Computers and Modern Art

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Note: the following text was written on the occasion of the launch of the Digital Art Museum in 2000 and reflects the structure of the website at the time. Although the current website does not follow the approach described by King, we have deemed it useful to include this essay as a form of documentation of the history of the DAM Museum itself and highlight the contributions of its author.

Introduction

Digital Art Museum (DAM) is a joint research project between London Guildhall University and two independent galleries, one in London England, and the other in Wiesbaden Germany. It aims to become a leading on-line resource for the history and practice of computer art. At the time of writing the focus has been on the Pioneers of computer art from 1956 to 1986, which is delineated as Phase 1 of the project. These artists are characterised by their engagement with early computer technologies for image production, which technologies include both analogue and digital circuitries, and may only remotely resemble modern digital computers. Many of the pioneers were not in the first instance artists, or not necessarily trained artists, and may be included in DAM more for the historical significance of their work than for their artistic abilities. However in the first instance the emphasis in DAM is always on artistic excellence, and in particular on those artists who have stayed in the field for a substantial period.

The date 1956 has been chosen for the birth of computer art because a number of commentators, including SIGGRAPH panels and Jasia Reichardt, director of the prestigious Institute of Contemporary Arts in London England, have cited this date. It is a little arbitrary for several reasons, firstly because much of the 'digital' art starting in this period was in fact analogue, and because the experiments of both Ben Laposky and John Whitney Sr. started a little earlier. Nevertheless, it marks the beginnings of computer art experiments by a third early pioneer, Herbert Franke, and in some sense also the beginning of a movement. 1986 has been chosen as the end of this pioneering period with a similar arbitrariness, but not without some important historical landmarks, all to do with the paint system. Firstly, Britain's BBC TV broadcast a series called 'Painting with Light' which followed a group of well-known modern painters as they came to grips with the Quantel Paintbox (a pioneering television graphics paint system); secondly, Andy Warhol made a series of works with the Commodore Amiga, including self-portraits and portraits of singer Deborah Harry; and thirdly it was the year in which Photoshop was written (though not yet released for the mass market).

Phase 2 of Digital Art Museum (tentatively called 'the Paintbox Era') runs from 1986 to 1994, in which year the world wide web took off. Phase 3 (tentatively called the Multimedia Era) will include artists from 1995 onwards, and is intended to showcase new and emerging talent.

This paper will focus mainly on the Pioneers of digital art and the relationship of their work to Modernist art styles. In an odd way the computer emserged as a tool for artists at just the wrong time: too late for the mathematical explorations of Constructivism and Suprematism (by decades), just too late for Op Art (by a few years) and just in time to see Postmodernism make the kind of content-based art that the computer lends itself to somewhat redundant. Hence computer art has never been mainstream and has also been dogged by its association with the non-artist and art-naïve practitioner from the computer sciences. Some of the most significant practitioners of computer art, including John Whitney Sr. and Harold Cohen have been highly critical of much of computer art, and rightly so. However the observation behind Digital Art Museum is that the best work from the best digital artists is compelling as art, historically important, and significant for its interdisciplinary creativity.

This is a good point to add a personal note. I work at the intersection of art, science and the spiritual, regarding each as an open and systematic inquiry into different aspects of the deep structure of human experience. Clearly this essay focuses on the border territories between art and science, but it is obliged to touch on the spiritual in passing for two reasons. Firstly the birth and progress of Modernism is associated with the spiritual in unexpected ways, and secondly a number of the digital art Pioneers had or have explicit interests in this field. One can make a fairly rounded analysis of both Modernism and digital art without reference to the spiritual, but it seems pointless to leave this gap of comprehension.

Phase 1 artists

As Digital Art Museum is an on-going research project it is not possible at this point to give a comprehensive list of pioneers, or at least not one that would satisfy everyone. Hence the list in Table I is tentative, and will be reduced or expanded on two criteria: (1) the historical contribution to the field (2) the substantial nature and quality of the body of art that survives. (Readers are cordially invited to contribute to the selection process, and to alert us to any historical omissions or inaccuracies.) Note that the column marked 'Enter' is the approximate date that the artist started working with computers (where known).

Artist	Category / Comment	Country	Enter
Ben Laposky	Mathematician / artist	US	1950
Herbert Franke	Mathematician / artist	Germany	1956
John Whitney Sr.	Filmmaker – as artist in residence with IBM	US	1958
Charles Csuri	Artist – Algorist	US	1960

Artist	Category / Comment	Country	Enter
Michael Noll	Computer Scientist – Riley and Mondrian simulations	US	1963
Frieder Nake	Mathematician	Germany	1963
Edward E. Zajec	Artist / Animator	US	1963
Kenneth Knowlton	Computer Scientist	US	1967
Ruth Leavitt	Artist	US	
Lillian Schwartz	Artist / filmmaker / art analysis	US	1968
Vera Molnar	Artist	France	1968
George Nees	Mathematician – computer sculpture	Germany	1969
Manfred Mohr	Artist – Algorist	Germany	1969
Harold Cohen	Artist	UK	1972
Joan Truckenbrod	Artist	US	1975
Yoichiro Kawaguchi	Artist / animator	Japan	1975
Laurence Gartel	Artist – early paintbox	US	1977
Jean-Pierre Hébert	Artist – Algorist	US	1979
Mark Wilson	Artist – algorithmic plotter art	US	1980
Roman Verotsko	Artist – Algorist	US	1982
David Em	Artist – 1st significant use of 3D	US	1983
Rejane Spitz	Artist	Brazil	1983
Paul Brown	Artist, educator	UK	
Yoshiyuki Abe	Artist	Japan	

Table 1 Phase One of Digital Art Museum, tentative selection

In Phases 2 and 3 of the project it is the second criterion that will mainly apply. The few artists discussed in this paper have been selected to show how their work related to modern art movements, and not to give a comprehensive development of the field.

Making a brief historical journey through the Pioneers, we note an early cluster of activity in the 1950s with Ben Laposky and John Whitney Sr. in the USA, and Herbert Franke in Germany. Ben Laposky was a mathematician and artist who died in 2000. His first artworks, which he called ‘oscillons,’ were made with an oscilloscope in 1950, and he

claims to have exhibited them from 1952 to 1975 in over 216 exhibitions in the US and abroad, and to have been the subject of 160 publications [1]. It was Herbert Franke's publication 'Computer Graphics – Computer Art' [2] that brought to light the almost simultaneous, yet independent development of this artform in Franke's own work, and also in that of John Whitney Sr. Yet all three came to these experiments from rather different approaches, Whitney's being the most rooted in modern art. Whitney was an experimental filmmaker, interested in the visual parallels with music and the possibility of new abstract cinematic forms, gaining the necessary technological and mathematical skills to realise his artistic purposes. Franke, scientist first and artist second, was active in the production of works of art and their exhibition, just as Laposky was. Both started from mathematics. The concerns of some of the Pioneers who were not primarily artists can be understood from a comment made by Franke:

If one is engaged, as we are, with an inventory of all mathematical branches and with an interest in visualising all forms that come to light, one can obtain plenty of forms, shapes and structures never seen before – an expansion of our treasury of forms. Many of these forms have considerable aesthetic charm. According to the usual criteria we cannot call them original works of art. But they can be considered elements available for new creations and can be used to develop artworks. [3]

A focus on mathematics, in this case, or on the technology itself in other cases, is characteristic of some early computer art, and provides a very different motive from that of the artist. Laposky, Franke and Whitney were interested in artistic forms deriving from simple mathematical elements, principally the interaction of sine curves upon each other, and in time. (Whitney tells us in a 1970 interview that he took to the computer because he realised that his earlier equipment was doing mechanically what an oscilloscope would do [4]). However, Whitney is primarily an artist, Franke a scientist, and Laposky somewhere inbetween. Whitney tells us that his motivation lies with the artistic nature of harmony:

Indeed, "The nature of art has become uncertain," and for one sizeable block of composers, that grand Pythagorean certainty – the harmony – has come apart. Even so the foundation of my work rests first upon laws of harmony, then in turn, upon proof that the harmony is matched, part for part, in a world of visual design. That is my hypothesis. [5]

Another artist whose work explores the visual equivalencies of musical structure is Edward E. Zajac, though he seems to have reached his inquiry and conclusions independently of Whitney. [6]

Jumping now to 1969, we mention the work of another German artist, Manfred Mohr, whose work has a mathematical basis, this time principally in the hypercube. Although Mohr had strong interests in music, this time jazz, he only in his later work experimented with animation, focusing instead on a long series of print-based work that sometimes demonstrated visual equivalences to music. In his early work, as a transition from his painting, Mohr experimented with dense rows of symbols, selected and placed using

pseudo-random techniques, a process more located in semiotics than mathematics. Then began a life-long exploration of the cube, itself perhaps the meeting point of sign and mathematical abstraction, and at first sight an unpromising basis for a personal oeuvre. However, with astonishing persistence and originality, Mohr began to make variations, fractures and dimensional progressions that gave him a reputation in Germany and beyond, his prints finding their way into significant collections. The principle element of his later work, projections of n-dimensional hypercubes, fractured onto the 2-dimensional plane, is an artistic obsession that has an interesting history in modern art, and will be explored later.

Adopting the computer somewhat later than Mohr, painter Roman Verostko developed a body of work over 25 years that explored the computer's algorithmic capability. Interestingly, the pre-computer paintings of both men show abstract expressionist influences. Verostko's use of algorithms is quite different however, reflecting a stronger interest in the organic, and eschewing 3D or higher dimensional representations. He is also unusual in his calligraphic interests, which led to experiments in using the plotter with Chinese brushes and inks, specially adapted for the machine. Verostko introduces the Leonardo essay on his work by saying "The software, called Hodos, can generate paintings that bear an uncanny resemblance to my work made by hand over 20 years ago" [7]. The paper goes on to discuss the main themes in his work, including the idea of tension between 'control' and 'uncontrol', a significant area of exploration with many computer artists.

Manfred Mohr and Roman Verostko are, since around 1996, part of a group called the 'algorists', along with artists Mauro Annunziato, Charles Csuri, Helaman Ferguson, Jean-Pierre Hébert, Ken Musgrave, and Mark Wilson. All use computer algorithms as the basis for their work, and a subset exclusively use plotters. The 'algorists' had of course been working with computers for many years before forming the group, Charles Csuri for example as far back as 1960 or earlier.

One of the most unusual computer art oeuvres of the last 25 years belongs to Harold Cohen, a successful British abstract painter, who abandoned his career in painting in the early 80s to program computers. His ambitious aim was to 'teach' the computer the rules of artistic composition that drove his own work, and this resulted in an Artificial Intelligence program called 'AARON'. Initially running on minicomputers the size of a large refrigerator, and exhibited in this form at the Tate Gallery, London UK, in 1983 [8], it is now housed in Cohen's laptop, and has the alarming capability of 'painting' to itself.

The last of our very small (and not particularly representative) selection of computer artists is Laurence Gartel, who started working with video synthesizers in 1976. This is some 10 years before the watershed of 1986 (marking as we saw earlier the introduction of the Paintbox to painters, the use of the Amiga by Warhol, and the creation of Photoshop), and was at a time when the video image could only be crudely manipulated and then photographed off the video monitor. While the 'algorists' and artists working in similar ways with plotters could manage with relatively cheap computer equipment, the video and pixel-based image required expensive equipment far beyond the budget of

individuals. In Ruth Leavitt's 'Artist and Computer' we learn that the necessary equipment in 1975 would comprise a computer ($50,000) a frame-buffer ($80,000) a tablet ($5,000) and a colour TV monitor ($5,000) [9]. In the year 2002 all this hardware is subsumed within a cheap personal computer, totalling around $1,000, apart from the tablet which would be a small additional cost. The frame-buffer, essentially fast video RAM with a controller chip and digital-to-analogue converters, has experienced the most astonishing drop in price, from $80,000 to $80. Gartel is unusual for having entered the paint-box style of work so early, and having persisted through the evolution of this technology to the present day.

Some Modern Art Movements

Leaving technology for the moment, we now look at painting. The origins of Modern Art may not be exactly disputed, but there are numerous myths about its motives that bear closer examination, for example that modernism rejected the irrational and superstitious; that it represented progress and democracy; and that above all it was a break with the past. These were some of the themes of a UK Channel 4 TV documentary and booklet called 'Hidden Hands – a Different History of Modernism' [10] which focused on the spiritual interests of modernist painters, the obsession with cleanliness following the first world war, and the patronage of the American Abstract Expressionists by the CIA during the cold war. There is no need to dwell overly on these factors that undoubtedly helped shape modern art movements, but a brief look at the spiritual influences will be useful as several digital artists amongst the pioneers had such interests.

Norbert Lynton in his introduction to 'The Story of Modern Art' points out that the conventional or received views on modern art were determined by a small group of curators and critics, such as Alfred Barr, director of the Museum of Modern Art in New York [11]. Maurice Tuchman has been foremost amongst those who saw Barr's formalist critique as one that suited the time but failed to probe beneath the aesthetic, formalist structures of abstract art to the spiritual motivations of the artists [12]. I have explored the issue of the spiritual and occult influences on the artists of the early 20th century in several papers [13] and [14], drawing on the work of another art historian, Roger Lipsey [15]. Lipsey's seminal work has the phrase 'An Art of Our Own' as part of the title, a reference to a comment made by Constantin Brancusi that artists at the beginning of the 20th century had struggled free of the prime patron and subject matter of thousands of years – religion. Yet the paradox for modern art lies here, because Brancusi's work, as with other pioneering artists such as Mondrian, Kandinsky, Itten, and Arp, to name just a few, drew explicitly and intentionally on spiritual material. According to Lipsey, Brancusi's bed-time reading for many years was the 'Life of Milarepa' an autobiographical account of an 11th century Tibetan Buddhist, and so it went with many artists at this time, drawing on a wide variety of new and ancient spiritual traditions. In the late 20th century it had become intellectually inconceivable that writers, artists and thinkers could be so interested in such material, let alone be fully signed up members of occult organisation such as Theosophy and Anthroposophy, or followers of spiritual teachers such as G.I.Gurdjieff. Alfred Barr did not single-handedly bury these real and important influences on modern art, it was

Western culture as a whole that denied these facts, and held up a rational modernism, one that was to be understood in terms of aesthetics, formalisms, and polemic.

The tensions between aesthetics and polemics, between spiritual content and socialist principles marks 20th century art, and impacted on the digital art pioneers as much as the other artists. While the artists at the start of the 20th century were widely influenced by the spiritual, it was the impact of world war one, the Russian revolution and world war two that progressively cemented the shift towards the polemical, socialist, egalitarian, and finally a content-free art. The reason for pointing this out in this context is that the computer, as a tool for working on content, has only a marginal role in the kind of art that now dominates the fine art world. Hence to understand many of the digital art pioneers we have to look at earlier modern art movements, though it is a vast subject that can only be lightly touched upon here. Norbert Lynton has this to say on art movements:

The story of modern art is usually told in terms of movements: Fauvism, Cubism, Futurism, Expressionism, and so on. It was as group events that developments tended to come before the public, and in some instances (futurism, Surrealism) it is true that the art and its movement context fittingly went together. But in most cases the movement was a fabrication — [16]

Lynton goes on to say that despite this the 'movement' is of course a useful handle on art, as it is for us with our Digital Art clusters, such as the 'Algorists'. Of the early modernist movements, we can select a few that have a particular bearing on digital art, in particular Cubism, Constructivism, and Suprematism.

Cubism might be seen as the modernist precursor par excellence, an art that rejected older methods of representation and subject matter, and which resonated with discoveries in mathematics and science, in particular of the fourth dimension and relativity. Cubism developed between 1907 and 1911 in the work of Picasso and Braque, who later commented that "We were like two mountain climbers roped together". The paintings fractured the three-dimensions of space, iconically represented by the cube, and attempted to show all sides of an object at once, at the same time stripping out colour to the basic greys and browns. Leonard Schlain, in his book 'Art and Physics' has shown that not only were these artistic revolutions directly related to the discoveries of Einstein, but that such advances always anticipated those of science [17]. The latter claim is radical, but the parallels between art and science bear up under close examination. Schlain points out that travelling near the speed of light results in the observer seeing gradually more and more of the normally occluded sides of an object, until at the speed of light one sees all sides at once; at the same time colour is stripped out – exactly what the cubists were indicating in their paintings. However higher dimensions were not just a scientific or mathematical interest, it was also a spiritual one, and was the particular obsession of a Russian philosopher who had an impact on Russian Constructivism and Suprematism – P.D.Ouspensky. I have explored some of these issues around dimensionality elsewhere [18], but we can say that the lasting legacy of cubism is, paradoxically, the jettisoning of the third dimension in 20th century art in favour of flat surface.

Moving on to the Constructivism of Tatlin and the Suprematism of Malevich (both Russian artists) we see the flattening of the picture plane, the abstraction of once-familiar representations, and the stripping out of colour, or its handling in new and unrealistic treatments. Explicit now are concerns with technology, concerns that presage those of many computer artists, and present, but hidden in creative tensions, are the conflicting impulses to the spiritual, and its denial via the imperatives of the socialist systems of thought emerging after the Russian revolution. The obsession of pre-first world war artists and thinkers with the occult, so strange to present sensibilities, give way to the more recognisable Marxist preoccupations, even within the artists that fled Russia and invigorated European and American art movements. Inherent in Kandinsky's analysis of the spiritual art was an elitism, symbolised by his upward-moving triangle [19], which ran counter to the new thinking. At the same time the spiritual interests prior to 1914 were seen as impotent in halting the barbarity and horrors of war; art itself was under challenge from the socialist perspective for similar reasons.

It is perhaps in the work of Naum Gabo that Constructivism has the closest relationship with science, and hence with some of our computer art Pioneers. Gabo attended lectures on relativity in Munich as part of his studies, firstly in medicine, and then in applied science, though these remained incomplete in favour of art [20]. In fact he received no formal training in art, though he absorbed influences from across the spectrum of Expressionism and Constructivism. Gabo's first works are figurative, often constructions of heads, but these give way through a process of abstraction (common to many artists of the period) to completely geometrical forms. Unlike some artists who made mathematics their starting point Gabo worked spatially, intuitively, and one may add more controversially, emotionally and spiritually.

If the First World War turned many artists and thinkers away from the spiritual and towards socialist ideals, then the Second World War created further hostility towards occultism. Tuchman tells us that to use the word spiritual in the late 1930s and 1940s was near-heresy and dangerous to an artist's career because of the political associations of such ideas with Nazism [21]. Once the full horrors of the Nazi experiment were known such associations were entirely negative. Yet despite this, the American Abstract Expressionists had a range of spiritual interests, from Jungian archetypes, to Zen Buddhism, to Native American Shamanism. Pollock for example was deeply influenced by Native American artforms and the influence can be traced right through his entirely abstract action paintings [22].

After WW2 Abstract Art also flourished in Britain with both abstract and figurative elements and led to new movements such as the Situation group (which included Harold Cohen before his involvement with computers), Colour-Field painting and Op Art (short for Optical Art). Op Art grew more from Constructivism, and developed through artists such as Josef Albers and Victor Vasarely in the 1940s and Bridget Riley in the 1960s. This is one of the few modern art movements to overlap with computer art developments.

Pop Art, an art movement which derived its imagery from mass-communication media and popular icons, developed in Britain and the US independently at first, in the

mid-1950s. It was not until the mid-80s that computer technology had developed enough for a mainstream Pop artists such as Richard Hamilton to take it up seriously (though he had used them as early as 1963 for specific tasks [23]).

To sum up this very brief survey of some Modern Art movements, we can identify interests with the deep structure of human experience, whether expressed through the spiritual or the scientific, as an important element in abstraction. Whether the art that so evolved was put to socialist purposes as with Russian Constructivism, or whether on the other foot it (supposedly) received backing from the CIA as with American Abstract Expressionism is a secondary issue. The abstract, geometrical, mathematical, scientific and technological bases for such art forms make them important sources for early computer art explorations, even if the computer artists were revisiting themes at the end of the 20th century that had been discovered at its start.

Anti-art is also an important strand in modernism, expressed sometimes as a deliberate rejection of deeper meanings, focusing, as in Pop Art, on the surface glitter of modern life, reflecting just the sheer vibrancy and energy of the city and its fantasies. More generally artists might reject art itself (e.g. Marcel Duchamp), or its capitalist context, its exclusivity, or any of the values previously held central to its pursuit.

Relationships between Computer Art and Modernism

Let us return now to our focused selection of digital artists and examine how their work might relate to modern art movements. Frank Dietrich, artist and media researcher at the University of Utah, USA, has written several valuable papers dealing with the history of computer art and its relationship with modernism, but with a focus on how the computer takes art in new directions [24] and [25]. Here we look rather at the relationship with old ones.

With the cluster of Laposky, Franke and Whitney we might observe that soulmate to all three could be Naum Gabo, whose work in the late 30s predates the computer explorations by 20 years. While Gabo realised his ideas in sculpture, the computer artists were using oscilloscopes and purpose-built equipment, often conveying their ideas on film more than with prints or photographs. The Constructivist ideals and preoccupations may not have been researched in depth by the computer artists, but they would have been aware of some of the work, and more to the point they gravitated to the artistic forms because of a fundamental interest in the aesthetics of mathematics and science. Laposky claims ‘abstract geometric painting, cubism, synchronism and futurism’ as his inspiration and ‘op art’ amongst the art forms that his work related to [26].

Whitney describes his work in terms of ‘harmony’, but not just the abstracted harmonies of musical theory or the science of waveforms. They are specifically the Pythagorean harmonies that informed artists of the Renaissance and religious painters through Western history, and which Whitney used the computer to visualise. In fact the Whitney family, which included a number of artists and filmmakers, were influenced by a range of spiritual sources including Buddhism, and which informed Whitney’s work. These were

shared of course by many Constructivists, including Gabo, who often referred to the emotional and spiritual significance of his works.

Cynthia Goodman, author of the well-known survey of computer art 'Digital Visions' writes:

'In Europe, in the late 1960s, artists with strong visual and conceptual alliances with the Constructivist tradition, including Manuel Barbadillo, Edward E. Zajac, Vera Molnar, and Manfred Mohr, were the first to use computers for artistic ends.' [27]

Gabo continued with his constructivist sculptures until his death in 1977, just after a solo show at the Tate Gallery. This longevity of pursuit in a single artistic style is typical of the mathematically-inclined artist, and we see it with Mohr and Verostko. This is not to say that the oeuvre is not rich and varied, but it is a contrast to the continuous revolution that was for example the artistic life of Picasso. Mohr's work in the 1970's could almost have been part of the Op Art tradition, but once he started the cubic experiments in 1975 he stuck with it. The Op Art aesthetic, perhaps accidental, gives way to the fractured projected n-dimensional cubes that formed the basis of all subsequent work, the only major innovation being the introduction of colour in 1999. Can we relate this body of work to cubism, or is it only a coincidence of name? The fact is that the fractured projection of cubic space onto canvas, and the interest in the fourth and higher dimensions is common to Cubism and Mohr, and to a succession of artists in the 20th century, well-documented by art historian Linda Dalrymple Henderson [28]. The exploration of this by computer has also been the work of artist Tony Robbin. [29]

But modern art movement intertwine and produce a rich set of conditions for the computer art Pioneers. We can see Cubism, Constructivism and Op Art aesthetics and concerns in the art of Mohr, and discern Abstract Expressionist influences on his paintings. Verostko shared these influences, but it is more specifically the work of Jackson Pollock that inform Verostko's interests in the placing, rhythm and densities of line in his plotter art. The Dadaists, with their interest in 'automatism' – the visual equivalent of automatic writing – were also an important influence on his explorations of 'control' and 'uncontrol'. We noted that Pollock's influences include the Shamanistic artforms of Native Americans, and that this spiritual thread runs through Verostko's work, and his writings (he doesn't hesitate to cite spiritual traditions such as Buddhism and Taoism). In contrast Mohr rejects 'metaphysics' and in doing so again highlights for us the opposing ideologies buried beneath the surface of 20th C art:

The world will not be changed from the outside but from the inside and aesthetical decisions will be more and more based on knowledge rather than on irrelevance. The shift from uncontrollable metaphysics to a systematic and logical constructivism may well be a sign of tomorrow [30]. [my emphasis]

In fact it was the technology that drove the early computer art experiments as much as the artistic influences of prevailing art movements. We can see this in an influential cluster of activity at the Bell Laboratories, New Jersey, USA, described for us in an illuminating article by Michael Noll [31]. Noll himself typifies the computer professional who took an

interest in art and produced computer-generated works, rather than the artist who took up the computer. Bell Labs had an open research strategy that encouraged such explorations and allowed for collaboration between engineers, such as Noll, and artists such as painter Lillian Schwartz, animator Stanley Van Der Beek and video artist Nam June Paik. Indeed quite a proportion of the names we associated with the Pioneers of digital art came out of this venture, including Edward E. Zajac, mentioned earlier. The work produced from the Bell Labs experiments in the 1960s was influenced by the art movements we have discussed, in works that sometimes mimicked paintings (such as the line compositions of Mondrian, or Op Art pieces by Bridget Riley such as 'Current'). Other works reflected the interest in the fourth dimension and hypercubes, and led to a 4D animated title sequence for the NBC television company. Whether Manfred Mohr had been aware of this is unclear, but it shows again the iconic status of the hypercube in 20th C art.

Noll was involved with a seminal art show at the Howard Wise Gallery in New York in 1965, where work from Bell Labs was exhibited, and which led to exhibitions round the world. At almost exactly the same time two German computer artists, Georg Nees and Frieder Nake, mounted a ground-breaking show at the Galerie Niedlich, Stuttgart, Germany.

Harold Cohen in contrast had already achieved critical success in painting before taking up the computer, showing internationally including the Venice Biennale in 1966. His work is described in many books and papers [32], and his incisive thinking on the work and art in general has enriched the field for several decades (see for example the paper for Creativity and Cognition 3 [33]). More than any other computer artist his work represents a challenge to notions of art, a challenge that lives alongside the tradition started with the Dadaists but asks perhaps the most awkward questions yet. I once asked him why so few artists and researchers had followed in his footsteps, why no art movement had grown around his pioneering oeuvre, to which he replied 'it is just too much hard work' [private discussion at Creativity and Cognition 3 conference, 1999]. This is undoubtedly true as the sheer size of his AARON programme testifies, but perhaps few artists also have the courage to face the question: if a machine can make art, then am I a machine?

When looking at modern art movements in the 20th century we can find identify many of the artistic concerns that also drove the computer art pioneers. However, none of the digital art genres became a significant art movement compared to those recognised in the fine art world. Jasia Reichardt, director of the Institute of Contemporary Arts (and curator of the 'Cybernetic Serendipity' exhibition) in London UK during the 70s made this observation about the early digital work:

Most art movements are remembered for the relatively few great works which are associated with them and the exceptional individuals who brought them about. — Those trends or movements which demonstrate a current preoccupation but fail to produce works of great quality leave an incomparably lesser trail. — Since the early 1950s, however, there have been two international movements which in this context constitute an exception. An exception in the sense that there are no masterpieces to be associated

with them, nevertheless these two movements have unique significance both socially and artistically. The first of these is Concrete Poetry, and the second, Computer Art [34].

Since Reichardt wrote this in 1971 it may still be true that there are no great masterpieces of computer art, but there certainly is a substantial body of fine work that can stand as art.

To finish, it is important to point out that Digital Art Museum aims to serve contemporary artists through showcasing their work, just as much as by archiving the achievements of the past. However, many young artists might be tempted to ask how the majority of the pioneers might be relevant to the current situation, given the dominance of programming in the early years and the present availability of high quality software ready-made for the artist. I addressed this question in a 1995 Leonardo paper [35], citing many of the artistic inquiries discussed in this paper: control / uncontrol, algorithmic art, rule-based art, visualisations of mathematical entities, and even artificial intelligence. It is by collecting a credible body of early computer art together that DAM can present the case for an art/ science collaboration that would match the early efforts and bring to fruit these many promising experiments.

Conclusions

This short paper has attempted to survey two extensive fields: digital art, and art movements of the 20th century, and to demonstrate how one is located in relation the other. Only a few of the computer art Pioneers could be discussed here, and an even tinier proportion of Modern Art movements could be introduced, but the main areas of overlap have been set out. Digital Art Museum is a project in its infancy but it is clear that further work on the Pioneers will better show the way in which their concerns were embedded in the artistic life of the 20th century.

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