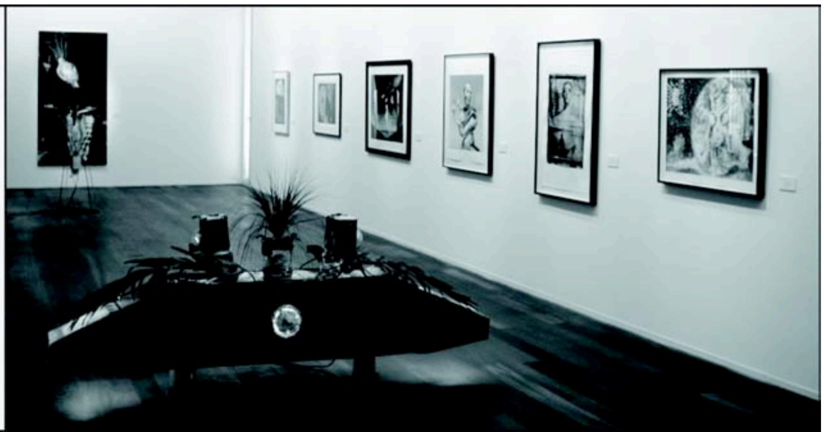
In 1993, SIGGRAPH decided to make their annual art show, *Machine Culture*, the first international survey of interactive and robotic art. As such, they did not include static art or digital prints. The New York Digital Salon was started as a "salon des refuses" to this art show. It was organized by the New York Professional Chapter of ACM SIGGRAPH, curated by the author and the jury consisted of Barbara Nessim, Judson Rosebush, Lillian Schwartz and Kenneth Snelson. One of the first exhibitions dedicated to digital prints in New York City, it was held at the Art Directors Club. Approximately sixty works were selected from over six hundred entries.

One unique aspect of this exhibition was that it was one of the first contemporary art exhibitions to be curated using a computer. SVA MFA Computer Art graduate student Fury Nardone-Sabato constructed a virtual gallery of the New York Art Directors Club using Autodesk 3D Studio software. Artworks were then scanned and re-formatted as texture maps onto planar shapes. These were then used to try out different exhibition layout scenarios in the gallery.

The positive response and curiosity sparked by the exhibition prompted a second show and the number of entries from artists increased significantly. This trend continued and the Third New York Digital Salon partnered with *Leonardo, Journal of the International Society for the Arts, Sciences and Technology*, to create a special annual issue as the catalogue of the exhibition.

This continued until 2003, when the New York Digital Salon celebrated its tenth anniversary. One of the reasons for the partnership was to develop a body of literature about digital art, along with the exhibition.





First New York Digital Salon Catalogue 8th New York Digital Salon in Malaga, Spain

Over the years, the concept of the exhibition had expanded from being a digital print only exhibition into a more comprehensive and inclusive venue for all types of digital art. This included prints, installations, sculpture, computer animation and web sites. 1998 also marked the first international venue for the exhibition. Blanca Mora, an art consultant from Spain brought the exhibition to the Circulo de Bellas Artes in Madrid. At that time, curiosity about digital art is Spain was high, and the opening reception drew over one thousand people, and the exhibition hours had to be expanded so that school groups could come to the exhibition in the mornings. Total attendance for the one-month exhibition exceeded ten thousand.

After being the curator of the first three exhibitions, the author took over as the Director of the New York Digital Salon in 1998. Following the success of the Madrid venue, additional venues were added, including the Centre de Culturea Contemporania de Barcelona, and the Sala de Exposiciones in Alicante and Malaga, Spain, as well as the Triennale de Milano in Italy. During this period of the salon’s development, and in response to the requests of large international contemporary art venues, we decided to stabilize the format of the exhibition to include approximately forty prints, four to five CD-ROM or disk-based works, eight to ten installations, five to ten Web sites, and about an hour each of computer animation and digital video. The large size of the contemporary art centers in Europe allowed us to place interactive works in their own rooms, as well has have screening rooms for the computer animation and digital video works. The number of artists submitting works had now grown to approximately one thousand, and artists from fifteen to twenty countries were being represented. This was the result of several factors, including an increased number of submissions, international publicity and venues, as well as a conscious effort to make the New York Digital Salon more representational of the international digital art movement.

With the Seventh New York Digital Salon, we began to create a permanent online archive of the exhibitions. The exhibition had developed a significant history and interest in digital art was very high during this period. It became obvious that there was a need for an online archive for the New York Digital Salon. Currently, most of the exhibitions can be found at www.nydigitalsalon.org. Efforts are under way to finish a complete online archive of all the exhibitions, and increase the content, links and supplemental information. The goal of the Salon’s web site is to become a useful resource of information on digital art, including information about the exhibitions, links to other sites, and Webcast lectures and panel discussions featuring artists, curators, and art historians. The further development of the web site is a major priority for the future.

10th New York Digital Salon in New York City in 2003

In order to mark its tenth anniversary, the organizers of the New York Digital Salon decided to do something different. While the previous nine salons had been selected by curators and a jury, it was felt that it was time to have a more comprehensive international view of digital art represented. In 2001, there were major exhibitions of digital art at the San Francisco Museum of Modern Art, Whitney Museum of American Art, and the Brooklyn Museum of Art. The original goal of the New York Digital Salon in 1993 was to establish an annual venue for computer art in New York City. Eight years later, there were two major museum exhibitions of digital art in New York City. We felt that the goal had been achieved and that it was time to make a major statement about computer art. Since the trend for the past several years had been to take a more comprehensive international view of digital art, a survey exhibition was decided upon. While there are many international organizations involved in digital art, as mentioned above, there had been no recent major cooperative projects. During our research, we also learned that there were no major museum exhibitions of digital art being planned for the 2002-2003.

The New York Digital Salon has historically operated outside the established art community, and we also thought it would be important to invite curators from major museums and institutions to select the work for the tenth anniversary. A large group of curators would eliminate personal biases and provide a wide variety of viewpoints, as well as reinforce the new sense of legitimacy that digital art was gaining in the contemporary art world. The curators selected for the Tenth New York Digital Salon included Christiane Paul, Adjunct Curator of New Media Arts at the Whitney Museum of American Art; Jon Ippolito, Assistant Curator of Media Art at the Guggenheim Museum; Gregor Muir, Kramlich Curator of Contemporary Art at the Tate, London; Steve Dietz, Director of New Media Initiatives at the Walker Art Center; Benjamin Weil, Curator of Media Arts at the San Francisco Museum of Modern Art (and Chief Curator at Eyebeam, New York); Yuko Hasegawa, Chief Curator 21st Century Museum of Contemporary Art, Kanazawa, Japan; Joel Chadabe, President, Electronic Music Foundation; Lev Manovich, Associate Professor, University of California, San Diego and a representative from the ZKM Center for Art and Media, Karlsruhe, Germany. Joel Chadabe's charge was to focus on music and sound art works, and Lev Manovich was asked to select ten important books or writings on digital art. We asked all of the curators to define "works that have changed and are changing the course of art and music history, from the earliest days to the present, with an eye on the future."

We gave the curators a wide range of freedom in their choices in order that the history of computer art be represented fully, rather than narrowly defined. We asked them to look at this project as more of an art historical process rather than trying to have everyone agree on a specific selection of works for a single exhibition. This freed them from the constraints imposed by a specific set of dates, arranging for the works to be exhibited, and a particular venue. With this approach, we also believed that it was more important than ever to bring the curatorial perspective into play. This was the reason why we brought together a group of international curators in the first place. It is through their eyes that we can see and learn how to decipher the evolving aesthetic that is digital art. Due to financial constraints, the exhibition at the World Financial Center in New York City was a small selection of the one hundred works included in the Leonardo catalogue. A comprehensive web site was created that included all the works selected, as well as essays by the curators. We also had a timeline of computer art and technology at the entrance of the exhibition to educate viewers how the creative work was situated in relation to the development of technology. [3]

THE FUTURE OF THE NEW YORK DIGITAL SALON

The New York Digital Salon has entered a new phase of its development since the tenth anniversary in 2003. Our original mission of providing an annual venue for digital art in New York City has been accomplished, as evidenced by the growing number of major museum and gallery exhibitions and their recognition of digital art as a major force in contemporary art.

We have now shifted the focus of the New York Digital Salon away from being an large open call annual exhibition to being involved in the development, exhibition, interpretation, and recognition of international digital art. The smaller annual salon exhibitions have expanded their scope by including new mediums of digital art, computer animation, digital video, interactive installations, CD-ROMs, digital audio and music, and other emerging digital technologies.

Web image from the 2006 New York Digital Salon Technocultures Panel Discussion

Public lectures and panel discussions have been presented in the United Kingdom, Italy, Japan, Korea, Hong Kong, Xian and Beijing, China, and throughout the United States. We now provide public programming, exhibitions, and events on a year-round basis under the umbrella of the New York Digital Salon Touring Program, and have received support from organizations including the National Endowment for the Arts, the Rockefeller Foundation and the New York State Council on the Arts. The web site will continue to be expanded as an online archive and resource for digital art. In March, 2009, we partnered with the Computer Art & Technocultures project to present *The History of Computer Art: A Conversation,* featuring pioneer artists Ken Knowlton, Margot Lovejoy, Lillian Schwartz and Kenneth Snelson. The panel discussion was videotaped and is archived on the Website. The New York Digital Salon will continue its mission as a leading proponent of international digital art and hopes that contemporary art will remain a vital force for promoting cultural exchange and understanding.

MERGING WITH CONTEMPORARY ART

The merging of digital art with contemporary art began many years ago and is accelerating, as a new generation of artists are producing creative work using digital tools and techniques. The resistance that the traditional art establishment showed against digital artists has weakened. Painters, sculptors, and installation artists are all using digital tools, if not as their final medium, but at the minimum, as an important adjunct to their creative inspiration and process. For example, young painters now routinely use Adobe Photoshop as a conceptual tool for their final work. Installation artists use 3D and other software tools to visualize and sketch out their installations, before they begin construction. Museums and galleries often prefer to have digital visualizations of the final installation and exhibition as part of their planning process.

CONCLUSION

Whether it is called Computer Art, Digital Art or Contemporary Art, the importance of rewriting and filling in the gaps in contemporary art history is paramount. There exists a huge vacuum of information between the 1960s and about the year 2000, when the traditional art community originally resisted and rejected Computer Art and has now finally began to see it as Contemporary Art. The reasons were many. Early computer art did not fit into any traditional art category. There were some serious archival issues, as early plotter prints, photographs and other digital output was done with media not designed to be archival. There were tremendous technical complications, included the brief longevity of operating system software and equipment to support this type of creative work. While this was certainly significant in the 1960s and 1970s, rapid developments in technology and software also had a profound negative effect on Net Art. During the emergence of the Worldwide Web (www) in the mid-1990s, Internet software had a half-life of about six months and Net Art works often became obsolete or difficult to archive within a year of their creation. We are now fortunate that there are ways to preserve and revisit computer art. Emulation software is revitalizing obsolete operating systems. Also, many artists are porting their original works over the new platforms that are more accessible to a wider audience.

All of these activities contribute to the preservation and placement of Computer Art history into the mainstream of Contemporary Art. As these efforts continue, and as the new generation of artists create a body of work that seamlessly employs digital and traditional techniques, we will finally see a true merging of creativity between the traditional and the digital.

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Recently Published Surveys of Digital Art

Oliver Grau, *Virtual Art: From Illusion to Immersion*, 2003, MIT Press, Cambridge, MA, United States

Margot Lovejoy, *Digital Currents: Art in the Electronic Age,* 2004, Routledge Press, 3rd edition, New York, NY, United States

Christiane Paul, *Digital Art*, 2008, Thames & Hudson, 2nd edition, London, UK

Frank Popper, *From Technological to Virtual Art*, 2007, MIT Press, Cambridge, MA, United States

Edward Shanken, *Art and Electronic Media*, 2009, Phaidon Press, London, UK

Bruce Wands, *Art of the Digital Age,* 2006, Thames & Hudson, London, UK

Stephen Wilson, *Information Arts,* 2002, MIT Press, Cambridge, MA, United States

Digital Art Online Archive Links

There are many organizations that maintain online archives on digital art. The ones listed below will provide a good starting point for research in this area.

www.aec.at
www.dam.org
www.fondation-langois.org
www.isea/org
www.leonardo.info
www.nydigitalsalon.org
http://rhizome.org
www.siggraph.org
www.technocultures.org
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