ISEA 93

Papers

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the art factor:
fourth
international
symposium on
electronic art

Papers

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PREFACE

By way of introduction to these symposium papers let us say a brief word first on the term "electronic art"and secondly on the focus of the symposium, "the art factor." Our task is twofold: (1) to specify more clearly what we mean by "electronic art" and (2) to begin developing the critical understanding necessary for filtering out the finest artistic manifestations of its use.

ELECTRONIC ART. Recently a colleague suggested that the term "electronic art" was an oxymoron. By this I believe she meant a self contradictory term. Several years ago when we contemplated this symposium I also questioned the use of the term "electronic" as did our committees and many others. But no longer.

Changing technologies in the practice of art are not new. They have been with us from prehistoric times. Thus the art of the brushed Chinese character is "shufa"; the art of the manuscript is "calligraphy"; and the art of typesetting is "typography."

Since World War II the field of electronics has achieved radically new capabilities and has attracted hundreds of artists to experiment with its use. There are over 1800 entries in the 1993 edition of the *International Directory of Electronic Art*. Although reference to "electronic" music dates back to as early as the sine–wave tones of Leon Theremin in 1924, it was the perfection of the tape recorder in the 1940's that thrust electronic music forward. For the arts in general, the term has been in substantial use for several decades with a pronounced presence since the founding of "Ars Electronica" in 1979 at Linz, Austria.

What is the new post WWII technology in electronics? It is the integrated circuit (1948) making possible the use of sophisticated logic circuitry in everything from desktop computers to cruise missiles. Today's electronic controllers exhibit an uncanny capability — a semblance of "intelligence," capable of flying airplanes, simulating the human voice and controlling vast networks of information.

These controllers are driven by electronic circuits capable of processing logical procedures lending them a seemingly intelligent behavior. These procedures may be software controllable (open for instruction) and self adjusting to the environment they are designed to control. Procedures may be designed to simulate practically anything we can conceive including "evolution" which is what the "genetic" algorithm does. Through such procedures an artist may breed "form" which is what William Latham does in *Biogenesis* (FISEA 93, Electronic Theater). This is only one of many possible directions an artist might explore.

Many FISEA 93 presenters are artists who have created work which is radically informed by electronic procedures — work which may clearly be called "electronic." Others have collaborated with artists as electronic toolmakers. Some of these artists have wrestled with the giant for many years — prodding it to serve their artistic vision. To our earlier question, then, "Is electronic art an oxymoron?" we must say emphatically, "No!" It is not any more so than "graphic art," "stained glass art" or "film art."

THE ART FACTOR. In "Electronic art" exhibitions we have seen examples of novel and brilliant electronic technology. But a brilliant technology without "art" may be likened to a body without mind and soul, a floundering entity or a corpse. For this reason the Program Committee for FISEA 93 chose to focus this year's symposium on "the art factor." Flying "by the seat of their intuitive–intellectual pants" they have struggled with their personal (internal) definition of the "art factor." The papers in this volume address artists' concerns related to aesthetics, terminology, "self" expression, and the problems associated with collaboration and interactivity between humans and electronically controlled machines.

The interactive works in the FISEA 93 art show display the more obvious use of such technology. But there are many less obvious applications. Artists who make use of this kind of technology generate work as diverse as the applications of the technology itself are diverse. Thus "electronic art" may, in some instances, appear to be formally indistinguishable from familiar forms of "performance" or "painting" or "printmaking." But stop. Look again. Listen again. Is this so? If not, why not? These questions are the substance addressed by the papers presented here. We thank the authors of these papers whose work sheds light on "the art factor" in this new frontier.

Roman Verostko, Program Director, FISEA 93

From Appearance to Apparition:
communications and consciousness in the cybersphere

Roy Ascott

"The mod does two things...it stops me collapsing the wave function; it disables the parts of the brain that normally do so. But the mod also allows me to manipulate the eigenstates - now that I no longer clumsily, randomly, destroy all but one of them."

"So what should we call it?"

"...neural linear decomposition of the state vector, followed by phase shifting and preferential reinforcement of eigenstates". She laughs. "You're right: we'd better think of something catchier, or the whole thing will end up being grossly misreported."

Greg Egan, *Quarantine*, 1992

Schrödinger's Cat has to be the most celebrated creature in the bestiary of science, and the paradox it proposes is perhaps the most complex in our understanding of consciousness and reality. It describes the problem of measurement at the quantum level of reality, the level of subatomic particles, atoms and molecules.This gruesome thought experiment involves a black box containing a cat and radioactive material positioned so as to trigger the cat's death if the particle decays. The process is quantum mechanical and so the decay can only be predicted in a probabilistic sense.The whole boxed system is described by a wavefunction which involves a combination of the two possible states that the cat can be in: according to quantum theory the cat is both dead and alive, until we observe or measured it, at which point the wavefunction collapses and the cat will be seen to be in either one state or the other. And just as the electron is neither a wave nor a particle until a measurement is made on it, so the cat is neither dead nor alive until we get to take a look at it. We are dealing here with observer-created reality. To look is to have the system jump from a both/and situation to an either/or outcome, the quantum jump producing what is known as the eigenstate. But there is no agreement amongst physicists about precisely where, in the chain of events in this wavefunction collapse, the measurement result is ultimately registered.

Greg Egan places the point of collapse, the point at which reality is created, right in the brain. By proposing a technology which could be inserted in the brain to modify this eigenstate effect, to block it and thereby prevent the collapse of the wave function. his scenario gives a post-biological context to the idea that reality is constructed. Egan speaks the language of the coming decade. His 1990's science fiction addresses issues of the neuro-cognitive sciences with the prescience that William Gibson showed towards computer communication developments in the 1980s. And just as Gibson's *Neuromancer* correctly identified cyberspace as an important cultural construct of the late 20th century, so Egan's *Quarantine* identifies the issues likely to preoccupy us at the turn of the millennium. The question of consciousness, the technology of consciousness. the transcendence of consciousness will be the themes of 21st century life. Fundamental to this evolution is the development of a telematic art in the cybersphere, and fundamental to that art are the experiments, concepts, dreams and audacity of artists working today with telecommunications systems and services.

Questions of consciousness and the construction of reality are at the centre of any discussion of the status, role and potential of art in the emerging cyberculture. The fundamental question is this: Can an art which is concerned, as western art has always been, with *appearance*, with the look of things. with surface reality, have any relevance in our systems-based culture in which *apparition*, emergence, transformation are seminal? Can Representation co-exist with Constructivism? It is the overarching concern with appearance and with representation which has hitherto characterised western art and which has made it the servant of ideologies, of both church and state. It is its concern with appearance which has kept it in line with classical science, looking no further into things than their outward forms allow, making of the world a clockwork machine of parts whose movements are regulated by rigid determinism. and seeing Man as little more than a material object. It is the art of appearance which is purveyed in boutiques, galleries. museums and on the pages of chic art magazines. It is International Art . And it is dying. It is dying because it is no longer relevant to a culture which is progressively concerned with the complexity of relationships and subtlety of systems, with the invisible and immaterial. the evolutive and the evanescent, in short. with apparition. Questions of representation no longer interest us. We find no value in representation. just as we find no value in political ideologies. We do not wish to keep up appearances.

The telecommunications of cyberspace, on the other hand, offer the contemporary artist the means of interaction (both his own and that of the viewing subject) with dynamic systems. with creativity-in-process, with the emergent properties of an art of transformation, growth and change. It is for this reason also that the narratives and technology of Artificial Life are so important to us at this time. Cyberspace is the space of *apparition*, in which the virtual and real not only co-exist, but co-evolve in a cultural complexity . Apparition implies action just as Appearance implies inertia Apparition is about the coming-into-being of new identity, which is often at first, unexpected, surprising, disturbing. If appearance is claimed as the face of reality, of things- as-they- are, apparition is the emergence of things-as-they-could-be. However, our insight into the ways in which reality is constructed in our consciousness, leaves us in no doubt that the processes of apparition are authentic and that appearance is a fraud. Representation in art was always essentially mendacious, illusory, and counterfeit. The mirror always lies.

More and more artists now take global networks. virtual reality, high speed computing for granted. These technologies are no longer seen as simply tools for art. they now constitute the very environment within which art is developing. Given this increasing familiarity, artistic questions now are not so much concerned with these dataworlds per se but with the interface between them, between us, between our own minds and that larger field of consciousness we call the world.

Whether or not Egan's fictive brain modifier gets to be developed, the fact is that our technologies of perception. cognition, and communication - the interface to the complex computer systems that both mediate our consciousness and construct our reality - are moving closer and closer to the body and into the brain. Just as the keyboard and mouse are being consigned to history, so too will the Head Mounted Display, the DataGlove, even the datasuit soon be consigned to the museum. Conceptually, they already are. We want the systems interface set within our brain. We want the boundaries between "natural" and "artificial" to be as redundant technologically as they are becoming conceptually and spiritually. This is to talk about the post-biological body as interface.

Progressively, we artists want to be creative in cyberspace by controlling computer-mediated systems through biological input sensors and biocontrollers in our own nervous system responding directly to signals from the brain, eye and muscles. However, while the advent of neural interfacing will certainly have enormous consequences for the development of art in the Net. and as much as it fascinates our speculative nature, it is not the most fundamental question at present for artists in the cyberculture. More important to us now is the conceptual implications of the shift taking place in art from appearance to apparition, from object to process. Art. which was previously so concerned with a finite product, a composed and ordered outcome, an aesthetic finality, a resolution or conclusion, reflecting a ready-made reality, is now moving towards a fundamental concern with processes of emergence and of coming-into-being. This raises critical. theoretical, and aesthetic questions which we can no longer avoid . In an important sense the issue is political, it concerns as much the democratisation of meaning as the democratisation of communications, that is to say a shared participation in the creation and ownership of reality.

The revolution in art which prompts these questions lies in the radically new role of the artist. Instead of creating. expressing, or transmitting *content*, he is now involved in designing *context*: contexts within which the observer or viewer can construct experience and meaning. The skill in this, the insight, sensibility, feeling and intelligence required to design such contexts is no less than that demanded of the artist in classical. orthodox art. But the outcome is radically different. Connectivity, interaction and emergence are now the watchwords of artistic culture. The observer of art is now in the centre of the creative process not at the periphery looking in. Art is no longer a *window* onto the world but a doorway through which the observer is invited to enter into a world of interaction and transformation. The importance of telematic networks, of the inherent connectivity of cyberspace, in all of this. cannot be overestimated. These ubiquitous networks are themselves undergoing significant augmentation with the capacity and speed now available in the so-called 'dark' fibre, as George Gilder explains:

"Fibre comes in threads, as thin as a human hair, as long as the British Isles, fed by lasers as small as a grain of salt and as bright as the sun. A single fibre thread can potentially hold all the telephone calls in the United States at a peak moment of Mother's Day. Fibre is not really a replacement for copper (wires) ...it's a replacement for air. Dark fibre, lit with different colours for different protocols, will deliver one thousand times our present total broadcasting capacity. The recently developed Erbium Doped Amplifier which will send an infinity of messages through glass on wings of light, is the communications engineer's Holy Grail - the dream communications system. capable of communicating over vast distances with huge information capacity."

So, dark fibre. boxed cats and biocontrollers are directly relevant to the development of art in the cyberculture, this domain of apparition in which natural intelligence and artificial life can interact creatively. Whatever the dominant media, whether electronic. optical, or genetic, the art of the cyberculture is generically interactive. This interactive art is characterised by a systems approach to creation, in which interactivity and connectivity are the essential features, such that the behaviour of the system (the artwork, network, product or building) is responsive in important ways to the behaviour of its user (the viewer or consumer). More than simply responsive. it constitutes a structural coupling between everyone and everything within the Net. This kind of work is inherently cybernetic and typically constitutes an open-ended system whose transformative potential enables the user to be actively involved in the evolution of its content, form or structure.

Science fiction such as Egan's is not alone in positing scenarios in which human consciousness is seen as the instrument for creating reality. Outstanding amongst philosophers from the point of view of cyberculture is Paul Watzlawick whose contributions to Radical Constructivism can be seen as directly relevant to the interactive art aesthetic. Radical Constructivism is as incompatible with traditional thinking as interactive art is with traditional art. As early as 1973 the cybernetician and biomathematician Heinz von Foerster gave his classic lecture *On Constructing a Reality* showing how the environment, as we perceive it, is our invention, describing the neurophysiological mechanisms of these perceptions and the ethical and aesthetic implications of these constructs.

What both the art and technologies of cyberculture are able to show is that there is a radical shift in our perceived relationship with reality, where the emphasis has moved from appearance to apparition. that is from the outward and visible look of things to the inward and emergent processes of becoming. In this culture. neither the precise state of art nor its cultural status can be fixed or defined: it is in a constant state of transformation. This is not a state of transition between two known and fixed definitions or destinations, rather is it transformation itself as a defining characteristic. as intrinsic to the identity of interactive art as the composed and finite object was to its classical predecessor. interactive art is art in a state of endless becoming. It is art-in-flux. This is so at present both in stand-alone systems, whether hypermedia or multi-media in format, as much as in the Internet with its global multiplicity of inputs and outputs.

A culture concerned with appearances bases itself on certainties. a definitive description of reality. Uniformity of dogma, uniformity of outlook and goals. cultural continuity and consensus, semiotic stability, these are its distinguishing features. Within this larger frame. aesthetic changes, when they occur are merely cosmetic, the basic conformity to an approved model of reality remains. There have been paradigm shifts in art just as in science , but it could be argued that the canon of Western art has maintained a much longer consistency and continuity than science. since numerous scientific revolutions have come and gone while art's preoccupation with appearance. with the surface image, with ready-made reality, has held for millennia.

In contrast, a culture concerned with apparition bases itself on the construction of reality, through shared perceptions, dreams and desires, through communication, and on the hybridisation of media and the *celebration* of semiotic instability. The shift in art towards apparition and construction as its primary concerns is a paradigmatic shift. We now realise that an art dedicated to appearance. simply gives the lie to whatever is the case, since the retinal gaze can penetrate very little of the material state and almost nothing of the spiritual state of things. The surface of the world hides more than it discloses. Science in the 20th century has been based largely on what is invisible to human retinal vision since it has always attempted to comprehend the forces and fields, and relationships underlying "our" visual world. In the earlier art of the 20th century this also to some extent was true: Kandinsky, Duchamp and Pollock, distinguish themselves, in their radically different ways, by their attempts to reveal the invisible, and construct their separate realities. Of these, it was Pollock whose intimations of connectivity brought to modern painting the great commanding images of a networked world, in the the swirling, circulating, linking. confluences of line and colour. It was Pollock who first brought the tight-framed picture window of painting off the gallery wall and onto the surface of the earth, marking out an arena for action and interactivity, and thereby laying the groundwork for those holistic ways of viewing. imaging and constructing, an entirely new *attitude* towards art and aesthetics, of which we in our digital space are the principal heirs and benefactors.

But until the effects of cyberculture were felt, until the radical implications for art of the new technologies had begun to be recognised and adopted, those artists whose practice. complicitly or unthinkingly, upheld the old orders of perception and knowledge. aided and abetted by the de facto controllers of representation and consciousness, the curators. critics, historians and dealers, resisted the radicalism of these pioneers. The great shame of American scholarship is that Pollock has never been properly appreciated or understood, nor, as Tim Hilton has noted in reviewing the current. disastrous Royal Academy Exhibition *American Art in the 20th. Century* , has he ever been given a serious full scale retrospective, nor a fully sympatheic book. "America wishes him to be a dead movie-star rather than an artist." And yet Pollock first created the *aesthetic* possibility, in a sense the historical permission, for our own radical constructivism in the cybersphere to come into being. Because, at base. working with networks, is a matter of attitude before it is anything to do with machines. Telematic art is conceptually driven not technologically led. The fundamental concepts of art as action, interaction with the art-in-process, the artwork as arena, art as transformation, change, flux and flow, these are in origin Pollock's -with the acknowledged provenance of course of navaho and the visual culture of native america. If thre is any link whatsoever between the art of cyberculture and the art of the pre-telematic era, it llies in the painting of Pollock. The link is one of sensibility not style, of attitude not form.

The collapse of the New York School, the market rise of resurgent German expressionism, the despairing flounderings of post-modernist solipsism, the dismal return to nineteenth century academicism, figuration and narrative. the whole miserable confusion, demoralisation and splintering of art at the fag end of this century is evidence of the major paradigm shift which we are undergoing. Nothing is spared in the process: galleries become redundant, museums have to be rethought and redesigned, academies have to be abandoned and reconstituted,the patronage, placement and perpetuity of art are all to be reconsidered.

In our present understanding of the world, nothing is sufficiently stable for us to wish to give a permanent form to its representation. Nor do we wish it to be. We are on that evolutionary spiral which has returned us to a more Taoist desire for flux and flow, for change and transformation. No eternal verities present themselves as worthy of consecration in manuscripts or monuments. We want now an art which *constructs* new realities, not one which represents a world preordained, finite and ready-made. We want now an art which is instrumental rather than illustrative, explicatory or expressive. Rather than to simply embellish the world and add to its ornamentation, the artist of the cyberculture wishes to engage in its renewal and reconstruction.

Above all we do not need any longer, hovering like vultures at the periphery of the old order of art, the cultural theorists, critics and academics who winge and wince at technology, who wag endlessly their disapproving and despairing fingers at the daring perceptions and dazzling innovations of science. Cultural theory was little more than ideological determinism dressed up in pretentious rhetoric, all show and no action, ideally suited in these latter years to preside over the demise of the old order of art, the art of appearance.

Art in the cybersphere is emerging out of the fusion of communications and computers, virtual space and real space, nature and artificial life, which constitutes a new universe of space and time. This new network environment is extending our sensorium and providing new *metaphysical dimensions to human consciousness* and culture . Along the way, new modalities of knowledge and the means of their distribution are being tested and extended. Cyberspace cannot remain innocent, it is a matrix of human values, it carries a psychic charge. In the cyberculture, to construct art is to construct *reality*, the networks of cyberspace underpinning our desire to amplify human cooperation and interaction in the constructive process.

 3231 words

NOTE Simultaneously with the FISEA conference, the Spanish version of this text will be published in Madrid in the first issue of the new journal INTERMEDIA, Nuevas Tecnologías, Creación, Cultura, edited by Orlando Carreño.

BIOGRAPHICAL NOTE

Roy Ascott has initiated many global telecommunications projects since 1980 when, with an NEA award, he created *Terminal Art* one of the first artists' international computer conferencing projects. He created *La Plissure du Texte*, a planetary fairy-tale, involving "distributed authorship" through electronic networks for Electra 1983 in Paris. He was International Commissioner (Art, Technology, Informatics) for the Venice Biennale in 1986, for which he organised *Planetary Network* and *Laboratory Ubiqua*. His multi-media installation *Aspects of Gaia* was presented at the 1989 Ars Electronica Festival in Linz. He is founding member of the Interactive Art jury of the Prix Ars Electronica and consultant to the new Ars Electronica Center . In 1991, as a protest against the invasion of Iraq, he proposed *Texts, Bombs and Videotape*. The networking project, *Telenoia*, was at V2 in s'Hertogenbosch, Holland in 1992. He lectures and publishes widely in Europe and North America. He directs the Centre for Advanced Inquiry in the Interactive Arts (CAIIA), at Newport School of Art and Design, Gwent College,Wales.

Holography and the Landscape Tradition

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ABSTRACT

This presentation will examine the relationship between artist-made holograms and the landscape tradition in art. Following selected examples of significant historical movements, various directions in the visual arts from throughout the second half of the twentieth-century will be explored as well as specific post modern strategies in image making. The presentation will then focus on more recent technology-based and media works including video, installation art and holography. Finally, examples of landscape and nature-based imagery in holography will be examined in depth through works by individual artists. The motivating ideas and issues behind landscape holography will form the basis of the presentation's conclusion.

HOLOGRAPHY AND THE LANDSCAPE TRADITION

"One of my dreams is to build a lab in the countryside to bring high technology into nature and nature into the lab. Working in the woods through all four seasons, I would like to use natural shapes and forms, recording elusive details."[1]

With these simple words holographer Rudie Berkhout poetically describes a union of two seemingly irreconcilable worlds: the existing natural environment and technological progress. Berkhout is certainly not the first artist to express an interest in uniting the two, but he is a new addition to a long tradition of individuals who seek to unify potentially opposing realms. In painting, photography, installation, video and now holography, artists throughout history have turned to the landscape and nature-based imagery as their source of inspiration, the subject of their explorations and more recently, the material of their art itself.

For centuries artists have consistently employed landscape iconography as both central image and background element. Without recounting the history of landscape art here, it is important to recognize the fact that many artists working at different times have felt a closeness to nature. During certain periods, groups of artists depicting the landscape have produced revolutionary works which have had lasting effects on the history of art, for example, seventeenth-century Dutch painters or, of course, the French Impressionists.

Landscape painting, however, relies partially on the pictorial illusions created with devices including perspective and color modulation, as well as the viewer's "willing suspension of disbelief" to borrow a term from the theater. In this way, a painting of the landscape functions like a window, the perimeter of the canvas or panel determines one's view. In photography, another medium in which the landscape has, and continues to play, a significant role as subject, this window allusion is also applicable. But it is ultimately in holography that a true "window" is possible; a window which reveals its subject as a volume occupying space.

To expand on the area of landscape photography, it is evident, in exemplary works by masters such as Ansel Adams or Minor White, that photography has a suitability for recording and interpreting the landscape in a medium other than paint. But beyond the more straightforward approach taken by many artists making photographs, other directions have evolved which use photographic techniques to image the landscape in less than traditional ways.

More recently an interest in painting and photographing the landscape has emerged as a discourse of post modernism. Younger artists including Joan Nelson, Chris Pfister and Lorie Novak use landscape imagery as a device to investigate their conceptual concerns. In Nelson's intimate panel paintings, cracked and distressed surfaces and image fragments resemble sections of larger, antique, landscape pictures. Pfister's "hunting scenes" and similar pastiche subjects teeter between post-modern irony and drawing room kitsch. Novak's color photographs record the ephemeral illusions created when the artist projects slides onto towering trees during the dead of night, and combine images of the human figure with that of the outdoors. The elusive quality of these temporal installations, made permanent in the photographs, is metaphorical for the changing nature of both individual and collective memory. Yet whatever the intellectual strategies at work in these examples, the fact remains that a landscape image is their visual core.

In addition to work in the established media of painting and photography, a number of artists who work with installation, technology and time-based media have similarly embraced the landscape as their point of departure. These include temporal site-specific works (for example, Christo's Running Fence, Sonoma and Marin Counties, California, 1972-1976) and earthworks (Robert Smithson's Spiral Jetty, 1970). More recently there has emerged a number of artists whose work strives to effect measurable change on the existing environment. They take this art in directions other than that of solely employing imagery derived from nature, sited in the landscape or using the earth as its substance. The work of these recent artists is often collaborative and cross-disciplined, engaging and involving both artists and non-artists alike.

The exhibition Fragile Ecologies: Artists' Interpretations and Solutions,[2] and its accompanying catalog, is an excellent survey of artists working to produce real environmental change. In the catalog's introductory essay, the exhibition's organizer Barbara C. Matilsky eloquently describes the artist's role in effecting this change, "Artists are in a unique position to effect such environmental changes because they can synthesize new ideas and communicate connections between many disciplines. They are pioneering a holistic approach to problem solving that transcends the narrow limits of specialization. Since art embodies freedom of thought, spirit, and expression, its creative potential is limitless. Art changes the way people look at reality. In its most positive mode, art can offer alternative visions."[3]

While some of the artists in Fragile Ecologies incorporate a variety of kinetic and electronic media in their work, it is also important in this discussion of the landscape to consider works based primarily in advanced technologies, including the medium of holography. While much of this technology-based work is diverse in terms of concept, format and presentation, and might involve elements of time and/or interactivity, there are relevant and persistent questions which must be put forward: Why do artists consistently attempt to reconcile the natural world with human invention and progress through the creation of technology-based art using landscape subjects? And what connection does the work of these artists have to static works created without the use of advanced technologies, connections to painting and photography? While it is impossible to address these questions in a general way, they are important to consider in examining the works on an individual basis. Before leaping into a discussion about holography it might be beneficial to review a selection of examples created using other, yet related, media.

In the area of video there is an ongoing relationship between subjects based in nature and video's high-tech materials and processes. This relationship is manifested in both what might be termed "broadcast" video and video installation. Unlike video installations, which often include static sculptural elements in addition to moving images, in broadcast video the work exists solely in the world created on the monitor's screen, independent of other components. In this discussion, however, three-dimensional installations, which incorporate video, will be discussed.

In the mid-seventies video guru Nam June Paik created, among other works, a TV Garden (1974-1978) which interspersed monitors among live plants, and Video Fish (1975) which incorporated aquaria and live fish. While Paik's contributions unquestionably opened the medium up in innumerable ways, and the artist is still likely to be the most visible video artist in the world, a generation has emerged whose individual and collective approaches to video have expanded the groundwork laid by Nam June Paik. In the late 1980s, the exhibition American Landscape Video: The Electronic Grove explored the work of seven artists through their large-scale installations.[4]

In his essay for the accompanying catalog, the exhibition's organizer William D. Judson elaborates on a central thesis of the project, "'Landscape video' has become a genre not only through the representation of landscape, but also through the appropriation and modification of what landscape means in our cultural and artistic traditions. Indeed, video has been an especially important medium for defining new directions in which to carry the landscape tradition."[5] With great confidence the terms "landscape holography" and "holography" could be substituted throughout this quotation to make a corollary statement on that medium. Included in the exhibition were large-scale works by Mary Lucier and Rita Myers, individuals who have established themselves in both the field of video and in a larger contemporary art arena. Certainly the work of any of the other artists included could be examined here, but this essay will focus on installations by these two.

Mary Lucier's Wilderness (1986) is a three-channel work presented on seven monitors each sitting on top of a faux classical column. In Wilderness, the artist explores a relationship between nineteenth-century American painting and the contemporary landscape. In writing about the work, Lucier describes her intentions in creating Wilderness: "By returning to many of the original sites depicted by 19th-century painters, I have attempted to simulate on video the qualities of atmosphere, light and time as rendered by these artists, and at the same time, to set up an ironic dialogue between the past and present, the mundane and the poetic, real and ideal."[6] In Wilderness, Lucier employs various strategies to visually interpret, connect and subvert images from nature. It is also important to keep in mind that the "ironic dialogue" to which Lucier refers is evident not only in video works, but other technology-based works which explore the landscape including electronic and computer art, sound art and holography.

Rita Myers' contribution to the same exhibition, entitled The Allure of the Concentric (1985), uses four channels of video which play on individual monitors placed amid sculptural elements including large rocks. The worked is centered, both figuratively and literally, around a dark pool of water over which are suspended three leafless trees. On one end a metal gate allows passage into Myers' world, and diagonally opposite the gate, across the pool, are three fortress-like towers. The monitors and other elements surround and face the work's center. As the artist describes, The Allure of the Concentric is "an expression of the mythic desire for ultimate renewal and regeneration....

Concentric circles created by water droplets cause the pool to metamorphose from an abyss into a source, metaphorically calling forth, at its outer reaches, the archetypal landscapes of the desert, mountain and forest, eternal, boundless, yet mutable."[7] For Myers, video serves as an ideal medium through which to develop her interests in sacred sites and natural cycles with it ability to repeat sequences of images, manipulate time and motion and simultaneously present distant locations or distinct terrains.

In addition to video installations, prior to embarking on an exploration of holography, it is relevant to this discussion to examine pieces by the collaborative team of Kristin Jones and Andrew Ginzel and by audio artist Liz Phillips. Quite different in concept, subject and material, the work of these artists is related in their common use of interaction, energy and motion.

For a number of years, Jones and Ginzel have created environments that incorporate low-tech, "erector set" engineering to produce ethereal, phenomenal effects. While much of the artists' work is temporal, their creative process involves developing full theatrical tableaux which often appear to the viewer as mystical, even magical, landscapes. From a viewing position, all sorts of rotating, swinging, hovering, misting and kinetic activities recall the changing complexion of the desert or rain forest, the eruption of a volcano or a winter blizzard, or perhaps the surface of some distant planet or what lies at the earth's core. Behind the scenes, however, much of what creates this magic is simple engineering. Often the artists adapt household appliances or commercially available devices to produce these awesome effects.

While their installations may not resemble the natural environment in a literal way, they are tied to the landscape tradition in their reverence for the sublime forces of nature and the miraculous effects of its seasonal cycles. In the course of their construction or exhibition, some glitch may interrupt or halt movement or prevent a pivotal action from taking place. Similarly in nature, small and unnoticeable upsets to the ecological balance produce serious ramifications.

Liz Phillips uses sound as her primary medium. In 1987 Phillips produced the environment Graphite Ground based on a Japanese garden. Originally created at San Francisco's Capp Street Project, and subsequently re-erected at other museums, Graphite Ground is an installation, an audio work, an interactive exhibition and a contemplative site. Created in response to Phillips' visits to the manicured gardens of Japan, the work includes a small central screened structure housing its electronic "brain"; a slightly raised wooden walkway; stepping stones, raw copper elements and large rocks which are grouped throughout a ground covering of raw wool, and a sound system which responds to the garden's visitors. This sound system uses energy fields created around specific copper and rock groupings to activate changes in what Phillips describes as the work's "soundscape."[8] As the fields are changed by the number, location and movement of viewers, the sound of the piece changes in response.

Graphite Ground uses a combination of organic materials (raw copper, raw wool) and sophisticated technology (sound system, electronic "brain") to create a surrogate of nature. Actually, Phillips' garden is not much further from the natural world it replicates than are the controlled environments of the Japanese rock gardens on which Graphite Ground's imagery is based. Whereas in Japan the gardener is responsible for the various elements which he or she tends, in Graphite Ground the viewer plays a part in shaping the final work.

With an entire history and tradition of landscape art in perspective, and with the brief preceding exploration of how it has continued into the present through a wide variety of media, an investigation of the work of artists making holograms is now appropriate to consider. I have chosen to discuss seven individuals, taken from a much larger group, who make holograms with landscape imagery.

Rudie Berkhout, based primarily in New York, is one of the best established artists making holograms. For some time Berkhout has used abstracted landscape subject matter. Recently he completed a large permanent public work in the central atrium of a new classroom facility at the University of Wisconsin-Madison. Light Train (1992) incorporates eight thirty inch by thirty inch holograms that cascade down a towering wall near the building's entrance. A waterfall, a spring shower, a series of shooting stars, Light Train feels particularly at home in a structure dedicated to producing future engineers. The installation also provides an excellent example of how public art can, and often should, reflect the complexion of the surroundings for which it is created.

Prior to Light Train, Berkhout produced numerous smaller works using a landscape theme. Event Horizon (1980) not only reveals to the viewer a swirl of abstract elements in a horizontal composition, but the title allows its viewer to immediately grasp the artist's intentions. The New Territories (1984) presents, in diptych format, a deep and seemingly never ending field. The viewer is invited to journey into the work, beckoned by glowing trails and seduced by intense colors. Transfer 339 (1987) uses two well-delineated paths to entice the viewer to move deep into the hologram's core. Later works, including Primal Mix I (1988) and Breakthrough (1990), create more fanciful, if not fantastic, worlds in which the viewer may enter. While in some cases these works present their landscape imagery in a literal fashion, all examples point to Berkhout's consistent and persistent employment of landscape subjects.

Japanese holographer Setsuko Ishii has incorporated images from nature in many works, some taking the form of sculptural installations. In Riverside (1983), Ishii embeds holograms in a swirl of white pebbles. Walking through this environment one discovers glistening glass plates on which the artist has recorded images of the pebbles that she mounded and shaped to form the imaginary river bank of the work's title. The experience is reminiscent of that of finding smooth rocks, shiny shells and tiny sea creatures on a routine walk along the beach. Instead of an obvious image like that of a starfish or a fragment of driftwood, Ishii offers no prize for this beach hunt but rather more of the work's rock subjects. The holograms embedded in Riverside's pebbles are anticipated as rewards for the chase, rewards which in reality are only illusions. This consistent subject matter manifest through the various materials comprising the installation also evoke the focus and feelings of solitude or isolation one might experience even when submerged in an environment as concentrated and intense as the artist's Tokyo home.

In 1985 Setsuko Ishii installed Riverside at the Museum of Holography in New York as part of a solo exhibition. In that installation, Ishii hung large sheets of clear flexible plastic from the ground to above the viewers' heads to form a semi-circle behind the low, floor-oriented piece. Not only did the plastic sheets create interesting visual effects, they made conceptual references as well. While extending the water illusion back and up, the semi-circle formed a relationship between land and sky, simultaneously acting as both. Perhaps more interesting, however, is the way in which this backdrop reflected the visitors' images and in a sense allowed them to enter the work on a different level. Viewers could not only walk among the artificial river bank created with holograms and pebbles, they became part of the entire visual tableau.

Like Berkhout and Ishii, New York-based holographer Dan Schweitzer is another firmly established artist whose vision has, and continues, to shape the directions of holography. And like these other two, Schweitzer employs landscape subjects as either the primary or secondary imagery of his art. In some cases the landscape has a significant presence, as, for example, in Stargate (1980), which imagines a futuristic terrain, or We'll See (1981)/Timescape (1978), which presents a window view of changing seasons in the form of a small sculpture. In several of Schweitzer's holograms or hologram/sculpture combinations, the landscape is one of many sources on which the artist draws his visual, conceptual and spiritual inspiration.

Londoner Martin Richardson used a wide variety of materials to make a series of works which originate in the philosophies and traditions of Conceptual art. English Oak (1982) brings together a hologram and a sculptural tree trunk;

Triangle in Landscape with Hologram (1982-1983) combines holography, photography, drawing and writing. It is a complete year's work in the form of a sketchbook, photographs and a hologram. While the sketchbook became the artist's personal journal or diary, the photographs recorded seasonal changes at a specific site which Richardson selected.[9] In a way that is common to the other artists already discussed, Richardson sought to somehow reconcile or unite the natural world with the technological one: "In retrospect I think it was the complete opposites that attracted me. On one hand I had attempted to work with the complete and infinite simplicity of nature itself, whilst on the other felt drawn to the sophistication of man-made technology. My guess is that Triangle in Landscape with Hologram forms the pinnacle of both interests."[10]

Betsy Connors, based in Somerville, Massachusetts, came to use the medium of holography after working for some time in photography and video. In 1991 Connors completed Future Gardens, an installation comprised of over forty holograms, a computerized lighting system and an audio component. Future Gardens, like Liz Phillips' Graphite Ground, is the result of the artist's visit to gardens in Japan.[11] When Connors returned to her studio she attempted to recreate, or perhaps interpret, experiences similar to those she had when wandering through these foreign environments. The botanical imagery which appears in the holograms is derived from the landscape near and around Connors' home in the Boston suburbs, and includes not only bamboo, but maple, oak and similar foliage. Three-dimensional illusion, animated lighting and sound are combined in the installation to simulate the atmospheric conditions of its garden source. For Connors, "The real yet unreal quality of the formal Japanese gardens created a feeling that only art or music had previously inspired in me. I was very affected by the power of these gardens which in most cases was visual but was also sometimes very spiritual."[12]

In addition to Phillips' Graphite Ground, Future Gardens is more directly related to another media installation piece: Nam June Paik's TV Garden. Connors acknowledges Paik's work as a source of inspiration and point of departure.[13] And like both Graphite Ground and TV Garden, Future Gardens employs surrogate elements to replace real things, for example, in Graphite Ground a sandy surface cover is created with raw wool; TV Garden's video monitors become living, blossoming bouquets, and Future Gardens uses three-dimensional illusions to evoke a lush, dense garden growth. In each of these examples one experiences, again in Connors' words, the use of "new technology to explore older subject matter or traditional concerns."[14]

The collaborative team of Susan Gamble and Michael Wenyon (working under the name Wenyon & Gamble) have explored nature-based imagery in their installation works at times, primarily through phenomenological subjects. The artists recently relocated to Boston from London, after having spent an extended period living and working in Japan. Beginning in the mid-1980s, Wenyon & Gamble explored these subjects in works including Trail (1987), The Heavens (1989) and Stella Maris (1989-1991), often combining theatrical lighting effects and other light-based media (slide projections, etc.) with holograms. Stella Maris goes beneath the sea to imagine an ominous underworld "contained" in a monolithic wall on which the holograms are mounted. Theatrical lights hidden behind the wall create a blue aura around it perimeter. Without using literal images of underwater creatures, Stella Maris evokes a dark, mysterious place which exists concurrent with the one above water level that is dry, sunny and land-bound. The Heavens incorporates a series of narrow holograms lined end to end to form a strip of sky. Like Stella Maris, The Heavens incorporates lighting effects. When the viewer peers into the narrow strip holograms an entire galaxy of stars is visible. As Susan Gamble describes, this work directly resulted from the artists' own experiences in nature: "In 1986 we purchased a home by the sea. At night we would look out at the light changing on the sea....The Heavens was inspired by looking out at the sea and sky at night, where you see stars and lights from passing ships on the horizon."[15]

The artists and works discussed here offer only a glimpse into the use of landscape and nature-based imagery in holography and this discussion can in no way be limited to these examples. As a guide to those interested in exploring the art of additional individuals who work or have worked within the landscape tradition, the following brief list of names is offered: New York-based artist Sam Moree, who incorporates whole or fragmented landscapes in his elegant sculptures; Doris Vila, also based in New York, and in particular XICO (1983-1984), a large multi-hologram work which records rock formations in a horizontal format that recalls geological stratification; Montreal-based artist Georges Dyens, who creates large- and small-scale multi-media sculptural tableaux, and finally John Kaufman, who works in Point Reyes Station, California, and whose sensuously colored holograms often employ fragments of natural imagery or render artificial landscapes.

It is impossible to close this discussion of the relationship of technology-based media, including holography, to landscape art because it has only just begun to develop. The work of all of the artists surveyed in this essay is meaningful to a truer understanding of how the tradition continues, regardless of creative approach or choice of material. Furthermore, the visibility of this art, through exhibitions such as those I have described are critical steps in broadening the knowledge and appreciation of the work both in terms of the general public and the art world. Rather than approach the work as a complete break with what had come before, it is more accurate to connect it to the past and see it as a new and distinct direction for the future. The French Impressionists took their canvas and paints out-of-doors to work directly in and from nature, an experience not altogether different from Rudie Berkhout's desire to "build a lab in the countryside."

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Creativity and computation.
Tracing attitudes and motives.

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Abstract

The present paper suggests a framework for critical evaluation of computational approaches to creativity and aesthetics from a trans- disciplinary point of view. We suggest various models for building systems that exhibit aspects of creative behaviour. The alternatives include traditional knowledge-based systems, constructs inspired by linguistics and the concept of self-organization as perceived in products of natural creativity. The evolutionary paradigm is outlined and its application in evolving cellular automata is briefly documented.

1. Introduction.

This paper aims for the creation of a framework to address the following questions: can we build machines that merely simulate human creative activity or is there potential to emulate true creative thinking in a computer program? How do we build self-reflective programs given certain aesthetic criteria and what are these criteria supposed to look like? Social expression, introspection and the synthesis of meaning while handling multiple views of the same thing at the same time are at the heart of human creative behaviour. All this seems hard to expect from a machine though quite powerful statements have been produced in recent years, in particular by using methods of artificial intelligence and algorithms inspired by biological evolution.

We are forced to study the psychology of creative decision making if we ever want to implement aspects of it in a computer program. These aspects have many faces including the creation of contexts to augment the chances for something interesting to happen, the invention of problems and questions (not answers), the persistence on exploration and flexibility rather than final products and precision, the expression of interest in the meaning of things rather than (or in spite of) their possibly extraordinary visual appeal, and many more.

Because much computer art focuses on the generation of intricate structures does not imply that critique should be limited to formalist criticism i.e. the study of formal relationships or excellence in designed visual organization. Criticism should not be blinded by the complexity of the medium but receptive to the expression of intense feelings, the communication of ideas of truly great intensity and question the relevance of artistic statements i.e. do they say anything on the human condition as it really affects us? Or should critique be focused on the consequences of the ideas and feelings expressed, for instance, by serving some social end beyond the form of the work itself? Obviously, impressive pictures do not provide a useful ground to guarantee artistic integrity. In any case, a work must offer the potential to raise questions and, possibly fundamental questions which trigger a creative response in the observer or listener. Perhaps, because of its interactive nature, the computer is the ultimate channel for introducing augmented responsiveness in the appreciation of artistic statements.

People are creative because they interact as social species, they express an opinion toward society as well as to the self. This global awareness and explicit physicallity of the human body is important to note both as a structural constraint for machine creativity as well as a source of inspiration. Indeed, we have witnessed the emergence of various socially inspired, distributed, computational methods like the actor paradigm, robot ecology, or even massive parallel hardware. On the other hand, physical interaction with an unpredictable environment; the study of artificial life through actually physically building synthetic entities, is a topic of intensive research. As a matter of fact, ever richer cross-fertilisation grows between art and science. Scientific discoveries suggest new imagery as well as new ways of thinking about the laws and processes forming reality as we experience it.

2. Overview.

We shall outline possible computational strategies for the implementation of an artefact generating machine but first we shall trace the attitudes toward the computer as a medium for artistic experimentation and expression. These attitudes range from seeing the computer as a tool for basic, deterministic visualization, to computer-assisted, interactive evaluation of ideas, to the delegation of responsibility and autonomy to a synthetic art system based on a hypothesis of how human creativity works. In addition, it is observed that attitudes range from passive imitation to interactive introspection, from a collaborative, conversational approach to a wish for independent creative autonomy and, finally, from the creation of physical end products to the promotion of ideas and focusing on the conceptual, the immaterial aspects of the medium.

A creative algorithm should exhibit maximum opening towards anything that could possibly happen; we must start by having all degrees of freedom potentially available, it must produce something new given the constraints of an existing aesthetic paradigm and its output must be useful in the sense that it forces interpretation and the synthesis of meaning. It must explore the unpredictable, thus it must be non-deterministic. Evolution theory according to Darwin provides the ultimate example of non-deterministic activity: the genetic materials of life are combined and modified arbitrarily and from a mass of results non-viable products are eliminated by the constraints imposed by the environment. The emergence of life itself has taken nature millions of years though very fast parallel processing computers may detour the very inefficiency of the evolutionary approach. Incidentally, genetic algorithms, mimicking the mutation and cross-over operations in DNA have been used explicitly (Sims, 91a) as well as implicitly, as metaphor (Verostko, 90) to grow synthetic creatures with considerable success. Note that the building blocks under evolutionary consideration need not be limited to formal elements like perceptible structures but may extent to the the procedural modules themselves (programs as genotypes) while the programmer's opinion about the current state of affairs constitutes the aesthetic constraints for deciding what gets a chance to survive.

Another class of algorithms imposes constraints at the generative level, and is much more efficient than the generate-and-filter method. Generative grammars, as inspired on the work of Chomsky, are good examples of computationally powerful methods. Once the building blocks and rules designed, the system will run itself and breed a rich variety of instances from which the program (or user) may select at random.

We shall interpret the above methods in the light of the two prevalent lines of research in artificial intelligence today: first, within the framework of knowledge-based systems and, second, in the sense of behaviour oriented experimentation. Expert systems using (aesthetic) knowledge representation in rules and facts and relying on inference as their basic mechanism are exemplary for the first category. In sharp contrast, the principle of self-organization and spontaneous pattern- formation from local operations in permanent interaction with the environment are characteristic of the second.

3. Motivation.

It has been argued repeatedly that the digital medium liberates the artists from the limitations of conventional media (for instance, lack of precision and physical inertia) and that the computer offers "seemingly infinite capabilities". It is stated that the computer provides potential for fundamental novel ways to create new images and transform existing ones. These claims definitely sketch a wrong perspective. When viewing computers as mechanistic extensions of the hand, it makes them an ideal environment to both preserve existing modes of expression and guarantees a fluid continuation of conventional aesthetics. In sharp contrast, the machine should be seen as a liberation of the mind, not the medium. To this end, it is essential to regard computers as perfectly general purpose symbol manipulators, to view them as open-ended systems, as tools in which programs live. To write programs is to invent conceptual machinery that reflects a personal attitude towards the act of creation itself.

Computers are vehicles for exploring ones own belief systems of what it means to be creative. One is forced to program them in order to discover their language and gain freedom of expression. The question of representation of what constitutes creative behaviour, then, becomes an issue of central concern. What is represented will set the scope of the system, how things are represented will determine its flexibility and usefulness. From this it follows that software systems are by no means neutral, e.g. a lot of work with paint systems is very similar and the hand of the machine (programmer), so to speak, is clearly visible. On the other hand, since AI systems are built on descriptions of what is thought to be known in a specific domain, they are, by definition, coloured by the subjectivity of their designer.

Most algorithmic approaches to creativity feature formalist representations borrowed from mathematics, the study of formal languages, physics or computer science. From cognitive psychology we know that emotions and affect play important roles in human motivation, intention and attitude -- all fundamental ingredients of the creative process. Yet, very few attempts have been made to build representations of these higher order factors. Given the difficulty to represent the semantic significance of artistic statements, in practice, syntax is favoured over meaning. However, some research has been carried out -- in the field of computer music -- in an effort to tighten the gap between the organization of structure and its appreciation and interpretation (Katayose & Inokuchi, 1989). This work is inspired by recent advances in AI which tries to model this higher order cognitive activity of the human mind; the theory put forward in (Minsky, 1986) has been very influential.

The insistence on flexibility, rather than on precision, is valued of greater aesthetic relevance by creative individuals. However, CAD systems were designed to automate the design procedure and do not constitute a platform for intimate man-machine cooperation in the sense where solutions emerge from collective evaluation of intermediate results. The same mechanistic view is expressed in the sequencer paradigm of computer music where timing may be excellent but is flexibility very poor.

Too bad, with digital accuracy, analog sensuality is thrown out on the same account. All the elements of appreciation that talk to the body rather than the mind, are very underdeveloped in computer art. Barnett Newman would never have painted large surfaces if it was not his intention to emancipate colour and relate the experience to the topology of the human body. Metaphorically speaking, digital quantization should remain characteristic to the computer and not penetrate our critical abilities.

4. Attitudes.

Four classes of motivations towards machines in the creative process received detailed outline in (Beyls, 1987) and are briefly summarized in the context of the current paper. Class one refers to the mechanistic point of view criticized in a previous paragraph. It implements established modes of thinking and existing ways of doing, it aims the production of unique works of art, it is object-centered. The second class acknowledges the unique features of computers to combine or transform pictorial or musical building blocks from explicit specification by the user. Examples include spectral interpolation in digital sound synthesis and frame interpolation in computer animation. A third class accommodates everything procedural. The design of algorithms and the evaluation of their behavioural potential is the creative act. Here, a more experimental attitude is expressed explicitly. Many procedural programs do not aim for single-ended results but for the creation of families or classes of works: all output is different but exhibits the same qualities. The development of ideas by a process of gradual definition of objectives is unique to the digital medium. Most composer's assistant programs are situated at the intersection of class two and three. Class four is characterized by cognitive modelling of creative activity and is the theme at the heart of the current paper.

The true instrumental power of the digital medium lies in the fact that it offers a play-ground for breeding ideas, a functional environment for experimentation, a field for growing and testing interesting procedural activity. In short, a computer is a conceptual microscope which reveals detailed explanations of how we navigate for surprise (or disappointment) in hypothetical worlds of our own design. The role of inventor and explorer coincides. From this it follows that the programmer and the user must be one and the same person. This form of intimate man-machine interaction (Beyls, 1986) can be potentially dangerous; the artist can get trapped in a perpetual design cycle since all output is, by definition, intermediate output. In such an interactive exploratory attitude of creativity, the objectives of both the programmer and the program may shift according to what suddenly appears as an interesting discovery. One discovers things by testing and doing, not by abstract contemplation. When the (aesthetic) goal or focus is redefined, the exploration will propagate itself and search for that goal. The intimacy of the process signals how computers are highly integrated in creative thinking and is evidence for the deep integration of concept and medium.

But the question remains; what do we start from, where do we start and where are we going. One thing is certain, any computer comes as a preformulated package, in terms of both hardware (e.g. processor speed, memory capacity) and software (e.g. operating system, man-machine interface, available languages). This uniformity will push the artist in a certain direction since one cannot start from scratch, or as (Nadin, 89) puts it "the machine as predetermined makes it a poor substitute for the empty canvas of the painter". It is indeed very difficult to build an empty computer and it should be realized that this has enormous aesthetic consequences.

5. Definition.

Creativity in humans seems to function as a delicate interplay of freedom and discipline. Freedom points to having uncertainty as a fundamental generative principle. From Prigogine we have learned that science is about the exploration of the uncertain and the relationship of man and the universe. Joseph Beuys has formulated the same idea as follows "The artist points towards the totality of the relationship between the physical incarnation of humanity and its total spirituality." (Nairne, 1987). John Cage has commented in a panel discussion "The function of art is to let us experience the general uncertainty without suffering but with enjoyment." (Cage, 1990). Uncertainty is not just identified as a universal underlying principle from the social, scientific and artistic points of view, but recognized as a necessary condition for creative evolution to unfold. So freedom refers to creating a context for the unpredictable to happen. On the other hand, total unpredictability divorced from a critical context does not carry much meaning. Therefore, the limiting forces of discipline have to be put to action. So the combination of uncertainty and constraints constitutes a productive ground for breeding creative ideas. Moreover, for an idea to work creatively it should be new and useful in the sense that its functions as an object of contemplation and provocation.

In computational terms, discipline may be formulated as constraints which act as critics that decide which random ideas get a chance to survive by examining their coherence with a body of existing principles. These principles have been referred to as conceptual spaces (Boden, 1990) or search spaces (Feigenbaum & Feldman, 63). Conceptual spaces stand for a frame of reference given a specific domain, in the arts it signifies an existing aesthetic style or idiom, in the sciences it is referred to as a paradigm. That space both specifies what is acceptable and provides information on the generative mechanisms of the given idiom. However, truly creative ideas seldom fit into a generally accepted, established conceptual space but signal a new style or paradigm. Incidentally, the insistence on experiment and the refusal to rely on historical pressure and to compose from self- designed first principles is at the heart of much 20th century music. So very creative people don't just explore a given problem but create additional problems, they redefine or extend a given conceptual space. This makes the difference between combining existing ideas into new ones using some rule-based method and the redefinition of a paradigm by changing its limits, for instance, by lowering the influence of constraints that define it or forcing additional constraints into consideration. Note that we speak in computational terms: rules are used to infer new and interesting conceptual configurations, while constraints delimit the field of all potentially possible configurations.

Let's consider the following examples where dropping constraints led to something fundamentally new. Mondrian's oeuvre is characterized by a gradual process of giving up representational considerations by using a restricted formal vocabulary in a wish to focus on intellectual order exclusively. Arnold Schoenberg decided to set free harmonic space by dropping the need of a tonal center in music. The quest for the spiritual, dropping representations of reality, the discovery of abstraction pioneered by Kandisky, and later, its evolution to post-painterly abstraction and an occupation with the coneptual most visible in Reinhardt's black paintings. Fontana transformed the canvas into something three dimensional. Marcel Duchamp was perhaps the most radical of all disregarding aesthetics as such by suggesting the ready-made.

The above formulation of creativity is only losely related to associative theories explaining the creative act. The latter define creative thinking as the formation of associative elements into new combinations hoping for a useful result. Of course, the combination of more mutually remote elements increases chances for novel results though they also receive increased critique given the constraints of the given stylistic paradigm. The theory of bissociation of matrixes of thought put forward in (Koestler, 1964) suggests that the creative act involves the linking together of two previously unconnected 'frames of reference' or associative contexts.

Randomness may function as a combinatorial device as in the cut up method devised by William Burroughs. It involves the snipping of newspaper texts and rearringing them at random until a suitable effect is obtained. To cook up fresh ideas, the approach was also explored by many composers ranging from John Cage to David Bowie.

New paradigms or styles may also emerge from discontent with existing ones. To break out of a feeling of frustration with current global aesthetics artists/composers would apply the negation operator i.e. they would react by doing the opposite. Note that the frequency of this process of switching back and forth is increasing toward the end of the 20th century. Consider the sudden birth of minimal music in the late sixties, composers rejected complexity resulting from mental gymnastics and suggested very simple formulae for motivic development instead. However, later, new-complexity emerged closely followed by new- simplicity.

6. AI approaches.

The goal of artificial intelligence is two-fold. First, to get a better understanding of how human intelligence works. Theoretical models are designed by questioning the functioning of human cognitive processes, including perception, reasoning and problem solving. These models may provide better insight into the nature of human creativity. Second, AI is interested in the implementation of natural cognition in artificial systems to serve various specific engineering goals. AI has also developed very advanced symbolic programming environments of exceptional flexibility e.g. Lisp, that are now very well documented and generally available. Lisp promotes creativity since it promotes interactivity and taking risks.

The idea of exploring conceptual spaces outlined above may be translated to the actual methodology of navigating in a search space. This view of creativity has been described by (Steels, 1986) and (Ames, 1992). In order to find out about the richness of a search space one must describe it in a functional model. The ideosyncratic features of a particular space can be represented in a computer using standard methods of AI. Then, the key idea is exploration. Early work in AI by Newell, Simon and Shaw on the programs Logic Theorist and later General Problem Solver (GPS) are of historical significance. They saw creativity as a special form of problem-solving activity characterized by novelty, unconventionality and the recognition that problem formulation is indeed very difficult. GPS and its predecessor are examples of rule-based systems; the idea is to solve a problem by applying formalized knowledge (represented in production rules), to grow a decision tree and navigate in that tree from given initial conditions toward a solution, known as the goal state. The machine has to keep track of partial solutions and if it gets stuck in an impasse it has to backtrack to a lower level in the tree and restart from there. So the program generates suggestions for getting to the goal-state and evaluates their distance from that goal-state. However, the decision tree may grow out of hand because of a combinatorial explosion, so special short cuts, known as heuristics, are needed.

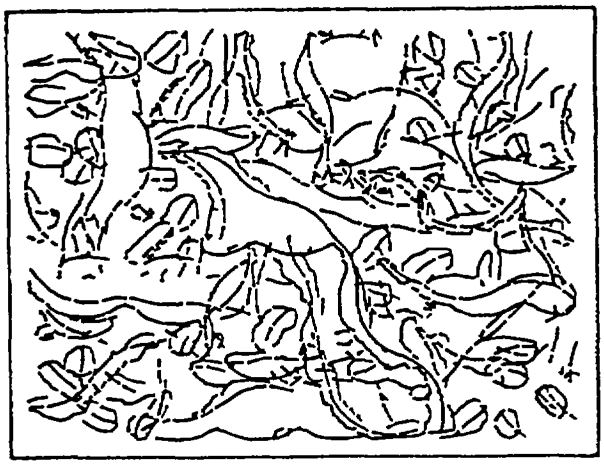
Heuristics are rules-of-thumb used to detour this problem as it occurs, for instance, in a chess playing program; the number of legal moves is so enormous that it would take too much time to consider them exhaustically. In addition, the pressure on memory, to represent everything possible, would grow out of hand. Therefore, these programs consider only a few moves and counter-moves up to a certain depth of reasoning. The most promising move is selected, the one that brings the current state closer to the goal-state.

The pioneering work of Newell and Simon led to the development of modern expert systems that are capable of handling ill-specified symbolic information about a specific domain. The most impressive example of the knowledge-based approach in the visual arts is the work of Harold Cohen documented extensively in (Mc Corduck, 1991). Cohen's pioneering expert system Aaron creates original simulated free hand drawings from artistic expertise represented as procedural and factual knowledge. The generative behaviour of the program evolved from abstract work to figurative drawings of human figures when Cohen added real-world knowledge about the relationships between parts of the human body. The total knowledge-base represents the artist's global concept space, a style which was developed -- and this is important to note -- before he got involved in computing. The stylistic continuity in his work is not surprising since Cohen was his own knowledge engineer, in sharp contrast to industrial expert systems where the task of knowledge acquisition and knowledge exploration are strictly separated.

7. Exploration.

My own work with expert systems is characterized by viewing them as exploratory devices explicitly. The accent is more on the process of collaboration between man and machine than on the creation of an autonomous art generating system. The artist does not formalize a pre-existing style as or does not manipulate a predefined vocabulary using a collection of previously stipulated rules. On the contrary, one aims at the discovery of a powerful strategy to generate pictures. Focus is no longer on visual structure as such but on methods to think about action and interaction. This requires maximum openness on the part of the programmer and maximum purity (minimum constraints) of the medium, an empty computer would indeed be most welcome.

Many artists borrow ideas from examples in nature. The wealth of imagery in nature makes us question, isolate and formalize the processes that are responsible for this richness. These processes are then used to produce works that relate to their real-world equivalents. Growing trees with a grammar is a good example (Smith, 84). The creation of hypothetical worlds is the other end of the scale: the artist relies on products of his own imagination. This is a definite wish but never exclusive since no



artist escapes the gravity of context. However, starting from simple representations of some hypothetical behaviour in an invented, artificial world and through gradual refinement of the algorithms involved, interesting phenomena (that map to pictures or sound) may emerge. One is involved in a circular process of optimization: evaluation of the continuous feedback from the program shows the road to changing the program in question. Designing such programs is planning for change. Note the relationship of this exploratory attitude with the evolutionary paradigm introduced in later on. A concise, illustrated definition of this experimental method featuring intimate machine interaction is given in (Beyls, 86). Refer to the three accompanying illustrations -- reproduced from a family of large plotter drawings -- for the 1990 state of affairs of EWA, a personal expert system developed by the author.

So the computer offers an instrumental channel for gradual specification of objectives while wandering though a given personal search space. Exploration is guided by what is discovered along the search path and is thus the key to surprise. There has been quite some research in AI to model the exploratory process explicitly in a computer program and in different domains of expertise. The pioneering work of Doug Lenat who designed an automatic mathematician (AM), a program that explored the space of mathematical rules in search of new theorems, was of historical importance. AM considered the beauty (interestingness) of mathematical expressions (using heuristics) it cooked up and consequently focused creatively on the most promising ones through self-modification of the program (Lenat, 77).

(Kahn, 79) has addressed the problem of making aesthetic choices in the context of computer animation. His program ANI is capable of making animated sequences in response to high-level incomplete story descriptions. The user describes personalities, their character and relationships. Suggestions for action are like rules that are combined and modified i.e. explored. The program makes choices for action based on minimization of arbitrariness and maximization of overall coherence.

The previous work is related to Talespin, a system that creates objects judged primarily on their aesthetic appeal (Meehan,76). The program writes stories from the description of animal characters and plans are produced to satisfy their desires i.e. to reach some specific goal. The stories document the problem-solving behaviour of their characters. Many different stories may be generated from the same rules since the objectives of characters are interacting and possibly in conflict. This program offers many possible solutions for the same problem so it may considered creative.

Conflict, confrontation and tension have been recognized as residing in the very conversational process of the artist with a synthetic personality of his own design. (Laske, 90) views composition as conversing with the machine as an alter-ego. The creative process is propelled by the tension that exists between ideas suggested by the program and their interpretation -- the meaning and function they receive in the mind of the composer.

My work in interactive composing has concentrated on the creation of virtual musicians designed explicitly to interact with a single human performer. The musical dialogue is propelled by a conflict the machine- performer aims for the expression of its musical character working simultaneously towards social integration with the human performer. The type of real-time expert systems used here are known as pattern-directed inference systems: they aim at the realization of their embedded goal while, at the same time, keep perceptive channels open to accommodate external stimuli and adjust their plan accordingly (Beyls, 88).

8. Behavioural approaches to creativity.

Observation of creativity in nature shows many processes where coherent structures or complex, coordinated behaviour emerge from the social interaction of many participating organisms as well as their interaction with the environment. This behaviour is referred to as the emergent properties or emergent functionality of a system that only survives if it keeps in continuous communication with its surroundings, just like creativity itself which cannot emerge from isolation. The behavioural approach finds its roots in many different disciplines such as non-linear physics (Babloyants, 86), the study of complex dynamical systems in general and mathematics (Wolfram, 84). In contrast to knowledge-based systems where logical inference over symbolic representations is a basic technique, behavioural systems use local operations on the microscopic level which give rise to complex macroscopic structures given the right environmental conditions. Such systems use distributed representations such as regular arrays as seen in both cellular automata and connectionist networks. The idea is to map the abstract behaviour of a given system to the specific problem at hand. Thus, the creative accent is shifted from designing a global rule-base to inventing interesting local rules -- self-organizing behaviour is suggested as an alternative to knowledge. Since KBS are designed by hand, there is a limit on the maximum complexity a human programmer can handle. In addition, expert systems do not show graceful degradation in performance when situations occur that were not anticipated by the programmer. Also, reasoning or searching over symbolic structures is often very slow which makes expert systems inappropriate for many time- critical applications e.g. interactive composing. All these problems have contributed to the adoption of the dynamics paradigm. For a complete comparative an illustrated discussion of subsymbolic methods and the role of randomness and chance in the context of musical creativity refer to (Beyls, 91).

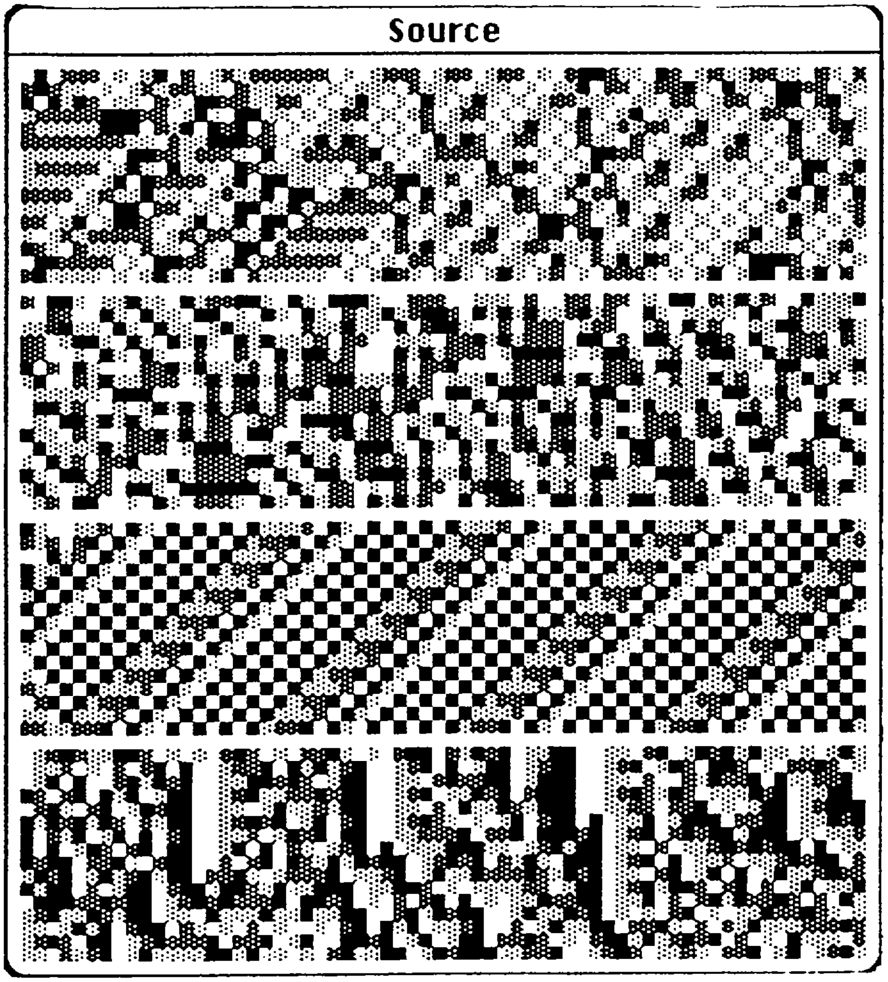
9. The linguistic approach.

The use of formal methods derived from linguistic theory – in particular the writings of Noam Chomsky -- have been very popular in music (Roads, 85) and, to some extent, in the visual arts (Gips & Stiny, 75). Linguistics describes creativity as the application of a finite set of rules allowing for the construction of an infinite set of possible utterances in any given language (Chomsky, 66). In composition, a generative grammar is used to grow hierarchical language constructs from a few basic starting blocks. The consistent, recursive application of rewrite-rules that define the grammar forces a data explosion. This explains the ultimate computational economy of grammars. In addition, a grammar keeps intrinsic relationships between overall structure and detail. In other words and in terms of music, the surface structure of a piece (events), the intermediate structure (motivic movement) as well as the deep structure (overall composition) are captured in a single, compact representation. Grammars are also used for analysis, for instance to parse natural language. (Cope, 91) uses symbolic pattern-matching to analyse sequences of existing music and extract "signatures" collected in libraries. An augmented transition network (ATN) grammar for parsing phrase-structured information is then used to reorganize these signatures into new compositions. Grammars may be context dependent meaning that other rewrite-rules will be executed according to the evaluation of the neighbourhood in which tokens happen to appear. This provides several alternative choices and is a source of additional complexity.

(Kirsch & Kirsch, 86) tried to describe the compositional structure of works of art in a formal grammar. This work starts from the analysis of geometric designs and produces a database of syntactic units. The deep structures, i.e. the semantic level is not taken into consideration and this points to a shortcoming of grammatical representations.

In conclusion, grammars are powerful devices for designing intricate, hierarchical structures with absolute control over the relationships among their various layers/components. However, grammars function in a single creative idiom: the rules don't adapt and the search space is not extended in the process of recursion.

Finally, an interesting parallel is drawn between the theory of formal languages and so called L-systems, invented by biologist Aristid Lindenmayer. He suggested mathematical models for biological pattern formation and natural growth such as models describing the development of branching



structures in plants. His research currently enjoys a renewed interest in the light of the emerging new discipline of artificial life (Lindenmayer, 68) which brings us to the fourth paradigm for viewing creativity: evolution.

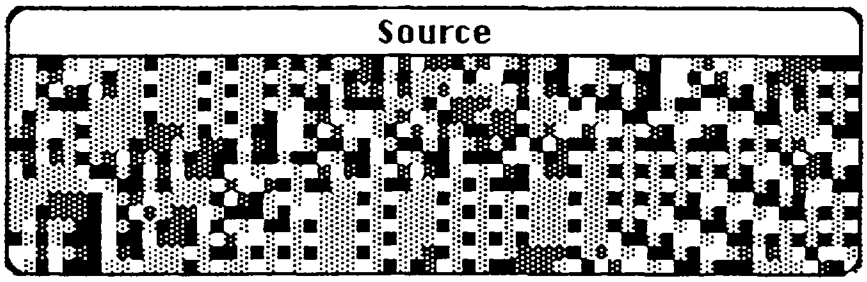
10. Creativity as an evolutionary process.

This approach tries to model creative decision making as an analogue of biological evolution. The diversity in living systems is brought about by the process of evolution; the process that alters the genetic information they embody to make them increasingly better adapted to the environment they inhabit. The set of genes of an organism is called its genotype. Organisms search for maximum adaptation by changing their genotypes keeping only offsprings that are well adapted i.e. exhibit maximum fitness. However, the number of possible genotypes is enormous. In addition, the genes inside genotypes also interact in a non-linear fashion, a phenomenon known as epistasis. Notwithstanding this combinatorial explosion of the search space, evolution has been extremely successful in breeding well adapted rich varieties of living systems. This observation led to the introduction of genetic algorithms (Holland, 75): the idea is to generalize critical processes of evolution and apply them to other search problems. In computational terms, a genotype contains a set of instructions, a micro-program. The execution of the genotype produces a phenotype, that is, a certain behaviour, a pattern or some conceptual machinery. The process by which the genotype evolves, generation by generation, under control of the genotype is called morphogenesis.

A genetic algorithm uses genetic operators that interchange and modify the contents of initial (possibly random) genotypes. Any computer program can be considered as a genotype, its output is viewed as a phenotype. The operators include variation (e. g. change part of a rule), cross-over (e. g. replace left-hand side of a rule by the right-hand side of another rule with cross-over points assigned at random), mutation (replace part of a rule by another one available). The resulting phenotypes -- more exactly, their underlying genotypes -- are evaluated for their fitness (i.e. interestingness or aesthetic appeal) and consequently survive or disappear. What remains will breed the next generation and so on.

The idea is to view this circular process as an instrument to create conceptual bridges between elements of the conceptual space determined by a given aesthetic point of view. This leads to discoveries, one finds patterns that were not anticipated by the programmer, complexities are generated without knowledge of how to generate them explicitly in the first place. More than merely exploring search spaces, genetic algorithms may actually transform them. Very interesting work has been done according to this computational paradigm in the field of computer animation (Sims, 91), computer assisted sculpture (Todd & Latham, 92) and a technique of thematic bridging of musical material using genetic algorithms is described in (Horner & Goldberg, 91).

It should be noted that genetic algorithms make the mechanics of evolution explicit. The evolution of art itself may be approached with genetic operators implicitly in mind. Artists have copied rules from each other with eventual random mutations, produced mixes of mutually borrowed rules as well as rejected common rules. This is how styles emerge, evolve and disappear in the course of art history. Most changes are gradual though: existing features are recombined into new works, the structure of the features themselves remain unchanged. However, when the procedural building blocks are mutated or rejected altogether, non- linear jumps occur that signal fundamental new paradigms: in this light consider, again, Duchamp.



11. Evolution in cellular automata.

As a final example, we shall briefly introduce the interactive evolution of complex dynamical systems formulated as cellular automata in the context of musical composition. A complete description, however, is beyond the scope of the current paper. Cellular automata (Toffoli & Margolus, 87) are very efficient for modelling a wide variety of complex phenomena including musical composition (Beyls, 89). They consist of some regular cellular structure in which the consistent application of simple local rules give rise to surprisingly complex structures. A CA- rule specifies the value of every cell in the next generation from the evaluation of that cells neighbourhood. The starting configuration consists of a random choice from all available values. The idea is to run different rules, evaluate the interestingness of the patterns they produce in time and, apply genetic operators on selected items. For instance, consider the illustration on the previous page showing 4 automata of 64 generations. The neighbourhood is 3, the number of values is 4, the rules (rule 1 to 4, top to bottom) are 80 digits long. The figure above, a single automaton, was produced through a cross- over operation: the first half of rule 1 glued to the second half of rule 3. Results like this are then subjected to morphological analysis, a program extracts and sorts objects according to their complexity. The morphs are then mapped to the musical domain; a polyphonic object results which reflects the behavioural complexity of the automaton.

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Jürgen Claus

ART IN THE SOLAR AGE

A paper in three sections:

I. THE BIOSPHERE INTERFACE

II. MIRRORS OF THE SUN

III. FROM PLANET OCEAN TO SOL*ART* SCULPTURES

Jürgen Claus
Sun Sculpture project, 1986

Jürgen Claus

THE BIOSPHERE INTERFACE

Some regards on visual arts in the Solar Age

I

The quest for a **Solar Age** is defined by a general change in ecological consciousness, by declining resources of non-renewable energies, by the extreme increase in global and local pollution, by a strong demand for decentralization in political as well as energy decisions, by the rising demand of the underpriviledged three quarters of the world to participate in a higher quality of living.

This quest for change cannot be based on traditional, non-renewable energies. The **Solar Age** in this respect is defined by a new policy of installing and using technologies that harvest the sun's radiation in a more direct way.

But: All plans for reforming our energy situation must be put into practice now, to be fully effective in 2025. (I just focus on the first quarter of the next millenium.) The estimated 10 Billion people in 2025 cannot live a human life on our present Western standards of energy consumption. This is far more than a technical problem and this is why I am talking about a new definition of art in the and for the **Solar Age.** A loosely connected group of artists today are fully aware of the necessary changes in contributing to new solutions, new materials and new strategies for an Art in the **Solar Age.**

The aim of *The Solart Global Network* which I'm preparing for 1995, is to bring some of these artist together in working with outdoor solar artworks. These might be outdoor holograms, light work depending on direct use of solar power, reflection of Sun light etc. Highlights of this Solar Festival are positioned on different parts of the Planet in July and August 1995. Every artist works in her/his own autonomy, sharing a common catalogue and a common film & video documentation of the events. Exhibitions are planned to show the resulting art works and their documentation. Network, for me, means a value-oriented networking of people who share the same vision of the **Solar Age.** Technology is used at the most advanced level but only to strengthen the underlying values of a critical and creative redefinition of art in the Biosphere.

II

The second point which I want to make is that the change towards a Solar Age has to stabilize our civilizations. In doing so it must be a cultural one. Ecological stability, which is the aim towards the beginning of the new millenium, must rely on cultural change to be seriously anchored within the different societies of our Planet. So we have to evaluate or re-evaluate the educational ground for advanced visual studies.

It was Jeremy Riffkin, author of *Biosphere Politics*, who, in his book *Entropy: A New World View*, 1980, postulated a new definition of education in the **Solar Age**. This includes a reduction of the flows of information and energy. Instead of an expanding storage of data, it is their interconnection, which counts, the flow of interrelated phenomena which the student has to evaluate. I strongly belief that the study of natural systems strengthen our creative understanding. It enables the student to create the most advanced biotechnological systems. And: It is within the very heart of art history that we can find supporting ideas of correlated systems.

Industrial ecology, which goes along with environmental stability, aims at an environmental design and environmentally sustainable technologies with nature - call it "biotechnique" design (Frederik Kiesler, 1938), "biomorphic" design (Victor Papanek, 1984), "biomimetic" design (Harden B.C.Tibbs, 1991) or, as I prefer to call it, Art in the **Solar Age**, Biospheric Art.

III

Art is part of the continous critical, as well as creative reflection of our life within the Biosphere. The *Biosphere concept* regards living matter in its entirety as the domain for the accumulation and transformation of the sun energy. Is art able to share this concept of all living matter? My answer is, that advanced visual studies should be directed towards these goals:

1. The study of the Biosphere, which is more than the study of ecology. Vladimir Vernadsky, one of the fathers of the concept, established "a gestalt view of the Biosphere as a solar, terraqueous being".[1] As art is deeply connected with the creation of *Gestalt*, we may talk about *"Gestalt technology"*, as I suggested for the 1984 exhibition *Art and Technology* in Bonn, Germany. *Gestalt* is, since Goethe, deeply connected with the idea and process of morphology. In constrast to the machine-oriented approach of information technology, *Gestalt technology* embraces human perception and creation.

2. The agenda for teaching and learning advanced visual studies should integrate the theoretical innovations which occured in the last two decades. Among those theories I would count the morphogenetic field (Rupert Sheldrake), the holistic-holographic universe (David Bohm, Stanislaf Grof) and others.

3. Another topic and goal of art education is the re-valuation of what art history means for the *Biosphere Interface*. Probably we have to go back into the 'deep

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[1] Dorion Sagan, *Biospheres* (New York:McGraw-Hill, 1990), p.42.

time' of art, leaving aside the narrowing views of 'modern' art, but not towards a random 'post-modern' everything goes, but towards values. Values in the visual arts are maybe less superficially detected than in medical education or in direct ecological activities. But indeed they relate every work of art with human perception of the world.

Jürgen Claus

MIRRORS OF THE SUN

Towards Solar Art - Some Examples - More to follow

PAUL HOENICH

This artist, born 1907, is a true pioneer in *Sun Painting* through the use of different reflecting materials. He emigrated to Palestine in 1935. In 1950 he became Professor for experimental art at the Faculty of Architecture at the *Technion* - Israel Institute of Technology in Haifa. He developed a type of kinetic art with direct use of sunlight from the end of the fifties on.

I suppose he was the first or at least one of the very first to coin the term *Robot Art* at the beginning of the sixties. The *Robot Picture*, which he developed from 1956 on, is a moving and changing sunlight projection system which repeats itself in a yearly circle. The robot projection, as he says, "makes use of the sun as a fixed lamp and of the planet Earth as a motor moving not a strip of film but rows of reflectors"[1]. The composition depends on the shapes and colours of the reflectors. Colour filters are added to the reflectors to change and determine the projected colours. The artist can predetermine a year's programme in setting up a whole row of reflectors, which will be effective differently during the year.

Besides the *Robot Picture* Hoenich has created the *Robot Painter*. Here the individual pictures cannot be foreseen. Besides using sun rays and the Earth's rotation and revolution around the sun, an additional energy source is needed to produce irregural moving pictures. Before turning to more recent solar art works, I may recall Walter Gropius' statement from 1963, in a letter to Hoenich: "I am convinced", wrote the founder of the Bauhaus, "that this is a field of research for the future and will become a true instrument of a new art".

DALE ELDRED

Other artists working with the *Mirrors of the Sun* followed. Since the late seventies Kansas City based Dale Eldred, born 1934, did numerous sunlight sculptures throughout the United States and Europe. He regards the human life cycle as being intimately related to sunlight. In his work he uses very large reflectors for the sunlight and projects the light rays partly onto walls and buildings. He deals with the relationship between man, the earth and the sun.

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[1] P.K.Hoenich, Kinetic Art with Sunlight, *Leonardo*, Vol. I, Spring 1968, p. 115.

In September 1981 he installed a 24 x 16 feet reflective unit on the south bank of the Charles River in Boston, opposite a mirror battery three-quarters of a mile away. When the mirrors are activated by the sun, the five-colour panel glows up as a brilliant temporary picture. As Dale Eldred sees ist: "There is complete non-particularity in the viewing of such a work, and there is no one 'correct' orientation"[2]. The changes, which photographs show, correspond to a decentralized view of the Planet. There is no 'static' picture of the sun and the solar reflections, as there is no 'static' viewer in the Biosphere.

Eldred: "What I'm involved in relates to a time incident and to a light incident. You'll se on the back of the mirror boards all the time is set and the far side is the moureceiver. That's a retro-reflective field" [3]. The artwork becomes a timefield, an energy field, related to the primary life energy source of our Biosphere. Art approaches a visualization of the cosmic data. What is impressive is the large scale of his outdoor sun structures, as in the case of his reflecting sculpture outside the Nelson-Atkins Museum in Kansas City, 1979.

The use of solar time as a determinant of space becomes evident in many solar art works. We have to add time to our definition of the urban space too. That is where the solar mirror work of Dale Eldred comes into regard and becomes important beyond the aesthetic values of his performances.

SHAWN BRIXEY

With him we are entering into a transition of cosmological and technological sources. He represents a third generation of artists working with mirroring sun light and cosmical light. Born 1961 in Springfield, Missouri, he was a student with Dale Eldred before he came to the Center for Advanced Visual Studies at the MIT, where he graduated as Master of Science in Visual Arts in 1987. The universe, for him, is a boundless stage and elusive map of our human knowledge. Here are some of the projects, through which he is mapping his vision of the universe.

Photon Voice was an outdoor event for the CAVS/MIT "Desert Sun/Desert Moon" events in the California desert near the small village of Lone Pine, 1986. Light waves were converted into sound waves and back into light waves. The

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[2] Dale Eldred, Sun Structures, *Sky Art Conference '81* catalogue, CAVS/MIT, Cambridge, Massachusetts 1981, p. 30.
[3] Statement in *ars electronica* catalogue, Linz 1982, p. 131.

mouvement of dancer and choreographer Laura Knott became visible in a glass terminal where her mouvements parallel the mouvements of graphite particles.

The central instrumentarium which he developed for *Photon Voice* had been used again for his project *Instruments of Material Poetry*. The title stems from the idea that his work can be described as poetry, made of expressive interaction of discrete forms of matter and energy. The project design orbits around the radical use of radiation pressure (the kinetic momentum of photons) to construct and animate microscopic events in a vacuum chamber.

From here Brixey went to the *Vista Genesis Device*. As he told me (in a letter from July 25, 1991): "It is a small noninvasive input-output device, that broadcasts an electromagnetic signal to override the electro-chemical response of the eyes into the optical cortex. By using data from optical and radio telescopes I was able to find astronomical sources (stars) whose signals mimic precisely these modulations. These stars produce a signature that creates a kind of internal aurora borealis of pastel colors and graphic pulsing patterns in the 'mind's eye'. The poetic reality that our brain can have a type of concrete communion with events (light) that occured billions of years before we were born, punctuates the basic core of my investigations". Even if this goes far beyond the use of solar light in an artwork, it might outline the actual research investigation which is done today by some artists.

JANET SAAD-COOK

She is the first woman who I'm including into this presentation of solar artists. The reflectors which she is using to beam the sunlight onto walls are made of steel, bronze and optically coated glass. Spreading the sunlight throughout an environment, she wants "to take the cycle of the sun and make it a human experience through art. The cycle", as she says, "is constant, and all of us who have ever lived on the earth have shared that cycle in some way. I believe that connecting with this cycle connects us on some level with each other, beyond any barriers of time"[4].

Janet Saad-Cook made numerous trips to the American Southwest to study the way in which prehistoric native Americans marked the sun's passage. These experiences became an integral part of her artistic orientation. Even modern astronomical observatories seemes to her to have an almost sacred fascination. So

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[4] Janet Saad-Cook, Sun Drawing, *Leonardo*, Vol.22, No.2, 1989, p.158.

she choose the National Radio Astronomy Observatory in Socorro, New Mexico, as the site of her permanent *Sun Drawing Project*. The model shows a nearly hemispherical shape, 49 ft diameter, 25.5 ft high, with a glass-covered opening through which sunlight enters. The reflectors, about 200 one-foot-square pieces of reflective glass, dielectrically-coated with a thin film of iridescent material, will be standing on an elevated platform located inside.

Janet Saad-Cook's sunlight 'sculptures' are as immaterial as it is said of all the electronically produced screen 'sculptures', but are related intimately to the Earth-Sun dialogue, which is in the very center of the Biosphere understanding.

PIERRE COMTE

Pierre Comte, who works in Paris, is one of the pioneers of Space Art, for which he developed an aesthetic dialogue both from Earth to space, and to Earth from space. Among his projects seen from space the biggest one is *Horus,* a circle of 24 prismatique structures each of 14 meters lenght. His proposal was to put them together on water, the diameter of the circle being 500 meters. The large structure would be seen from space ships as well as from satellites.

In 1981 he designed first drawings of an art satellite, called *Arsat*. Together with scientists and technicians he presented *Arsat 1* by the end of 1983. The second step led to the creation of *Arsat Helios* which took the shape of a rhomb. In all these experiments, which had not been realized, Pierre Comte could anyhow rely on his experience with pneumatic structures, he did in the seventies. The design covered a space of 800 meters diameter and 300 000 square meters. This enormous solar sail was thought to work with what is called photon propulsion. *Arsat Symbiose* finally, the City of Art in Space, as Comte named it, was designed as a satellite of the third generation.

In looking back to these earlier attempts of Space Art, the artist drew an account of all the problems he met. "When the invention is not a response to an existing need, it can meet with hostility from people in charge of the conventional process or, more generally, with mere apathy. If I introduce a new product, it might also mean that I am hoping to take over part of the market, even if it is a tiny part." Another severe difficulty is, the more one becomes involved in technical problems, one looses credit in the art world. Comte: "For them, at best, I am a kind of mutant without conncection to any artistic family"[5].

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[5] Pierre Comte, The Arsat Saga, *Leonardo*, Vol. 26, No. 1, 1993, p. 33.

Finally, in October 1989, Pierre Comte got the chance to establish *Earth Signature,* made up of 16 large square sheets made from black polyurethane material, forming a unit of cross and circle - symbols already used in ancient times and codified in the Middle Ages. The total field covered 390 000 square meters on an old airfield in Southern France, next to Plaine de la Crau. Photographs had been taken by a Spot satellite orbiting 830 km above Earth.

In recent years Comte developed his research into two directions: The first one is the project for an entirely artistic satellite, the other one is a technical and scientific program for a Solar Power Station in space that can be launched by existing launch vehicles. It would be a kind of experiment on a smaller scale to eventually launch large solar space power plants. It would unfold in space automatically with its 50-m-diameter parabolic mirror and would transfer about 0.5 Megawatt. As there is controversy about solar power plants in space this model would give some practical advice. Roger Malina, astronomer and art editor, comments on these kinds of space adventures by artists: "Space Art is an essential part of extending human civilization into cosmos. Scientists who dismiss artists' proposals as frivolous forget that one of the roles of artists has always been to create markers of human presence"[6].

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[6] Roger F. Malina, Art in Space, *Technology Review*, MIT, Cambridge, 3/4,1990, p. 61.

Jürgen Claus

FROM PLANET OCEAN TO SOL*ART* SCULPTURES

A short overview of some of my environmental art works from 1967 on

My own **Sol*art* Sculptures** developed from the ***Planet Ocean Project***. The crucial year for this development was 1983. In March 1983 I started my visual notebook, *The Ocean Dimension*, but soon the study of plankton and photosynthesis led me to cybernetic objects which show alterations when exposed to natural light. As a central grid for my artistic creation I saw the biological, the energetic and the technological dimension. My first project of transforming solar light into energy for art works was born.

In 1983 I participated with my new Sol*art* concept at several international exhibition among them *Electra*, organized by Frank Popper at the City Museum of Modern Art in Paris. I quote from my contribution to the *Electra* catalogue:

"In the second half of the sixties I began developing multimedia spaces using electricity and/or electronics. It felt like installing a 'fluid space' where images from film and slide projections appeared simultaneously. It defied one-dimensionality. When I began to work underwater my experiences affected my artistic concepts. By definition, the open space underwater is a 'natural' multidimensional area. Electricity and/or electronics were used as extensions of human sensory organs. Light was as important as was underwater acoustics, both related to the physiological reactions of man.
In my new project, Sun Sculptures, I am using sun energy to produce electricity underwater... Electricity brings light into the 24-hour-circle of light blue - dark blue - darkness of the natural Planet Ocean." (1983)

Different Forms of light had been used before in my underwater art events. When we made the film *Planet Ocean* in 1979 at Long Island, Bahamas, one of the key elements of the film, which had been commissioned by the biggest European Television Station, WDR Cologne, was a bright, glowing ball of fire sinking to the ocean bed. Like a star falling into the sea or a message from outer space. The film turns next to a large cocoon held by six female divers. A diver in the centre of the cocoon frees himself with a burning flare and moves up to the surface of the ocean.

Other parts of my *Planet Ocean* art events included divers with silvery shining 'stars' mirroring sunlight as it penetrates to a depth of about 12 meters. The late afternoon we added, to the sunlight, a set of artificial underwater lights. Quoting from my script: "Stars found beneath the glass plane of the ocean. A garden of stars planted in the water. We have placed them in the artificial solar system of our floodlights. Now they reflect." (1979)

My artistic and environmental investigations of the **Planet Ocean Project** started around 1967 and lasted for about 15 years. The shearing force which I experienced from diving in many parts of the world inspired my paintings, drawings, visions and several publications, among them my book *Planet Ocean - Art & Environmental Research Underwater*, 1972. Solar Energy was already in the very heart of my *Ocean Architectures* drawings from the early seventies on. In addition to this, decentralized energy supply came to my attention by practical use. The need of energy for recharging batteries on remote diving places like tropical islands, without traditional resources of energy, lead us to the application of small solar power stations. Later on I began to propose larger photovoltaic panels on top of the water to give electricity and light to underwater structures. The *Sun Pyramid*, for which I developed several versions, was an outcome of these structures. Other forms included light tubes and light spheres in the water.

When I devoted more time to the creation of **Sol*art* Sculptures** from 1983 on, I included the *Sun Pyramid* in exhibitions like *Art and Technology*, which I organized in the German Ministry for Research and Technology in Bonn, 1984. The separation of an outdoor solar supply station (from Siemens Company) and an indoor light sculpture was a transitional form, leading towards sculptures which integrate the aesthetics and the solar technology. Several of these tree-like sculptures had been constructed as models, exhibited and included in videotapes which I made with Vin Grabill (University of Maryland) and others.

Sol*art* Sculptures are vertical constructions with a height of approximately 30 meters in their final stage. Their wings would be furnished with solar cells and ideally follow the position of the sun. (But this includes a loss of energy for the tracking, as we know.) Just to give a very general idea of the technical side of these sculptures, let's focus on four big wings, each 3 x 5 meters, i.e. 15 square meters each. The total amount of solar resources would be 60 square meters. Given the reference system of 1 kW per square meter as the nominal power we could count on 60 kW available, provided that we have full sunshine and a surface perpendicular to the sun.

What I have called a *Solart Expert System* is part of the preparatory work and will serve as 'brain' for **Sol*art* Sculptures**. The sculptures are designed to receive natural light and transform it into energy - the principle of photosynthesis. So this bioapparatus follows the path of the "solid-state quantum-molecular miracle which involes dropping a photon of sunlight into a molecular device that will kick out an electron capable of energetically participating in the life of a cell," as Terence McKenna wrote. [1]

The **Sol*art* Sculptures** are energy banks as well as being part of an energy network. They are based on ecological systems, putting art back into the environment: Solar Art. These sculptures are, in a true and real sense, responsive, environmental, enhanced-dimensional, energy-transforming systems. They require

[1] Terence McKenna, "Plan Plant Planet", Whole Earth Review, No.64, Fall 1989, p.5.

a sort of a sensorium, an environmental steering system which might for the time being be best called an expert system. It works as a graphic interaction system through which images, data, and graphics can be called up in real-time. The knowledge base contains technical expert and environmental information, for instance about light, metabolism, landscaping.

As art is part of the search for a new holistic, ecologically based, responsive paradigm, every effort that goes into artistic research goes into a more general human definition of our planetary societies. The artistic phenomenon provides us with realities and metaphors of significance within social, cultural, electronic and biospheric changes.

As an artistic metaphor for the Solar Age my wife Nora and I created the installation *Carrousel of the Suns* for the exhibition *Artists and Light* in Rheims, 1991. Commissioned by the French National Centre of Art and Technology (*CNAT*) the installation occupied the entire upper space of the exhibition hall and covered a surface area of 530 square meters, bathed in blueish light. The argon gaz writing, about five meters long, is a metaphor reminiscent of the Solar Age of the Future. Two circles made up of nine 'suns' rotated slowly, intersecting with each other in a beam of yellow light. Two laser beams travelled across the space at different points. One may regard the complete form, or Gestalt, as a demonstration of the dynamic relationship between natural and man-made environments.

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Aesthetics of a Virtual World, Carol Gigliotti, PhD, Assistant Professor, Ohio State University, and Director of Education and Technology,The Wexner Center for the Arts

Discussing virtual reality with another artist recently, I was asked incredulously, "What do ethics have to do with aesthetics?" I might have dismissed the question as coming from someone whose roots are strongly attached to the modernist tradition. He doesn't grasp, I might have said to myself, that things have changed, that now, in this period considered by many to be postmodern, aesthetics is no longer regulated to a matter of form or style, but rather once again encompasses a philosophical stance towards the artmaking process. But that response would have missed an opportunity to develop an answer to another and central question about virtual systems. That question involves what the aesthetics of virtual systems have to do with ethics. My one word answer to both questions is, "Everything." The longer answer is less presumptive, more inquiring, and the subject of my ongoing research and this paper.

In my interviews with various artists, educators, cultural theorists, computer researchers, software and hardware developers, questions about the ethics of virtual systems often materialize as ambiguous but pressing matters. Finding substance in particular worries such as virtual sex, political and corporate domination, military uses, and mind-numbing, violence oriented entertainment, these questions continue to indicate the possibilities of directing the development of virtual systems in building virtual worlds. Ethical questions, after all, involve judgment. How should we act? The idea of judgment in ethics is an all-encompassing function. Involving our entire being, it is the way we choose among many possibilities. Those choices commit us to paths which are more less consistent with our nature and the rest of our lives. The accountability of our judgments is "part of the condition of our existence as social, integrated, affectionate, language-using beings" [27] and touches on questions about the nature of knowledge. On what do we base those actions? How can we know if the knowledge on which we base those actions is true?

Decisions about what is right or wrong are inextricably linked to a grasp of what is real and what is true. We approach an understanding of reality and truth through a variety of means. Historically, philosophical thought has offered us various positions on whether attempts at making ethical decisions are based on stable or shifting grounds. Current technology offers us countless means to reevaluate our perceptions of what reality and truth consist. Consequently, this attempt to suggest aesthetic frameworks for the design of an ethical interactive technology includes a brief, hopefully succinct, unraveling of the intricate connections among pertinent systems of ethics, the ontological and epistemological assumptions on which they are based, and the influence technology has had on those assumptions.

Two underlying issues consistently emerge in writings about virtual reality: simulation and artificial reality. [24, 30, 321, 40]. Rather than viewing these two issues as relatively new, and only connected with current technology, it is more helpful for our purposes to understand the design of present virtual reality technologies as habitual involvements with long-standing goals practiced for centuries. The emphasis on simulation and the development of artificial reality can be traced directly to the end of the sixteenth century and the beginning of the seventeenth when Kepler, Bacon, and then, Descartes set an artificial and unreachable limit for knowledge specifically undertaken to advance the possibility of modern science. Investigating these origins and goals may prove helpful in understanding the significance of their impact on ontological and epistemological assumptions used by the designers of today's virtual systems. As stated above, these assumptions are the ground upon which we grapple with ethical issues. In attempting to construct an ethical framework, then, for the design of virtual worlds, it is necessary to understand how it is that we have come to agree or disagree about what reality is and how it is possible for us to know about it. The effect of setting this unreachable limit for knowledge was the separation of moral and intellectual spheres that has been occurring for decades. The repercussions of that division are continuingly evident in every aspect of our Western culture. We have combined this misplaced need for epistemic certainty with the designing of machines built to obligingly fill that need, and subsequently, have eroded our faith in human judgment and human worth. Instead, we have begun to place our confidence in the machines which are unsurpassed in those qualities we have come to value most: efficiency, measurement, speed, objectivity, and innovation for its own sake. And in order to interact with those machines which have become so important in our culture, we have begun to think that we must think like them. Postman [28] suggests the direction of this line of faulty thinking:

> From the proposition that humans are in some respects like machines, we move to the proposition that humans are little else but machines and, finally, that human beings *are* machines. And then, inevitably, . . . to the proposition that machines are human beings. It follows that machines can be made that duplicate human intelligence, and thus research in the field known as artificial intelligence was inevitable.

To find this line of reasoning "inevitable", is to disregard the role that meaning plays in communication. Meaning includes feeling, experience and sensation; the same dimensions that make up the original formulation of the term aesthetics by the German philosopher Alexander Baumgarten. The term did not refer only to art, but to all of human perception and sensation. It is in this realm that ethical decisions are made. Haraway [19], however, sees possibilities in:

> . . . refusing an anti-science metaphysics, a demonology of technology, and so ... embracing the skillful task of reconstructing the boundaries of daily life, in partial connection with others, in communication with all of our parts.

and in so doing, "taking responsibility for the social relations of science and technology."

In working with and becoming involved in the aesthetic development of virtual systems, we, as artists, are either accepting or rejecting, stabilizing or altering our assumptions about the necessity of our human judgment and human worth. As we make aesthetic choices, artists have assumed certain ideas about the purposes and values of art making. Those assumptions have changed over time and have come from various sources, both internal and external to the art making process, but they have had primary impact on what was communicated by the art and about the art of any particular time. Ethics and aesthetics both can be defined in terms of judgment. It is this partnership that allows us to grapple conceptually with both areas of thought at once. But, it is their active involvement in the artmaking process that will allow us to understand the consequences of that partnership. The separation of moral and intellectual thought described above also has influenced our thoughts about judgment and its place in making ethical choices. This same separation had enormous influence over judgment involved in aesthetics.

Judgment in aesthetics can be taken to mean the evaluation of specific properties of a work of art, as well as an evaluation of the general quality of it. Though the history of issues referred to by the term *aesthetic* is as long as that of ethics, the term itself did not appear until Baumgarten, coined it in 1750 to refer to a special area of philosophy. Taken from the Greek word for "sensory perception", it signaled a shift of attention from things to perception of things [13] and a shift from thinking about separate qualities of a particular art object to underlying philosophies of art. It is this sense of the word on which we will rely. Limiting the description of artistic activity to choices about particular qualities of works of art, such as the use of light, line, form, shape in a particular time period would leave us with less than half the story.

The underlying philosophy of art that has been the most influential in thinking about aesthetics in Western culture was Kant's [20] outline of the characteristics of aesthetic judgment in his *Critique of Judgment*, and a direct descendant of Descartes. Battersby [3] contends that during the nineteenth century, Kant's notion of the aesthetic attitude as a "disinterested" withdrawal from all material and use-value was developed

> . . . to an extreme. The aesthetic was equated with a particular attitude of mind: with a blanking out of moral, social and political considerations . . . and with an indifference to bodily dictates and needs.

But even though Battersby rejects Kant's notion of 'disinterestedness', she goes on to say:

> there is no way of escaping the necessity of judging

> aesthetically. . . Even to give priority to political, ethical or utilitarian value judgments over aesthetic judgments is, in effect to opt for a particular variety of aesthetic value.

This dialectical consideration of aesthetics is one that is echoed by Eagleton [11], and with which I agree. To judge aesthetically is to compare values, and those values emanate from the totality of the judge and his context. In order to move from the extreme interpretation of Kant's notion of aesthetics to more contemporary views, such as Battersby's, Eagleton's and my own, contemporary critics[14, 25, 39] suggest that aesthetics, like knowledge, has had to go through a period of relativism. The objectivity of judgment in aesthetics, the values on which those judgments are based, and who makes those judgments, have been taken into serious consideration. Wolff [39] says:

> [T]he demonstration that knowledge (including science) is interest-related, that the practices of scientists are in one sense arbitrary, and that knowledge has a 'provisional nature', has been widely accepted among sociologists of knowledge. Relativism has become respectable as one position within the society of knowledge. . . But more recently. . .the problem of truth *has* emerged in a particular form in the sociology of art - namely, in terms of the question about true or valid art.

Though I would argue that art is still in this period of relativism, the most striking thing about technologically mediated art making is what it may offer for moving beyond this period into one in which aesthetic decisions work towards an ethic of care and responsibility. The focus of this much shared optimism about making art with current technology is what even that American arbiter of acceptance, Newsweek [21], has dubbed the "interactive" aesthetic, a year or so after it has become accepted in art circles. But what are the preeminent characteristics of an interactive aesthetic and on what ethical issues could they possibly have an effect? Once again, in order to begin answering those questions, we might find it more helpful to fathom some of the connective historical tissues of a whole body of ideas based on interaction, rather than envisioning this "new aesthetic" as only connected to current ideas and technology.

It was not a coincidence that Kant's notion of disinterestedness in his critique of aesthetic judgment coincided with Baumgarten's naming of the new area of thought. This emphasis on formalism may be viewed as an attempt to reconnect art with its capacity for what is qualitative in human experience. This capacity was almost lost through the myriad exploitations art had undergone in the past. The possibilities for art being disconnected from this kind of value still exist. The two most challenging cultural experiences of this century have been the rise of industrial and electronic technology and the increasing rise of democratization embodied in capitalist form. Both have offered renewed possibilities for abuses of the power of art. Both have been central issues in aesthetic theories calling for involvement in social change.

Through the twentieth century the most virulent attacks on the whole notion of art for art's sake and the most powerful examples of aesthetics connected to value outside the world of art have come from Marxists [14]. Whether the specific theory is from Soviet socialist realism, anti-realist positions, such as Bertoldt Brecht or Walter Benjamin, or French Structuralist Marxism, all have in common the ultimate objective of struggling to transform a particular society's dominant values. This trend would include the Dada and Surrealist movements. Both these movements had members who were overtly Marxist in their politics [31]. Two of the most influential thinkers, respectively, in dramatic aesthetics and the aesthetics of the visual arts are Brecht and Benjamin. The objective of Brecht's [8, 9] theories of 'epic theatre' is to deliberately break the illusion of reality created on stage so as to make plain the social forces behind a dramatic situation. Walter Benjamin's [5] prophetic inquiry into the undermining of the authority of art through the replacement of the fine art object by means of mechanical reproduction has at its source the analysis of the value of art according to political criteria.

Contemporary Marxist critic, Terry Eagleton [12], insists that in the various manifestations of the contemporary postmodernist aesthetic, one finds both defenses and antagonisms towards the

the integration of art and life, aesthetics and value. He sees these descriptions as applying *simultaneously* to postmodernist manifestations. For Eagleton, this is so because of contradictions between economics and culture:

> The avant garde's response to the cognitive, ethical and aesthetic is quite unequivocal. Truth is a lie; morality stinks; beauty is shit. And of course they are right. Truth is a White House communiqué; morality is the Moral Majority; beauty is a naked woman advertising perfume. Equally, of course, they are wrong. Truth, morality and beauty are too important to be handed contemptuously over to the political enemy.

Eagleton views the contradictory nature of contemporary aesthetics mirrored in modern ethical thought. Both the aesthetic and the ethico-political are preoccupied with the relation between particular and universal. And modern ethical thought, according to Eagleton, has disabled us from seeing "the need, method, or possibility of extending this value (love) to a whole form of social life" [12]. In other words, one way to transform the limits of our ethical thought to include the right of all and every sentient being to have his or her difference respected, is to transform the aesthetic.

Which leads us back to the central question, what impact does an aesthetic based on interactivity and virtual systems have on ethical issues? Or put another way, how does transforming the aesthetic through interactive virtual systems transform the limits of our ethical thought? Three bodies of thought have been particularly helpful in guiding me through through the maze of connections between traditional and emerging aesthetics, traditional and emerging ethical thought, and the seemingly brand new mix of aesthetics and ethics generated by the possibilities of virtual worlds. The first body of thought is that of Ludwig Wittgenstein, the 20th century German philosopher. The second is Bertoldt Brecht's theory of dramatic interaction. The third is contemporary feminist moral theory.

Wittgenstein was most successful in escaping the Cartesian prison in which we have found ourselves since Descartes [10] decided

> . . .to rid myself of all the opinions I had adopted, and of commencing anew the work of building from the foundation, if I desired to establish a firm and abiding superstructure in the sciences.

With Descartes, reality becomes external. We, as Cartesian beings who have to resort to our doubt that we exist to prove that we exist, find ourselves in an abstract universe, in which we can only exist if we answer the question, "Is it true?" According to Descartes, that question can only be answered by the mind's powers of representation because we are barred from knowing the world (reality) through any other way. Concrete experience is not justifiable for the bodiless mind to which Descartes has diminished us. Descartes' influence, not only on the sciences, for which he originally began his *Meditations*, but on the whole of Western thought and culture, is immense, and has left us with a true fetish for accurate representation. This representation becomes the foundation upon which we are then, in the Cartesian paradigm, to build our belief and understanding of the world.

The obvious problems with this approach, ones that succeeding generations of philosophers have had to contend, are the insistence on certainty, known as foundationalism, and the mind-body dualism that has fostered continuing problems with the status of "other-minds". Simulation is directly connected to the former while artificial reality stems from the latter. The general consequence of the acceptance of the Cartesian paradigm and its attendant problems has been to separate thought from the rest of life, ostensibly a purifying measure, and one that will insure a correct path to knowledge. This consequence has led to the continuing belief that disciplined thought is only possible in science and other uses of thought and, therefore, language, such as that used to discuss ethical issues, is unqualified to be ranked as true knowledge. Various philosophers have attempted to work under these constraints towards the goal of bringing questions of meaning back into the foreground of philosophical thought while attempting to bring philosophical thought back into the center of all human activity. Wittgenstein accomplished more towards the ongoing evolvement of this enormous task by refusing to argue with the established canon of Cartesian knowledge on its own terms. Instead, he offered a different view, one involved with the idea of wonder at the world.

According to Descartes, only man has the ability to think, and this ability separates him from the rest of the world, even from that part of the world which houses "this thinking I", the body. This separation is what Morris Berman (6) calls:

> the final stage in the development of nonparticipating consciousness, that state of mind in which one knows phenomena precisely in the act of distancing oneself from them.

Berman goes on to say the result of this distancing of nature and consequent reduction of its mysterious whole into distinct and, therefore, understandable parts is the supposed ability to manipulate it to our advantage. The manipulation and control of nature is a very different rationale for the accumulation of knowledge than the impetus for knowledge of the Middle Ages. Instead of teleological purposes of the acquisition of knowledge, Descartes, and Galileo before him, had very different reasons for their scientific inquiries, the results of which continue to affect our relationship to knowledge. "How?" became the important question, not "why?". Descartes [10] makes this goal explicit in the *Discourse of Method* :

> [My discoveries] have satisfied me that it is possible to reach knowledge that will be of much utility in this life; and that instead of speculative philosophy now taught in the schools we can find a practical one, by which, knowing the nature and behavior of fire, water, air, stars, the heavens, and all the other bodies which surround us, as well as we now understand the different skills of our workers, we can employ these entities for all the purposes for which they are suited, and so make ourselves masters and possessors of nature.

In this quote, we cannot but clearly understand the connection Descartes makes between knowledge and mastery. He compares the utility of understanding and possessing nature to the comprehension already in place to utilize "our workers". "All the other bodies which surround us" included all of the natural environment, animals, and human beings whose existence, for Descartes, was justified by their skills in working.

Berman [7], in his erudite history of the body in Western civilization, *Coming to Our Senses* cites the relationship between animals and man as a telling indicator of how the people of the period of history in question relate to their own bodies:

> . . . and that knowledge of this takes us directly into the Self/Other relationship, which in turn "unpacks" the culture in question, or the historical period being studied.

With Descartes' "proof" of the mechanical philosophy, animals became automata, machines that could be used for a specific purpose, that of experimentation. Since the seventeenth century, the use of animals in experimentation has grown to a large scale business, numbering in the millions of animals per year in this country alone [29]. And as Berman [7] points out:

> . . . animals are now regarded as laboratory tools, experimental "equipment, " no more significant on an invoice or order sheet than test tubes or graduated cylinders. They are literally "stuff," and this is the nadir of the Self/Other relationship. . .

Allucquere Roseanne Stone [32] makes an equivalent connection between Cartesian mind-body dualism and the politics of power:

> Because of the way power works, it is important to remember that forgetting about the body is an old Cartesian trick, one that extracts a price from those bodies rendered invisible by the act of forgetting - those on the lower end of the social scale by whose labor that act of forgetting is made possible.

The later Wittgenstein proves to be enormously helpful in offering us a different vantage point from which to view what is in the Cartesian paradigm the necessity of separating our bodies from our minds. In the previous section on foundationalism, we found Wittgenstein's offerings of an alternative image to the traditional Cartesian one based on rationality-as-representation. It is imperative to remind ourselves that Wittgenstein does not try to beat Descartes, and the whole inherited Cartesian tradition, by attempting to answer the need for Cartesian certainty. Answering that need for certainty as if it was a relevant question would then lead again to the concept of thought representing reality. And again our language, the external proof of our thought, and according to Descartes, our existence, would then be interpreted as merely reports of some reality. For Wittgenstein [34], language does not refer to sensation, but replaces it:

> Here is one possibility: words are connected to the primitive, the natural, expressions of the sensation and are used in their place. A child has hurt himself and he cries; and then adults talk to him and teach him exclamations and later, sentences. They teach the child new pain-behavior.
>
> "So you are saying that the word 'pain' really means crying?" On the contrary: the verbal expression of pain replaces crying and does not describe it.

Wittgenstein is putting before us an image of an entirely different view of the connection between internal and external, between the mind and the body. Wittgenstein shows us the possibility of our language being the embodiment of our sensation, thereby allowing us to imagine the possibility of the oneness of mind and body. Our "utterances" of pain do not represent our pain, they are the pain.

What Wittgenstein accomplishes in his later work is to offer us a way to think about meaning that does not rely on the Cartesian assumption of the separation of knowledge and meaning. He also gives us the chance to see ourselves as part of the world, not as the primary source of knowledge. We are able to understand or make sense of ourselves through communication with others. Once we understand that we are part of what we had considered to be the external world, we no longer have to build an intellectual superstructure that must stand in for the world, one that we rely on to answer our questions about how and why to act in the world. Wittgenstein offers us the possibility to comprehend meaning through the use of language, if we understand language as a particular kind of action. Language is interactive. Once more part of the world we are able to understand interaction as meaning, and offering us immediate answers to our questions about how and why to act in the world.

Like Wittgenstein, Brecht was attempting to free his discipline not only from the particular theories that had dominated that art form since Aristotle, but, in so doing, he was offering it the opportunity of a decidedly different worldview. Elsewhere, [16] I have detailed this difference more completely as it applies to dramatic interaction in the development of virtual worlds. In this paper I would like to emphasize how the connected concepts of the universal and the particular are viewed differently by Aristotle and Brecht. Aristotle describes the poet and the historian as differing not in their style of writing, but in what they express. For him, poetry expresses the universal, history the particular. We gain pleasure from the satisfaction of understanding something common to people of all times and places. He calls poetry "... a more philosophical and higher thing than history" [2]. Brecht [8] takes issue with this judgment, when he says:

> The 'historical conditions' must of course not be imagined (nor will they be constructed) as mysterious Powers (in the background); on the contrary, they are created and manipulated by men (and will in due course be altered by them): it is the actions taking place before us that allow us to see what they are.

Fate, or the gods, can not be blamed for all the evils which man brings upon himself by his own actions. If one is able to understand the real causes of poverty, war, slavery, cruelty, murder, abuse, starvation, ecological disaster, one may be able to take action for change. For Brecht [8], context is all important. The knowledge of it gives one the power to change:

> We need a type of theatre which not only releases the

> feelings, insights and impulses possible within the particular historical field of human relations in which the action takes place, but employs and encourages those thoughts and feelings which help transform the field itself.

It is this desire for change, what postmodern terminology calls "empowerment", that drives Brecht towards a dramatic theory that refuses to immobilize the viewer with a cathartic experience. Brecht wants to place the viewer in a powerful position. All of Brecht's directives are based on his desire to ". . .leave the spectator's intellect free and highly mobile". In this state, the viewer is able to clarify his thoughts and decide what action should be undertaken.

These two disparate worldviews underlie very differing approaches to the idea of designing a virtual world. Like myth, theatre, film, and the visual arts, virtual reality is an attempt to understand ourselves, understand our place in the universe. Our reaction to that understanding, that knowledge, may vary according to the ideas upon which the environment in which we come to that understanding is based. Brecht's theories of dramatic structure are vehicles for the imparting of knowledge, a means of understanding the context in which that knowledge is developed, and the encouragement to act on that knowledge.

This emphasis on the particular is echoed in contemporary feminist moral theory. Based largely on Carol Gilligan's [18] ground breaking empirical research and consequent seminal book on woman's developmental theory, *In a Different Voice*, contemporary philosophers and theorists [1, 4, 22] propose a conception of morality based on care, responsibility and relationship in contrast to the morality of justice derived from the philosophical tradition of Kant. In Gilligan's [18] own words, the far-reaching significance of the acknowledgement of a "care perspective"

> . . . in woman's moral thinking suggests that the study of women's development may provide a natural history of moral development in which care is ascendant, revealing the ways in which creating and sustaining responsive connection with others becomes a central moral concern. The promise in joining women and moral theory lies in the fact that human survival, in the late twentieth century, may depend less on formal argument than on human connection.

The idea that the ethic of care and responsibility might be extended, cries to be extended, to the political sphere, to our social life as a whole is affirmed by feminist political theorists, such as Katzenstein and Laitin [22]. They explain that although the fundamental morality of the care perspective derives from the conviction that responsibility is owed to the contextualized individual and not to abstract principles of justice, that conviction includes ideas about the political sphere:

> Central to this conviction was the belief that the private and public spheres could not be set apart. To foster mutual caring and responsibility in the private domain required the exercise of political power on the public stage. To achieve responsibility and caring in public life demanded that values learned and exercised in personal relationships and family life had to be transported into public arenas of authority.

This notion of the necessary relationship between public and private spheres is echoed in Eagleton's delineation of the "ideology of the aesthetic." As Eagleton [12] asserts:

> The aesthetic is preoccupied among other things with the relation between particular and universal; and this is also a matter of great importance to the ethico-political.

It is the actual needs and desires of individual beings that render them at the same time different from other beings and similar. To have the right to participate with others in the process of having these differences respected is what the ethico-political is about. Eagleton makes the point that Aristotle's idea of the *polis* is gone. Eagleton [12] critiques modern ethical thought as having

> . . . failed to take Aristotle's point that ethics is a branch of politics, of the question of what it is to live well, to attain happiness and serenity, at the level of a whole society.

As Eagleton explains, and I contend, in the development of the political goal of recognizing and taking responsibility for the care of others as individuals with needs and desires as important and necessary as one's own, ethical values in the aesthetic tradition work both towards and against that goal. It is imperative that we understand the history of the connection between ethics and aesthetics. This connection has had, and will continue to have, great impact on how technology defines and is defined by culture.

The preceding is a summary of connections and contrasts among several aesthetic and ethical spheres of thought I have found most helpful to me in contemplating making art with virtual systems. If virtual reality is to play a role in the emergence of a new cultural paradigm of interaction, one whose agenda encourages the participants to take responsibility for their actions and their world, then it is imperative that we begin to develop an interactive aesthetic based on those goals. What recommendations can I offer the development of this ethical interactive aesthetic? Several general recommendations seem in order, as well as more specific ones. Elsewhere[17], I have listed six factors useful in critiquing current trends in the design of virtual systems. These factors can be identified as including, but not limited to: interface, content, environment, perception, plasticity, and performance. This list was constructed out of the factors emphasized by present virtual reality design trends, and the factors which are felt to be integral to the project undertaken by the emerging aesthetic of interactivity.

That virtual reality systems must be open systems, not closed, is an encompassing recommendation that can be made across all six factors of interface, content, environment, perception, performance and plasticity. That access to the technology by all kinds of people, in all segments of society is another inclusive recommendation. Distributed access involving telecommunications will provide a wide range of contextual interventions to impede any monopoly. Certainly Brecht's notions of how dramatic structure can encourage participation and responsibility may be applied to these factors in general. From Brecht, we have learned that an environment that is not completely immersive, one that provides us with reality checks, pointers to physical reality with its messiness and jumble of perception, environment, content, and behavior, is one that ultimately will be the most creative and productive where it counts most, not for ourselves only, but for the desires and needs of others in the real world. Simultaneously allowing the participant as much freedom in defining his world, developing tools, and contributing his own sense of content will in turn offer the participants a confidence in the importance of their particular involvement in determining the future of our relationship with technology. In looking at present trends in virtual reality design, one has to account for where it is being made, how it is being made, and why it is being made?

The following specific questions and accompanying recommendations address each of the factors' potential for opening up a multimodal information exchange, for distributing control and contextualizing judgments, coupled with encouragement of concern or caring for the needs and desires of others as if they were our own. These descriptions were used originally for critiquing present trends in virtual reality design. Here, they are used for making recommendations for their use.

Interface . According to Brenda Laurel [23], editor of *The Art of Human-Computer Interface Design*, the most complete compendium to date of ideas concerning this subject, the concept of interface has changed from one that only included the hardware and software through which the human and computer communicated to a concept that includes the ". . . cognitive and emotional aspects of the user's experience as well" (p.xi). She adds,

> An interface is a contact surface. It reflects the physical
> properties of the interactors, the functions to be performed, and
> the balance of power and control.

She also suggests that one of the reasons why interface design is so hard to accomplish is that it is "interdisciplinary and highly political". These remarks by Laurel, one of the pioneers in thinking about virtual reality design, are extremely applicable to a definition of interface that considers contexts in which the points of contact between humans and computers are developed. Perhaps Myron Krueger's ideas on unencumbered responsive environments have been on the right track all along. As an interface, they seem to solve many of the problems that encumbered immersive environments generate. Ultimately, the interface must reflect, since it will direct, our sense of wholeness as physical beings, and our trust in our ability to make judgments.

Content. The content of a virtual world can be defined as what that virtual world purports to be about, its' meaning. In a virtual world designed by the Human Interface Technology Lab at the University of Washington, Seattle, one is immersed in a underwater shark filled world in which one is directed to net the sharks. In this world, the content of the world, on one level, would always have to be about netting enough sharks. Since netting automatically disintegrates them, the meaning of our relationship to the sharks can only be one of dominance and destruction. Meaning can be derived, however, from a combination of content and the context in which that content exists. The "angry god" face that appears and announces that the game is over because not enough sharks were netted provides the context of the world. In this world, the user has extremely limited control or choice. This context is one in which the author of the software program has given the computer the control of this world. This world's meaning exists in the hierarchy and dominance demonstrated by the consequences of not netting the sharks. The content of a virtual world must be able to be defined by the participants, its meaning then reflecting the context of their physical reality. Engagement should not take precedence over the knowledge offered in meaning.

Environment. This would include the space in which the world exists and all the identifying physical qualities of that world. In what relationship the participant was engaged in the world would be in some ways determined by the environment. How changeable by the participant is the environment, how infinite, how limited? How much of it does the participant determine? The environment, also, must be able to be molded by the participants. Together, they will map meaning on the world.

Perception. How close or far away to what we think of as human perception: sight, touch, smell, hearing, kinesthesia does the world allow us to come and how much control do we have over those perceptions? How much does our involvement in the virtual world depend on "amplifying" or manipulating our senses? Control over the participant's perceptions should be ultimately under the direction of the participants.

Performance. How and why do we interact with and in the virtual world? On what does our behavior depend and does our behavior affect others in the virtual world, or outside of it? In what way does our behavior affect the virtual world, or the actual world? Is it an open or closed system? How and why we are interacting with, and in, the virtual world should be made clear. On what our behavior depends and how our behavior affect others in the virtual world, or outside of it, should be made manifest. The consequences of our behavior in the virtual world and their consequences in the actual world should be transparent.

Plasticity. How moldable, flexible, pliable are the characteristics of the world? How much does it push back? What does it give the participant back? The virtual world should be moldable, flexible, pliable, but, it should also push back: The cause of that pushing back should be the actual, physical reality of which virtual reality is a part.

That virtual reality is only a humanly constructed part of the actual physical reality in which we exist is an important and often overlooked idea. We, after all, have created it in our image. What it mirrors to us are all of the same nagging questions about how and why we are to act that we thought we might have left in the "real" world.

Contemplating any one of these six areas will necessarily bring up issues involved in any of the other five, and in doing so, one may successfully engender enough thought to assist us in developing other recommendations for an ethical aesthetic for virtual worlds. My hope is that the preceding demonstrates not only the advantages of working towards an ethical aesthetic for virtual worlds, but the implausibility of doing anything else.

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ART IN THE AGE OF UBIQUITOUS COMPUTING:

Rich Gold, Xerox PARC 1993

1) Sensuous works that can hear, see, feel, touch, smell, know where they are, who is in the room, where their owner is, what's going on and what went down.

2) Reactive works that can change their skins, activate motors, laugh, cough, blow bubbles, make sounds, sing and tell jokes.

3) Communicative works that whisper, lie, conspire, kibitz, talk and gossip together. These works exchange information, knowledge, insults, truths, untruths, random thoughts and tall-tales.

4) Tacit works that are invisibly embedded in daily life. Works that become habitual and relied on, forgotten about (like riding a bicycle) or deeply integrated (like a contact lens).

5) Colonizing works that inhabit all of our daily goods, camouflaged as it were, in simple commodities and enspiriting the landscape with minor gods, clever deities and unusual ghosts.

Art in the age of Ubiquitous Computing will not be in galleries; rather, we will live within its general hubbub.

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TECHNOLOGY, ABSTRACTION AND KINETIC PAINTING

By Samia A. Halaby

There are many types of pictures and many uses for them ranging from practical applications to experimentation and to decoration. Which of them is appropriate to the electronic media and to digital computing?

Some picture makers have long since embraced the electronic media and depend on it economically such as those who work for practical and commercial ends. those who make pictures for wall decoration or for status collecting may be hostile to it as it undercuts their economic base. One might be tempted to say that the practical arts have pioneered the use of computing and that the stodgy Fine Arts are still hiding in their ivory studios.

It is important to note however, that the practical arts and the so called Fine Arts should not be seen as unconnected categories. They differ only in their relationship to production. Some pictures are intimately linked to production such as industrial and technical drawings while others are a little less directly linked such as architectural or medical illustration. Pictures for entertainment, decoration, and illustration, though they seem to have no relationship to production, serve it indirectly. After all we educate and entertain the young so that they too can start working. Still yet there are other pictures which are experimental and their connection to production is similar to that of research and development. Thus ultimately all pictures, regardless of their distance in relation to production, serve its functioning to fulfill our needs.

Where do I as an artist locate myself in this continuum? Like many other painters, I define my artistic intentions as a search to expand the language of pictures. This follows the principles of the avant-garde and modern abstraction in the twentieth century. With such an ambition it is essential to experiment with new media. We begin by learning its technical basis so that we can discover what forms are possible based on these techniques and what new content these forms might convey. If we succeed, then our discoveries permeate all pictorial uses and become beneficial to our practical needs in production. Therefor, the artistic use of form suitable to a new technique is a progressive choice.

Technologies and media emanate out of our historic social and economic development. We use them as long as they remain economically feasible and we replace them when we have better methods. The most appropriate technique is used to create the form which will most expediently convey the ideas of the society. Of course, the most appropriate technique depends on the level of advancement of the society. Animal grease as medium and earth colors as pigments were state of the art for ancient European cave painters. The electronic gun and a cathode ray tube in connection with a CPU are state of the art in our time. Societies who have electronic media would certainly not be illustrating food procurement by drawing pictures of how to hunt bison. Instead they are more likely to be writing programs which let us do our shopping for food on our personal computers or interactive televisions. Yet they are free to imitate cave painting for purposes other than food procurement -- a freedom the cave dwellers did not have.

With this irresistible logic in mind, painters who consider their work to be experimental must necessarily explore a medium such as computers. We do not do this exploration without knowledge of the history of pictures and pictorial form. But what is it that constitutes new form and what is pictorial form? Pictures cannot be taken as a given. We must remain cognizant of the fact that they rely on a pictorial language which has taken millennia to develop and which will develop further yet. In exploring computing as a medium, to take pictorial illusions of a three dimensional space as a none historical given is to be stuck using new technologies to accomplish old tasks. If our understanding of reality leads us to understand space as having more than three dimensions then we will develop a pictorial language to describe this greater number of dimensions.

Pictures are flat and frontal and do not show us but one side of things at one time. This is also true of moving pictures such as film, video and virtual-reality, which persuade us that they take us inside things by utilizing moving flat pictures. Yet single frames of moving pictures show us only one side of things at one time and they conform to the language of flat pictures generally. This does not mean that beyond the language of the sill frame, moving pictures do not need a further syntax for the development of visual and audible events in time.

If we wish to understand form and move it forward we cannot be mistaken about this flat frontality of pictures. In importance it is equivalent to the alphabet of the written media. The flatness and frontality of pictures is of high economic value. It is precisely this flat frontality of two dimensional pictures bearing information about a multidimensional world that is the essence of pictorial form which is pictorial language. And, in the fact that we can duplicate flat surfaces and transport them economically lies our civilization's need for pictures and for their further development.

If since the Renaissance pictures have been flat and frontal and have successfully made illusions of a three dimensional world then what is it in the form of computer pictures that is an advancement in form? After all was it not during the Renaissance that painters perfected formal methods to convey three dimensional projection (perspective), shading, direct illumination, and reflected light. Are the new ray tracing mathematicians revolutionizing this formal language of illusion or are they only expanding it and making it more useful? Furthermore, should we consider the digital transportability and electronic duplication of pictures a new quality in pictorial form or a revolution in communications.

Before I answer these questions I want to state that I believe that electronic and digital methods are intersecting with visual form and resulting in a renewal of content, appreciation and criticism. Witness our presence here at this international computer conference with the art factor under consideration.

To consider what we can most learn from a new medium we need to understand what is not new in it current uses. It seems inevitable that the very first use of a new medium is the imitation of old methods. This is because the new methods are more economical and more productive in executing old tasks. But in time, experience in using the new techniques to accomplish old tasks sparks ideas. New technologies have the potential then to teach us how to improve our work, and consequently our civilization progresses.

In ray tracing, three dimensional illusionism in computer graphics, and moving pictures there is not a pictorial form which yet adds anything to the language of flat pictures. The super three dimensional illusionism computer graphics is capable of is not new form in painting. On the other hand when we compare Renaissance painting to ancient Egyptian painting and ancient Egyptian to primitive European cave painting we do immediately note a major improvement in the pictorial power of the more recent. Furthermore when we compare Soviet Constructivism to Renaissance painting we quickly understand that a revolutionary new language of form has appeared. Each succeeding historical form added a revolutionary new method of defining space. However when we compare the three dimensional illusionism of computer graphics to the Renaissance we see that what is new is not pictorial form but rather the data base on which it relies. That is there is not a new language of form but a more sophisticated and practical application of the discoveries of the Renaissance.

Further, the transportability of digital pictures through electronic highways has not yet imparted new principles to our pictorial language. Nor indeed has the imitate connection between information and picturing yet resulted in a new visual form. Although they have definitely given us new technical methods to create pictures and to animate and transport them. This does not mean that they will not very soon spark the creation of new form. The seeds are everywhere and they will flower.

Scientific illustration, fractals and other geometric illustrations are not new pictorial form either though they may be new geometric form. Their pictorial manifestations rely on the formal principles of abstract painting adding little to it. What is new is fractals as geometry, on the one hand, the language of abstract painting on the other. Remember that the sciences have always been creative and beautiful.

These are crucial considerations for the painter to contemplate when using computers. We do not have much of a tradition with this new medium and only a small audience and an even smaller platform from which to show our work. We receive very little feedback from those who understand that we are neither designers nor scientists but rather painters who experiment. We are lost in SIGGRAPH and we can lose our focus.

As a painter who experiments and seeks to be as advanced as possible based on an understanding of history and not an understanding of art world fashion, I believe that abstract painting is the most advanced area for exploration and experimentation. I wish to make abstraction as versatile as possible an imitator of the general principles of motion that we see in reality. I reject the persuasion of many twentieth century historians and critics who believe that abstraction is unrelated to reality. I understand it to be so related and all my abstract work has a visible and easily explained basis in reality.

Abstraction deals with general principles rather than particular appearances at particular times. The development of abstraction will allow us in time to contribute a precise visual language capable of describing general principles as genuine as the general principles of addition, subtraction and division.

Computing provoked three methods in my painterly explorations. the first was the use of programming to create kinetic paintings with sound. The results are programs performed on a computer. The second was the use of painting software combined with video to record painting sessions. the third is the use of interactive programming to automate the making of still or kinetic abstractions allowing serious painting without manual skill.

KINETIC PAINTING

Kinetic paintings resulted from my first explorations with computing. When I first began considering computers I found that the practicality of software programs defeated what seemed an exciting potential in computing. These drawing and painting programs had as their goal to prove to artists that they too can be used to do perspective and shading and imitate other media such as oil or watercolor or charcoal. Their very goals were precisely those that I have aesthetically rejected as an abstract painter. I started programming with logo on an Apple and continued with Basic on an Amiga and after a year I learnt C. what the computer let me do with programming was extremely exciting. I was very high on it at first. I could not believe that technology and civilization had put this stuff in my lap.

The way I work with the computer to create kinetic paintings is the same as with other painting media. I begin intuitively and type some initial program commands. I compile and link this initial small program and run it to evaluate. It is like putting some shapes on an empty canvas and then backing up to see what you have accomplished. After judging the results I react intuitively adding, adjusting, or deleting parts. I repeat this cycle of programming, compiling, linking, running, judging, and changing until the art work becomes a complete idea.

The end result is a program which when run creates a painting on the monitor which unfolds in time and possesses a stereo sound accompaniment. To me the medium is the computer and therefore electronic and digital. The program is like a recipe which can recreate the art on demand. Hard output from the computer such as prints, videotapes, photographs, and slides are a natural efflorescence of this medium. But, I view the program as the primary painting.

Formally, what has happened in my work on the computer is that the form of digital information and programming have influenced the language of abstract pictures. My first explorations with basic looked like basic. They were linear in the logic of their development in time. The simplicity of basic and the joy of working with the medium caused these early paintings to be high and happy. They resemble a birthday party. When a bit later I began to use C my paintings looked more like C. They were more unified and logical in their unfolding and they possessed certain rhythmic repeats all of which were based on the structured nature of C and the layering of routines which it allows.

Programming logic and digital structure influenced the form of both sound and image.

Loops, switches, the layering of routines, logical pathways, and the many types of variable, influence the sequence of events. There is an unmistakable way in which a loop, for example, will cycle through a set of visual and audio events. It contributes a fundamental flavor to the artwork, a flavor which deserves to be fully exploited because it is not available in other media and is, therefore, bound to be enlightening.

SOUND AND SHAPE

The computer gives me the ability to imitate the way things sound in addition to the way they appear. that is, it allows a more complete imitation of the general principles of motion. Things we see make a sound when moved or when we move past them. for example, we have learn from experience that there are certain sounds peculiar to metal as there are certain shapes, colors, and highlights also peculiar to them. thus, in my work, adding sound to shape and color is not an attempt to correlate music and the visual arts (1) nor is sound used as a musical accompaniment. that is, it is not a marriage of several distinct art forms such as in opera or theater or film but rather the exploitation of a known dimension of visible shape not yet fully used in painting.

Coupling sound with abstract shape has defined a new method in kinetic painting which depends on this natural audible attribute of objects. Sound in my kinetic pictures signals or reveals the visual rhythm. Although my ability to manipulate sound is very primitive, its presence adds a dimension of reality. It is like the first day of spring after a long winter when you first open the windows and hear the sounds of the street long since muffled by winter. Conversely, soundless kinetic paintings make me feel deaf -- as though a window had been closed and we have become a step removed from reality.

In terms of programming the sound statements and the visual statements are interdependent. Often the duration of sound is used to time a visual change. And conversely, visual activity is used to control the duration of sound. Occasionally I use the same variable within bounds to control both the frequency of sound and the behavior of color. There is nothing mysterious about how sound and shape coordinate. My simple goal is to imitate the rhythms of contemporary life.

UNFOLDING SHAPE IN TIME

If we walk around a still life or notice the motion of the street around us we can see the negative shapes between objects and the shapes of those same objects shifting. They fluctuate, stretch, compress, disappear, reappear, fade, and they make sounds. Finding a language to describe this modern perception of reality was the great gift of Cubism. Their paintings are a historical step toward a view of space and time in relative terms. On this basis painters built abstraction's ability to convey the general motion of things rather than their particular appearance at one time from one spot -- as though frozen in time and space.

With the computer we are able to expand this investigation. We can create shapes which grow and shrink and interpenetrate and gradually change colors. We can provoke our viewers to remember their own experiences with contemporary reality during the unfolding of the picture. Visual gesture, unfolding in time, will be recognized by viewers as a parallel to their own experiences of contemporary rhythms.

The astute reader wonders what is the difference between this unfolding of shape in time and ordinary animation or film. The difference is the same as that between abstraction and three dimensional illusionism. What I describe is the changing of abstract visual parts, their growing and their transformation. There is not a point of view or a viewing lens nor is there a resulting three dimensional illusionism present. Things do not move in relationship to a stationary seeing eye or in relation to a recording lens. this is not a motion that can be recorded with a camera or a camcorder. Rather it is the visualization of the growth and motion of things seen by our eyes as we move and that which is abstractly understood by our minds as we contemplate what we see.

THE PICTURE PLANE

The third new method is the electronic picture plane with its shifting complexity and mercurial qualities. It is impossible for hard copy or traditional painting to compete with the motion and luminosity of the monitor as a picture plane.

This picture plane has a memory. There is a magic in the way things return to the screen after they disappear. We are provided with a fast pace of changing images and huge amounts of data in a way that imitates our experience of the pace of modern cities and modern information. The speed of shifting shape as we view a concourse below from an over-fast escalator, or the changing imagery of plate glass shop windows are not the stuff of impressionist painting; yet they can be computed into our modern pictures. Scenes of lower Manhattan such as the hum of the big escalators descending to the Jersey trains, the commotion and gaiety of the lunch hour crowd, the neon light and the moving letter signs, can all comfortably live on a monitor screen as picture plane. Their mercurial rhythms are at ease here as they can not be in any other medium.

In contrast to traditional painting's surface color the monitor possesses an actual luminosity that is wonderful. We have always described abstraction's color and light as being self-luminous. the monitor fulfills this beyond the maddest dreams of the first true abstract painters -- the constructivists.

Kinetic painting, therefor, has helped me move forward in three significant areas. These are: The combination of shape and sound, the gesture of pictures unfolding in time based on the intersection of programming logic with pictorial form, and in concepts of the picture plane. I do not consider these to be a new formal language but rather visual methods which may with much future exploration on a social level bear some fruit.

PAINTINGS IN PROCESS

My second exploration involved video. It was inspired by the work of Roberto Matta which I saw in 1988 at the Venice Biennial (2).

Matta's videos were made using ready made painting software and video recording techniques. The pieces were composed of drawn lines shown in rhythmic sequence. It seemed as though we were watching a master draw. An image of the artist working was not present -- only his intellectual process. Nor was there an intention to present a process which led to a final picture. Rather it was the shifting and changing of the space, masterfully manipulated with lines and marks, that was the obvious subject.

Inspired by Matta I attached a VCR to my computer and began drawing with a paint program one night. My paint program allows me to hide the menu and to change colors and pen width through the keyboard while drawing with the mouse. thus with one hand on the mouse and the other shuttling between the keyboard and the pause button of the VCR, on that first night, I recorded six hours of painting work onto one hour of video. The result is a slightly edited recording of a long painting session.

There was a liberation from the expense and difficulty of mixing paint and from the problems of unwanted muddy color mixtures. I could mix a pallet of 36 colors, more than most abstract paintings contained, and proceed to paint without the physical drag of pigments. I could save anything that seemed beautiful onto disk and overcome the fear of destroying preliminary accomplishments. This gave a certain joy and freedom to the results.

This way of working with the computer taught me a lot about the creative process. I discovered that my working habits follow a wave pattern. I begin the painting with seeds of ideas and they develop. As the painting improves and nears completion there always seems to be one more thing that will make it perfect. A certain ambition or obsession prevents us from leaving well enough alone. Each attempt at completion only reduces the expression we were so near attaining. Eventually the painting is destroyed and a new stage is begun. The destruction seems to be an inevitable process liberating us from the hesitation we experienced when we felt so near discovery. Thus, just when the painting looks like a disaster the freedom of destruction gives birth to new combinations of form and new seeds of ideas are born and the painting begins to improve again.

This up and down motion of construction and destruction is a phenomenon in the creative process which I believe most painters experience. what the computer has contributed in this case is productivity. It would have taken many many years of experimentation with media, which present far more physical resistance and expense than a computer, to arrive at the same understanding of one's own creative limitations and process.

It is also important that what was recorded was the result of the intellectual and intuitive process of painting and not the appearance of a painter in person putting the paint on the canvas. The intellectual expose devoid of personal ego has a value that is typical of computers.(3) The retarding effect of ego on criticism is eliminated. The process holds an impersonal mirror up to our habits in ways that cannot be denied. It reminds me of when we first heard our voices on sound recording media some years back and failed to recognize ourselves. Now we know ourselves better as we see ourselves and our thoughts so effectively reflected in this media.

Watching our work from a long painting session compressed onto video can teach us more than several years of trial and error with oil paints and with cautious criticism. It is an example in painting of the productivity of computing.

PAINTING WITHOUT MANUAL SKILL

Recently I started working on a PC and found Visual Basic. I had often wanted to write an interactive program based on my kinetic paintings and on ideas of chance, but the programming task it involved kept me delaying. Visual basic jumped that hurdle for me. I began to program buttons for other users who might sit at the computer and enjoy what I so much enjoy when I program.

The result was an interactive program which allows users to create sophisticated still or kinetic paintings without programming knowledge or manual drawing skills. All that is needed is to click the buttons on the menu. This is different from normal paint programs in that the painting is automated. You need draw nothing nor cut or paste anything. You click the buttons and enjoy the results. Those who are afraid and hesitant find the program intimidating. but a lot of people love to push buttons and switches and they enjoy the rewards. With time they learn to trust their intuitions and come up with their own abstract painting expression.

As I programmed the different buttons I found that the process of providing parts to be mixed by a combination of chance and intuition forced me to analyze the components of an abstract painting. This analysis and its complement in the organized results are made possible by digital computing.

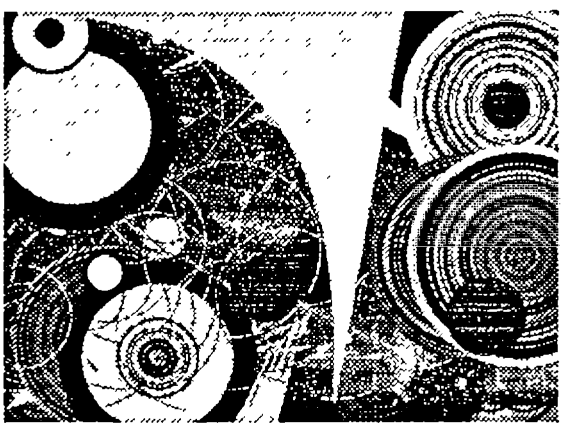
An example of the process of analysis and reorganization is the way I created a color menu. In considering the nature of color in abstract painting we note its relationship to light and color in reality. thus I mixed several palettes of 500 colors each of which imitates a time of day, an atmospheric condition, a geographic location, or a habitation such as neighborhood. The menu reads: high noon, morning, city lights, grays plus, etc. Once the user selects one of these conditions the colors which are used to execute all consequent shape activity will utilize this palette.

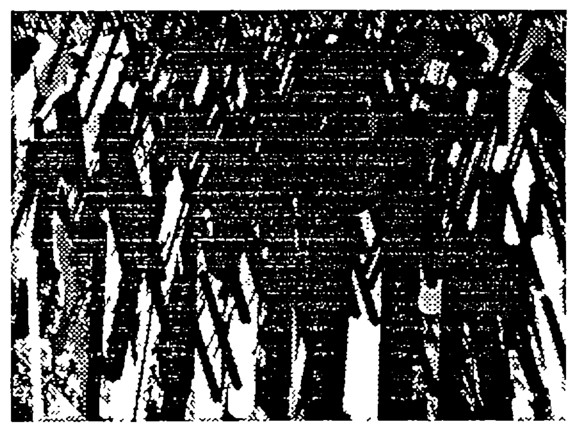
Another menu titled 'atmospheres', not yet complete, allows the user to select 'rain' or 'fog'. Yet, another menu allows the choice of color backgrounds as initial ground for the painting. Other than menus there is a frame made up of buttons which when clicked create other results. Some are devoted to shape creation while others to lines and line groups. some act subtractively while others act additively. One set of buttons which create line groups are intended to imitate the appearance of branches. In them scale and orientation and distribution possess qualities peculiar to trees.

There is a special set of buttons devoted to negative/positive space, to grounds of relative distance, and to visual curtains. They result from an analysis of the organization of abstract paintings. In composing paintings we always consider the presence of shape in relationship to the rectangle of the picture which is formally a representation of our field of vision.

There is a variety in the scale of shape which depends on the way we see the world when we walk through it. The larger shapes in our field of vision are things such as parts of the sky, expanses of land or road, large buildings, and things very near our eyes. In our field of vision these large shapes can be expanses behind things, which we describe as negative space, chopped up by things which lie nearer to us and which we describe as positive space. These major shapes are always in flux and interact not only with each other but also with the myriad types of smaller shapes such as objects, animals, people, and leaves of trees, all of which are themselves in motion.

In reaction to this understanding of visible reality demonstrated by abstract painting, I programmed a set of visual activities which can be these major positive and negative shapes. Thus some buttons cycle through a set of 8 or more such shapes which together form a unified negative/positive image. When mixed with the products of other buttons they act as background expanses and or large positive foreground shapes. Together they make an abstract illusion of the world we see when walking through it





Two Examples Produced by This program

Since all the buttons cycle through a set of shapes with variables which themselves cycle through a given set of conditions, and since all shapes cycle through the 500 colors of any given palette, the chance of a painting repeating is remote to the extreme. I have not yet seen the same painting twice in this program. Of course even though the possibility is remote it is nevertheless present.

Thus using interactive programming to automate the making of abstract paintings has provoked the analysis and reconstruction of its form. this is an analysis of how artists use nature and reality as a source from which to extract general principles that they then use in making their art. Colors, atmospheres, textures, types of shape, methods of addition or subtraction, sequencing and rhythm, major divisions of the picture's surface as negative/positive shape, all can be menu driven to create a pictorial art which does not require manual drawing skills.

WHAT WE PAINTERS NEED IN A NEW COMPUTER

In order that more painters and students may participate in programming, we need from software companies a programming interface that is easy to use but which has a substantial set of graphic commands rather than just two or three. We need to be able to control color and shape and line and texture and changes therein. We also need a versatile set of sound commands which allow us to program all aspects of sound including approach, duration, frequency, timbre, and decay. We need windows without borders, titles, buttons, or menus. We need multiple windows and slices thereof which we can manipulate easily. We also need windows with a transparent background color which we can overlay on other windows like sheets of glass or sheets of acetate. It would be nice to easily manipulate four or more transparent windows each of which might have some visual elements. This will allow us to program shapes that appear in the background or in the middle grounds instead of constantly appearing in the foreground.

If software has menus we should be able to hide them with a keyboard command. We should be able to work on a painting without menus in view.

In hardware we need a computer with a good quality sound card, good speakers, microphone, headset, CD ROM, and a lot of memory. For color 255 are plenty and 65000 is luxury. We do not need millions. A bigger screen, high quality video connection to record our work and the ability to playback video onto the same computer monitor to check our work would all be of great help. All this hardware is easily available today but not in one computer.

We also need printers which can print on acid free 90 lb and 120 lb. paper stock with dies which are light-fast. A printer which allows us to use our own water color paints would be ideal.

NOTES

1. There are those who do very methodical experiments attempting to din a direct relationship between music and pictures. Some dream of finding a system whereby any musical composition will automatically reveal a hidden visual face. I believe this is misdirected experimentation. The source of both our pictorial and visual ideas is material reality. It cannot be replaced by a methodical correlation of the meaning of shapes and the meaning of sound.

2. The four video pieces by Roberto Matta were: "Auto-Elasto biographie", 1988; "Oeramen", 1988; "Pas-sez-moi la quillotine", 1988; "Passez-moi le souffle", 1988; Video, paint-box, n.m. Shown at the XLIII Venice Biennale, 1988.

3. In education the gap in authority between teacher and student is not a matter which always benefits learning. There are too many teachers who misuse their power. The removal of this burden by the computer improves learning for many students by removing negative personal interference. However, the good teacher is an irreplaceable treasure.

Configuring Hospitable Space[1]

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Configurable Space

This is a retrospective describing a research project based on simulations of future artists' work environments. The *Configurable Space* project explores the creative process, and examines the tools and processes that form the foundation for technological resources designed to support creative activities. It is directed towards the development of a balanced understanding about how we use the visual, aural, tactile and configurable capabilities of digital technologies, and how the tools developed affect ways that we think, feel, formulate, and develop on intellectual, spiritual and emotional planes.

Configurable Space environments incorporate any available technology that could be used to support the illusion that the implied resources already exist. The simulations incorporate representations of interactive computer display tables, walls and holographic images, within a multi-dimensional sound environment. This creates the context for exploring relevant issues and for imagining how the space might be used in actual circumstances. This retrospective describes the various manifestations of the project, spanning a five-year period.

The design methodology is based on the creation of models that simulate the functioning and potential usage of hypothetical systems. This method allows for modeling without the limitations imposed by considerations for specific implementation details, and carries the significance of being able to address ideal states. The goal is to provide paradigms to guide long term development, a goal that is particularly essential in considering virtual reality or immersive simulation technologies, given the fact that the computer resources available today are so constrained relative to the hypothetical systems they are designed to emulate. Liberation from implementation considerations paves the way towards a clarity in conceptual design. Issues relating to the use or non-use of head or hand gear, or even physical versus virtual input/output devices, becomes a question of personal preference and contextual requisites, rather than a technological necessity.

The following descriptions outline the evolution of the project and the basic concepts which form the foundation for the research.

Configurable Space I: the original installation

The set for the original installation consisted of a light table, a light wall, slide projectors, a chair, a piano bench, and a table with a water jug and candles. The materials were installed in the corner of a large studio space. The design of the space, including the size and positioning of objects in the environment, was created to reinforce an impression of a totally immersive experience. The additional room props support the impression of the environment as a complete room view, surpassing the limitations of physical display devices.

San Francisco-based photographer Marion Gray took over five hundred photographs during multiple sessions working in the environment, using sketches on transparencies, colored gels, slide projections, and live drawing. These images capture various perspectives of room views and close images, documenting the sketching and representation process, the evolving environmental characteristics and the resource requirements during the evolution of a music composition. The original installation was constructed primarily for the purpose of creating the initial collection of slides and photographs, and not as a public art installation. The creative context emulates a non-real time studio shooting process, resembling a procedure which one would go through to create a series of animated sequences of visual material.

The envisioned technology supports the following resources and ideals:

- Large integrated and interactive display tables and walls; dynamically sizable interactive projected images.
- Multidimensional and multi-channel sound capability, with simultaneous record and playback facilities, and real-time digital mixing and processing.
- Comprehensive and integrated resources supporting transparent, translucent, reflective and opaque overlay and mixture of visual elements on any surface.
- Touch- and sound-sensitive surfaces, space and control devices, incorporating any images and sounds, or any combinations of images and sounds imaginable. Size, shape, sound, spatial characteristics, and styles of interaction are all elements that coincide directly with creative intent and personal style.
- Dynamic configuration of all resources with any kind of visual and audio templates for creating and performing in the environment.
- Direct control of the total environment, following the natural flow of an individual's creative energy. This is in contrast to resources that force one to work with resources that contain preconceived notions about what art is, or how the human process is supposed to work.
- Elaborate history tracking, analysis and presentation resources.

Sound and Image As ...

Sound as music
    Sound as environment
        Sound as signification
            Sound as articulation

Image as art
    Image as environment
        Image as signification
            Image as articulation

This is a poetic expression that characterizes the underlying concepts of *Configurable Space*, addressing global concepts that govern the senses of sound and sight. These categories orient the audience in fundamental concepts that guide development and communication. In this section I will briefly define each category, as they apply to the foundation for *Configurable Space.*

In order to develop effective and comprehensive resources that are intended to support human activity, one needs to address the various ways that we create, assimilate, and interact with sonic and visual material in an intricate and constantly evolving environment. It is essential to devote attention to, and to develop an appreciation for the fine detail of direct local interaction, and for the global perspective for environmental control. In the realm of direct interaction, communication and expression, one may turn something on or off, as in the beginning or ending of computer applications; one may initiate control commands for processing, as in editing within applications, or one may move items around to assign structure within the space. Indirect interaction, communication and expression would include creating parameters that control global environmental characteristics and processes, such as creating global environmental characteristics that affect ambiance, perception and orientation within the space, or an area within the space; configuring generalized space utilization principles governing attention, notification, history tracking, geography, and concept recognition and representation.

The sound and image realm discussed and portrayed embodies the *Configurable Space* concepts, and contains the basis for examining the character of the environment and its technological requisites. As is the case with any artistic expression, these sounds and images reflect communication on many levels. There are many interpretations which address issues of representation, interaction, performance, and communication to self and to others. Every listening and reading carries new significance, reveals new insights, affects perception of consequent hearings and viewing, and can be explored for its detail and for its overall character. It is further affected by the attention and intent brought to the activity, and by the orientation and personal history of the perceiver. The success of this endeavor depends on the ability for the sound descriptions, the images and the discussions to call upon the reader's and viewer's unique experiences and perspectives, and to excite their imagination to explore how the concepts relate to their individual domains.

Sound as music

Music can be played as a form of entertainment, carrying additional requirements for the nature of the attention and perspective that the perceiver brings to the situation. Concert music, whether performed in a concert hall or on an electronic playback system can fall in this realm. The musical and aesthetic perceptual mode may be reinforced by other elements when music accompanies or interacts with the visual domain, such as in an operatic context or in a ritual dance.

Sound as environment

Sounds and even music can be used for the ambient qualities, as a backdrop that reinforces the specific content or context within the environment. White noise or low volume music may be used to drown out other sounds in the aural space, or may further be used to intentionally create a mood conducive to orientation within one's work. One may maintain sonic palettes for orientation among multiple simultaneous threads, with discrete, controllable and configurable driving forces that transform dynamically as one maneuvers and works in the environment.

Sound as signification

In this domain a sound embodies a specific meaning. The sound of a streetcar going by or a dog barking carries different significance than the ringing of a telephone or a sonic indication that a process needs attention. These examples are different from a sound that relates to an element within a music composition, or a sonic representation of a scientific principle. In this category sounds carry significance, or meaning.

Sound as articulation

This category refers to sonically defined structure. Sound is used to articulate moments, such as might define a rhythmic pulse, the completion of a musical phrase or an entrance into a new local or global environment.

Image as art

This domain includes pictures, photographs, moving images, or any visual content presented in a context that is oriented towards the presentation of art. The context orients the perceiver in an aesthetic mode, requiring a specific kind of attention and participation.

Image as environment

Wall paper, even if it is animated and configurable, affects the character of the environment. In the same way, the furniture, ambient lighting, and directed spot lights all contribute to the character of the environment and the focus brought to its contents.

Image as signification

This domain includes textual meaning, such as text that is language, and iconic representation, such as graphic elements that reduce or define objects and concepts. In the case of an image of a piano keyboard, for example, the representation carries a meaning relating to a physical object, a sound realm, a method of interaction, and a nearly 300-year historical reference spanning multiple cultures and musical styles.

Image as articulation

Visual characteristics can be used to frame concepts, to articulate events within the space, and to define connections among collections of things along with defining the nature of their connections. Lighting may change in order to view an art video, articulating a change that serves a transformation that alters one's attitudes regarding that which is about to occur. This consequently affects the experience and the perceptual modes one uses to interact in the specific circumstance. These concepts are operative within a single image, a collection of images, the environment as a whole, a revised perspective of the environment, or an entirely new environment.

Topical Orientation

In order to delve deeply into the character and requirements of the imagined creative environment, fundamental issues are categorized into a collection of topics, and I explore the technological resources required to support activities in that category. The topical orientation consists of a series of scenarios composed of image and sound that form the basis for exploring the meaning of these captured moments. The content examines the origin and evolution of ideas, their representation and connections, and the nature of the technological resources required to explore, develop and express ideas completely. The depth spans a range from early sketching stages through to completely refined representations. Activity in any or all of the categories can exist at any time, in any relative weighting, affecting the balance on surface and deep structural levels. I endeavor to expand beyond the realm of specific task-oriented tool development, developing a perspective that incorporates the entire being and the total environment.

Idea and Representation

Idea and Representation addresses the arrival and character of ideas, and mechanisms for their representation during early stages of the sketching process. Resources at this stage maneuver in a delicate balance between requirements of speed, clarity, and flexibility. No assumptions are made about style, representation techniques, or even the character of the end product. In this realm the resources must respond to rapid sketching or prototyping requisites, and must be sensitive to broadly defined symbolic reference with respect to textual, graphic, sonic, and gestural activity. The refined line and specification of fine detail are superseded by the need to express concepts and relationships.

Elaboration by degree

Ideas progress at different rates from their raw forms to more refined and detailed stages as the sketching process continues. The tools needed at this stage must reconcile disparities between different styles of representation and varying degrees of specificity. Salient surface detail and structural features need to be carried through to each sketch or version of the work, with facile capabilities for viewing, developing and integrating sets of related sketches. Requirements in this arena include tools for representation and generation that span a vast range from the primitive to the refined, allowing the artist to work to the degree of specificity and at the rate of activity required by the context.

Levels of Detail and Structure

As music exists in time, so do the processes that create it. These processes are not purely linear. Multiple layers of activity operate simultaneously, ranging from local levels of detail to larger architectural design. Work in the environment operates on many layers of activity and levels of perception. Flexible and natural movement among concepts, versions and layers, maintaining clear connections among all elements, are characteristic of this category, whether the reference is to a specific work, or to the environment as a whole. Resources serve the artist's internal sense for spontaneity and continuity.

Different Views of the same thing

Several manifestations of an object are imaginable; several paths to follow in developing a concept can be envisioned. The orientation of the user and the specific context or function being performed affects the nature of the representation. Representation and resource requisites differ for such contexts as conducting, performance, theoretical analysis, musicological research, structural design and sound design, though all of these activities share a common set of related concepts and processes. In *Configurable Space* these become different views that combine to assist in refining concepts, and to enhance perception and communication. The ability to design multiple views and to maneuver among levels of detail and architecture within one's work places the participant beyond the surface of things into the realm of abstraction, enhancing the perception of simultaneous and contiguous threads of the same and different things.

Connections among Room Views

Decisions relating to potential paths or directions for exploration are connected directly with knowledge, experience and understanding about past and present circumstances. The recollection of history as well as the flexibility in its presentation enhances one's ability to understand the myriad of paths to and from a point, a concept or a moment. A configurable, "environmental" audit trail maintains a connection with the total work and the complete environment, including the character and qualities that were part of the developmental process.

Configurable Space Installations and Performance-Presentations

Each expression of *Configurable Space* incorporates material prepared for and created during prior manifestations, addresses the same essential issues as they evolve, and includes new issues as they surface. The following descriptions of selected manifestations of *Configurable Space* clarify and illustrate the design and nature of this evolving project.

Configurable Space II: hard copy publication

Sixty-five images from the original 1989 installation were integrated with a poetic textual storyboard based on the topical orientation described above. This was formed into a chapter for publication in the *Companion to Contemporary Musical Thought*, published by Routledge in 1992. [2] Each topic had a dedicated section of the chapter, with a design and layout that visually supported maneuvering through the information. Both text and images followed the storyboard, with the intention that the images could be read and assimilated independently, as well as in conjunction with the text. The images and text were indirectly referential, with no explicit mention of any images in the text, though the connections between their respective content were revealed in careful exploration.

Configurable Space III: synchronized multimedia performance-presentation

In the fall of 1989 I presented the first two public *Configurable Space* performance-presentations, as a special presentation at the 1989 International Computer Music Conference at Ohio State University, and as a guest composer at the University of Texas Arlington. The presentation technology consisted of three slide projectors, a synchronized, multi-channel audio track, and a microphone used for live commentary. A tone track on the audio tape controlled the slide carousel movement and light intensity for each slide projector.

The goals of these performance-presentations were to communicate the fundamental concepts of *Configurable Space* to musicians and music students using computers in music applications, and to digital audio and music software developers; to experiment with alternative modes of communication of ideas using both direct and indirect methods of communication; to examine aspects of focus, environmental impact, and perception on multiple planes.

In the visual domain each of three, different-sized image projection spaces overlaps partially with the other projection spaces, and each retains part of the visual plane as its exclusive domain. The projection of larger- or smaller-than-actual size images reinforces active participation on the part of the audience, inviting them to step outside the expectations of life and traditional modes of communication, and to experience the environment in a way that affects existence on non-linear planes. By manipulating the image placement and light intensity of each slide projector I transform the audience's perception of the room size, its shape and contents, and the focus, depth perception and visual orientation within the total space.

The sound track consisted of *found* sounds of the world, live and manipulated instrumental sounds from a composition in progress, representations of sounds from the inner ear and internal world, and control/response command communication between the artist and the environment. Each sound was processed using predominantly non-real time software systems for simulating room size and spatial trajectories, and then digitally mixed using software processes for filtering sounds, and for layering in multi-channel sound complexes. The sound track created rooms, and the layers supported the perception of rooms within rooms, with dynamic shifting among the imaginary environments. Live commentary provided declamatory, poetic and structural orientation throughout the one-and-a-half hour performance-presentation. Additional details regarding the structure of the music segments that comprised the sound track and the character of the sound realm can be found in the Proceedings of the International Computer Music Conference 1991.[3] Excerpts from *inDelicate Balance*, the composition that evolved out of this process, are available on compact disc through *Leonardo Music Journal*[4] and from Diffusion i MéDIA[5].

Configurable Space IV: videotaped and studio-edited documentation

In 1990 a creative residency at the Banff Centre for the Arts provided another opportunity to work with the same slide projection configuration as used in the synchronized multimedia performance-presentation described above, to further develop the sonic elements, and to experiment with video as a medium for clarifying, reviewing and documenting various aspects of the project.

New sound segments, new sketches and diagrams, and additional storyboard material were created and incorporated into the original material. The structure of the project allowed for concentrated time devoted to programming the slide projection control. The automated slide performance was recorded on videotape, and a fluid audio/video master was created in the editing suite.

In addition to previously stated goals, this manifestation of *Configurable Space* included the following goals and research interests:

- Develop the concept of perception and communication on multiple planes by enhancing resources supporting transparency, translucency, reflectivity and opacity.
- Develop the sound and music concepts to clearly convey the impressions of the space on indirect levels of communication, and to clearly demonstrate the evolution of the composition and environment.
- Probe into the implications of spatial representation to convey both detail and structure in musical and extra-musical contexts.

Configurable Space VII: live, multi-person performance-presentation

Configurable Space VII was a hybrid performance-presentation sponsored by Yamaha Music Technologies in Marin, California, in May of 1990. The purpose was to demonstrate the underlying concepts of *Configurable Space* in a context permitting experimentation with multimedia communication resources. The event space, appropriately located in an office presentation space intended for corporate communication, was built around a large, white wall. Three slide projectors were positioned carefully with respect to image size, angle, and proximity, following the same design as in the earlier manifestations. A video projection system was used to incorporate the Banff video into the design and content for the performance. The multi-layered sound environment included original music, prerecorded music from different cultures and styles, and prepared soundfiles of sampled and processed sound, all placed in a variety of simulated room environments. Sound from each of two microphones was processed to create a different ambiance, reinforcing different styles of communication. I used one, the evocation of a large room with a distant dreamy character, for story-telling and indirect communication and the other, which evoked a smaller, less-reverberant environment, for declamatory and direct communication techniques.

The work consisted of two movements. Each movement was weighted differently with respect to direct, linear presentation techniques, and indirect, non-linear modes of communication. Each movement consisted of a different balance between specific, timed accompaniment, quasi-random selection from sets of elements, and extemporaneous selection from a wide variety of sonic and visual material.

Score directions utilizing a 3-dimensional score notation were provided for live presentation assistants to perform the visual and aural components. During the event, I wrote and drew over the surface of the wall, selecting multicolored marking pens of different thicknesses, with attention towards the functional use of color, shapes and multi-dimensional containers. Writing and drawing on the wall reinforced main points, summarized internal sections within the presentation, followed tangential thoughts, and drew links between graphic and textual material written and projected. The performer of the visual component controlled slide carousel position and light intensity for three slide projectors, and also controlled the video projector. The performer of the audio component incorporated twenty channels of sound, including pre-recorded tapes and CDs, live performed sounds from the computer, live-processing of sound, two microphones, and an antique Victrola. Performers responded to what was seen, heard, and felt. Images changed and modulated in light intensities, blending, highlighting, and contrasting with the drawing on the wall.

Configurable Space VII was directed towards advancing the following goals and research interests:

- Experiment with aspects of presentation and performance that were predefined and non-changeable in previous manifestations, and work with of live configuration of materials.
- Examine technological resources which would be required to support the live event in a more interactive, multimedia environment
- Examine expressive power and effect of live drawing onto the white board while images were projected and changing.
- Expand the live commentary/presentation aspects to make use of audio support for different types of message passing.

Configurable Space VIII: customized performance presentation

In May of 1992 I presented *Configurable Space* to an audience of artists at the Exploratorium in San Francisco, California. The title of the work prepared for this event is *Configuring Hospitable Space,* created for an evening entitled *Fantasy and Fantastic Media.* In the Exploratorium presentation I constructed a twenty-minute scripted walk-through of the *Configurable Space* concepts, their origin in early childhood experiences, and the impact on my artistic development. This included descriptions about specific *Configurable Space* manifestations, a sequence of single slides, and a customized sound track offering poetic impressions of actual room perspectives. The two-microphone model used in *Configurable Space VII* was used in this circumstance. As the text moved between dreamy story telling and declamatory descriptive speech, the sound processing shifted between simulating a dreamy, distant character and a dry presentation room character, respectively. Subtle sonic punctuation on the sound track accompanied the text, articulating the grammatical and conceptual structure.

<u>Observations</u>

Total Environment -- Total Self

Configurable Space provides resources for the individual to control the entire range of local and global activity according to natural tendencies and work habits. Concentration on predominantly intellectual functions, linear thinking and task orientation, ignoring other sensibilities, non-linear perception and indirect communication imprints a seriously restricted focus on our activities, and consequently imposes limitations on the ultimate functionality of the resources. Developing the environment as a totality significantly enhances the level of creativity, and assists in maintaining a strong connection with all elements of human existence.

Displays and Surfaces

Large displays, touch-sensitive surfaces, and effective use of projected images offer considerable benefit in the environment. The single monitor screen, even including multiple window capabilities and many of the effective *Configurable Space* resources, does not provide the depth of perception or the freedom of movement required to simulate a truly all-encompassing environment. There is a significant difference between physical or virtual surfaces, and a fundamental connection between the selection and use of input and output devices and the internal processes used for assimilation, development and communication. The principles that govern the nature of an application originate in human perceptual orientation, and it is most effective to construct an environment around a freely moving human, rather than attempt to build the human into a fixed and restrictive physical machine.

Transparency -- Translucency -- Reflectivity -- Opacity

The visual and audio layering capabilities of immersive technology assist memory and perception on multiple cognitive planes, creating an environment that projects aspects of the inner self onto the physical world surrounding the participant. *Configurable Space* visual resources suggest thorough and comprehensive transparent, translucent, reflective and opaque functionality, along with their sonic counterparts. These capabilities are important components in creating the multidimensional effect, and in maintaining a close connection with work as one maneuvers in a spherical environment. Touch sensitive control of the coarseness or subtlety of the mix of multiple simultaneous planes of activity, color-coding and shading of layers as a means of connection and separation, and the ability to view the entire environment from any position in the space are all factors that combine to create the sense of integration between the self and the manifestation.

Sound in the Environment

The use of sound is a critical aspect in the creation of the environment, contributing significantly to the fusing of the senses into a comprehensive, comprehensible totality, and to maintaining continuity. The use of location and sound object cues to aid in context orientation, the use of ambient characterization to identify qualities within an environment, and the configurable nature of the sound resources all contribute to the creation of a comprehensive sonic world that emulates the human cognitive and perceptual mechanism. As a resource that can provide analogs to visual concepts, it can offer unique perspectives for understanding. As a resource that becomes the primary mode of communication, sound has the expressive power to reach human sensibilities in a way that is not possible in the visual domain.

Historical Perspective

The reconstructible nature of history, and the configurability of its presentation offer a means of getting in touch with many aspects of work, even after leaving it for long periods of time. The historical perspective that a configurable, multi-track and multi-layered audit trail can provide, especially with configurable analysis and display resources, facilitates in assimilating and understanding long term projects, and in maneuvering among sets of activities on several planes. Whether the use of the historical resources is in preparing chronological sequences of room views, random sequential presentation of environments, or simultaneous imposition of multiple perspectives from different times and projects, the history and presentation mechanism is an integral component in connecting the *Configurable Space* resources with the total self.

Communication

Using the resources for communication to self and others, applying both direct and indirect modes of communication, promotes an evolution in our interactive potential. Direct, linear communication during *Configurable Space VII and VIII* was extremely effective with the enhanced visual and aural reinforcement. Indirect modes of communication were powerful in expressing the character of the environment, providing an effective complement to the more traditional, direct techniques. The extended presentation resources facilitated dynamic and natural response to the audience, with the balance among communication modes shifting according to the specific context and orientation of the audience. The process presents a challenge to the audience to employ additional effort and concentration in processing the multimedia event as a complex formal presentation while assimilating it as a viewer of an art work.

Multidimensional notation systems

In developing the notation system for representing complex musical characteristics, it became apparent that the enhanced functionality experienced in expressing sonic behavior on multiple planes had significant implications when extended to other activities. As an integral component of the environmental design resources, multidimensional representation provides concrete visual distinction while retaining a conceptual and even time-based connection with activity on individual planes. In multimedia perception, assimilation and communication of concepts and related simultaneous threads of activity, representation on multiple planes significantly widens the bandwidth of information by providing an organization of complex data in a manner that is quickly assimilated.

Multiple person environment design

Configurable Space VII provided an important opportunity to explore the factors that a human observer/participant derives from a situation, and from familiarity with the concepts and the material presented. This helped to hypothesize about what would be required by a computer-based environmental presentation assistant. The combination of scripted or scored activity with simultaneous extemporaneous elements necessitates a collection of resources that spans a vast range from direct score-following to creative adaptation. The selection of individual sound and image components, and the careful shaping of the overall environmental character requires a sensitivity to specific content, general principles and even stylistic convention. Flexibility in real time reconfiguration of resources and content improves the ability to respond effectively to new circumstances or specific purposes, whether the situation involves artistic creation or presentation, communication, education or collaboration. The concept of an intelligent, conceptually and contextually-sensitive presentation assistant provides an intriguing model for adding additional depth to the multimedia, multi-functional, multi-person environmental design paradigm. Each participant has the opportunity to communicate using the resources which most effectively combine their natural inclinations and the current context.

Realistic Implementation

An evaluation of the *Configurable Space* project, and of long term development hypotheses in general, should examine not only the ideal state, but also should explore the model with respect to potential avenues leading towards realistic implementation of part or all of the paradigm. This evaluation process helps to assess the extent to which we need to develop a totally new technology, and the extent that current resources could be used or extended to realize the goals of this kind of environment. The knowledge and understanding resulting from this evaluation process further facilitates the development of an effective plan for implementation.

Several current projects exhibit components that can be synthesized into the integrated environment suggested in *Configurable Space*. There are active projects at Xerox PARC exploring applications of large, interactive display devices[6]; configurable, touch-sensitive surfaces; and environmental control. Don Buchla has developed a collection of touch and space sensitive control devices that could be applied to environmental control[7]. Fred Lerdahl[8] and Stephen Pope[9] have examined approaches to music architectural design and composition that have direct application to project management and environmental orientation. Other research in such areas as machine control and synchronization, learning machines, intelligent agents and probes, connectionism and neural networks, multi-functional and multi-layered linking, history tracking, multi-channel spatial sound control, and collaborative environments[10] all point to the potential of a comprehensive and integrated immersive environment. *Configurable Space* offers a perspective on how these resources are synthesized into a comprehensive creative environment.

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[1]The retrospective as it appears here is an abbreviated version of a paper being published in a forthcoming issue of the journal *Contemporary Music Review*, published by Harwood Academic Publishers.

[2]C. Harris, "Artistic Necessity, Context Orientation, Configurable Space", in Paynter, Howell, Orton and Seymour, ed., *Companion to Contemporary Musical Thought* (London, UK: Routledge 1992).

[3]C. Harris, "Found Sound - Found Structure Summary", *Proceedings of the 1991 International Computer Music Conference* (San Francisco, CA: International Computer Music Association, 1991).

[4]C. Harris, "Room Views", *Leonardo Music Journal Anthology of Music for the 21st Century*, Volume 1 (San Francisco, CA: Leonardo, the International Society for the Arts, Sciences and Technology, 1991).

[5]C. Harris, "Somewhere Between", *Électro Clips: 25 Électroacoustic Snapshots* (Montreal, Québec, Canada: Diffusion i MéDIA, 1990).

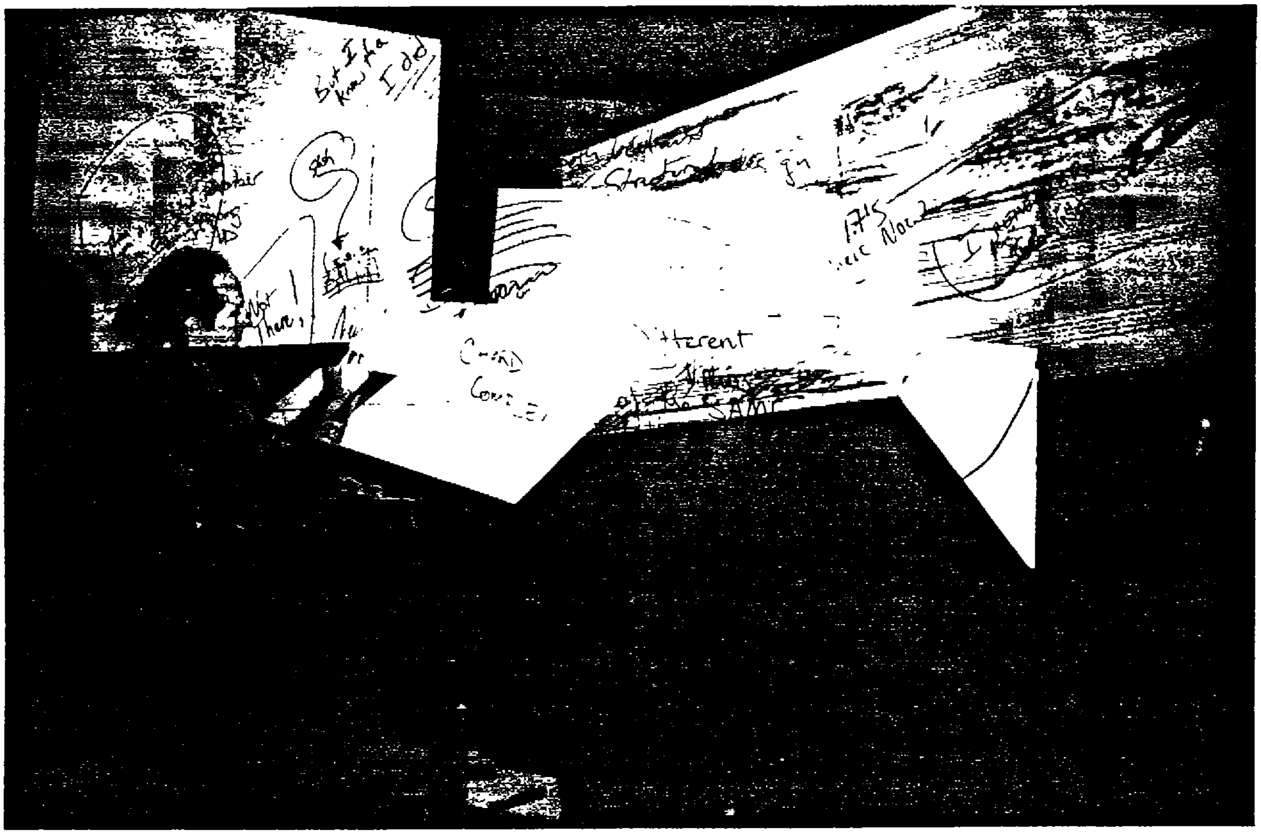
[6]S. Elrod et al, "Liveboard: A Large Interactive Display Supporting Group Meetings, Presentations and Remote Collaboration", *Proceedings of the Human Factors in Computing Systems CHI '92 Conference* (New York, NY: ACM Press, 1992).

[7]Buchla's *Thunder* device is a programmable, touch-sensitive MIDI controller; *Lightning* is a programmable, motion-sensitive MIDI wand.

[8]F. Lerdahl and X. Chabot, "A Theory of Poetry as Music and Its Exploration through a Computer Aid to Composition", *Proceedings of the 1991 International Computer Music Conference* (San Francisco, CA: International Computer Music Association, 1991); see also F. Lerdahl and Y. Potard, A Computer Aid to Composition (Paris, France: Rapport de l'IRCAM, 1982).

[9]S. T. Pope, "Producing Kombination XI: Using Modern Hardware and Software Systems for Composition", *Leonardo Music Journal*, Volume 2 (San Francisco, CA: Leonardo, the International Society for the Arts, Sciences and Technology, 1992).

[10]C. Codella et al, "Interactive Simulation in a Multi-Person Virtual World", *Proceedings of the Human Factors in Computing Systems CHI '92 Conference* (New York, NY: ACM Press, 1992).



Craig Harris, *Configurable SpaceVII*, performance–presentation, San Francisco, CA, 1990. The artist writes and draws on the surface of a large white wall as part of this work, which explores creative activities and communication by simulating future environments utilizing multimedia resources including sound, text and projected images. (Photo: Marion Gray)

Deterministic Chaos, Iterative Models, Dynamical Systems and Their Application in Algorithmic Composition

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1 Introduction

There has been growing interest in and an increasingly wide application of dynamical mathematical models in the domain of electronic music composition and synthesis. Iterative models and mathematical chaos algorithms provide for fertile creative ground among composers and researchers. Iterated functions systems, discrete time maps, and chaotic nonlinear systems and their applications in composition and synthesis have been discussed recently by a number of composers [Pressing, 1988], [Truax, 1990], [Di Scipio, 1990], [Gogins, 1991], [Xenakis, 1991], [Degazio, 1993] demonstrating the continuing fascination that these models hold in a wide variety of musical applications.

2 Dynamical Systems and Attractors

Briefly described, a dynamical system is a model for the motion of matter in a field of force. Dynamical systems can take various mathematical forms such as differential equations and iterated functions: nonlinear feedback loops where the output of the function is fed back into itself as new input at each iteration. These iterated functions are above all time dependent since their evolution depends quite sensitively on their earlier state. The solutions of iterated functions trace orbits in phase space and it is the study of these orbits that comprises much of the research in dynamical chaos. They are of great interest to the composer since music afterall unfolds in time and it is possible to "map" these orbits in a variety of ways in the musical output.

A fascinating interplay of order and surprise results from simple mathematical iterative models [May, 1976]. The systems which are of particular interest for this discussion are dissipative in nature, having internal friction and by necessity an attractor. It is useful to speak of "basins of attraction" in a dynamical dissipative system [Grebogi et al, 1987]. By example, this can be simply expressed as a discrete time map: $x_{n+1}=f(x_n)$ where x is a vector in phase space and the function f is some interesting function with finite constraints imposed by some external force. The basin is defined as the set of initial conditions that cause trajectories which converge towards the attractor.

Attractors can take any number of geometrical forms that characterize the long term behavior of the system. The attractor may be a point (steady states independent of time), a set of points or limit cycle (periodic trajectories in time), or quasi-periodic regimes consisting of superimposed oscillations that differ in amplitude and period. There is another category of attractors which consists of non-periodic regimes which appear disordered or chaotic. When these regimes are *deterministic*, that is, expressible as coupled differential equations and repeatable given the same initial variables yet highly sensitive to those initial conditions, their trajectories in phase space converge onto so-called strange attractors [Hénon, Pomeau, 1975]. Strange attractors are often complicated geometrical forms, depending on the dimension, which result from the trajectories of the iterated function stretching, diverging and folding between limits without ever visiting the same point twice. The strange attractor fills a fraction of its space with points, giving it a fractal dimension. Fractals are naturally produced by chaos; strange attractors exhibit self similarity on multiple scales [Hofstadter, 1985].

An apparent contradiction emerges from the two key concepts connected to strange attractors: attraction implies convergence of trajectories while sensitivity to initial conditions implies divergence of trajectories. What is important in this fact is that imperceptibly different initial conditions at the outset of a dynamical system lead to exponential differences later on in its evolution, a key component of Edward Lorenz's well known paper in which he presents a three dimensional mathematical model describing deterministic nonperiodic flow in thermal convection rolls [Lorenz, 1963]. His work calls into question the possibility of long range prediction of weather patterns. The Lorenz model exhibits strange attractors.

3 MAX and MIDIPascal

In this study, dynamical algorithms are employed as a means of generating musical material in a MIDI based electronic music studio consisting of different synthesizers, samplers, and a Macintosh computer workstation. Initially, a two dimensional dynamical model has been implemented in MIDIPascal expressing a nonlinear force acting upon an orbiting particle [King-Smith, Herman, 1988]. See Figure 1.

Figure 1: two dimensional nonlinear model implemented in MIDIPascal

```
program  Attractors;
  uses
    MidiPascalDefs, MidiUtilDefs;
  const
    n = 127;
  var
    a, c, x, y, vx, vy, ax, ay: real;
    modx, mody, skip, result: integer;
  procedure Wait (i: integer);
    var
      count: integer;
  begin
    for count := 1 to i do
      begin
      end;
  end;  {procedure   Wait**************}
begin
  ShowDrawing;
  MidiUtilInit(1000, 1000);   {buffer size}
  x := 15;   {15}
  y := -0.3;
  vy := 0.0025;
  vx := -0.5;
  a :=  2.68;{2.68 (chaotic regime)}
  c := 158;  {10, mass 33 (chaotic regime)}
  moveto(150 + 5 * trunc(x), 150 + 5 * trunc(y));
  framerect(140, 140, 160, 160);
  repeat
    if ((x - a) * (x - a) + y * y) <= 1 then
      begin
        ax := 1 / (a - x);
        ay := -1 / y;
      end
    else
      begin
        ax := a - x;
        ay := -y;
      end;
    if ((x + a) * (x + a) + y * y) <= 1 then
      begin
        ax := ax + 1 / (-a - x);
        ay := ay - 1 / y;
      end
    else
      begin
        ax := ax - x - a;
        ay := ay - y;
      end;
    vx := vx + ax / c;
    vy := vy + ay / c;
    x := x + vx;
    y := y + vy;
    lineto(150 + trunc(5 * x), 150 + trunc(5 * y));
    modx := (abs(trunc(x) * 100) mod n);
    mody := (abs(trunc(y) * 100) mod n);
    result := MEvtOut(144, modx, 100, 0);  {NoteOn 144-159}
    result := MEvtOut(144, mody, 100, 0);
{MEvtOut (statusbyte: INTEGER; data1: integer; data2: integer; timestamp: LONGINT);}
    Wait(6300); {procedure for variable pauses}
    result := MEvtOut(128, modx, 100, 0); {NoteOff 128-143}
    result := MEvtOut(128, mody, 100, 0);
  until button;
  QuitMidi;
end.
```

In the model, vx and vy are the horizontal and vertical control velocities of the particle while ax and ay are accelerative forces acting on the particle along the horizontal and vertical axes. The variables x and y represent the present location of the particle. As can be seen, x and y are modified recursively in the model. Furthermore, the variable c, or particle mass, markedly affects the evolution of the system. The model is mapped or folded into MIDI pitch space with a modulus routine. The model's behavior over time is characterized by the emergence of a heterophony in which certain kinds of intervals and chords are "favored" by the system, due in part, no doubt, to the constraints of MIDI and the particular mapping of this model, but owing in greater part, I believe, to the nature of dynamical processes. This has been born out through ample experimentations with the values of variables and output mappings in the model. A consistent feature is the emergence of stable, sometimes quasi-tonal harmonic areas and energetic rapid-fire pulse trains.

This two dimensional model sends visual output to the drawing window as the MIDI events are heard so that a correspondence might be drawn between the visual and auditory domains with regard to the emergence of stable or unstable attractors. Figure 2 shows several such orbit trajectories generated by the model.

Figure 2: orbit trajectories of a two dimensional nonlinear model in MIDIPascal

Among other algorithms that have been used are the simple iterative model:

$$x_{n+1}=f(x_n);$$

the 2 dimensional model:

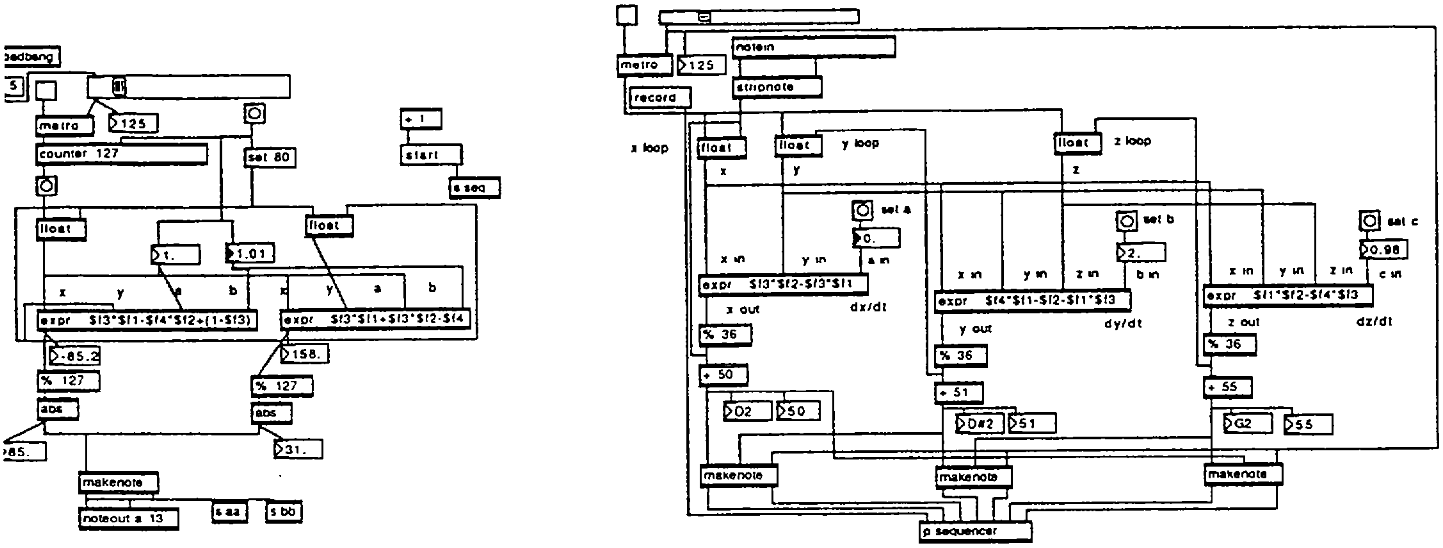
$$x_{n+1}=ax_n-by_n+(1-a);\; y_{n+1}=bx_n+ay_n-b;$$

and the 3 dimensional Lorenz model:

$$dx/_{dt}=ay-ax;\; dy/_{dt}=-xz+bx-y;\; dz/_{dt}=xy-cz.$$

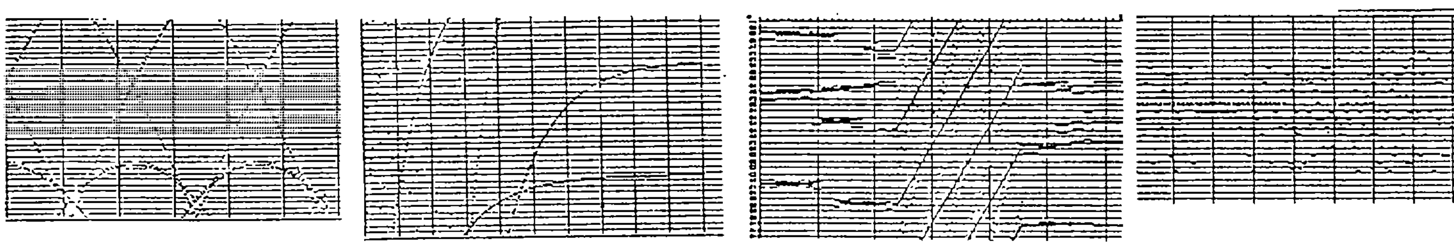
These algorithms have been realized in MAX, [Puckette, 1988, 1991]. With MAX, simple recursive functions and higher dimensional dynamical models are mapped onto pitch, velocity, timbre, dynamics, and duration on synthesizers and samplers and interacted with on the fly. "Expr" objects comprise the engines of the models as shown in Figure 3. As can be seen, octave mapping routines are realized with "mod" and "abs" objects. While all of the pitch material is generated by the computer, decisions of texture, register, and proportion are made by ear. In these models, the musical equivalent of a phase space is established in which there are continually evolving curves and orbits which tend to stabilize around periodic cycles or fly off into more chaotic or unstable regimes.

Figure 3: MAX patches for two and three dimensional iterative models



These models are simple yet they yield quite varied and elaborate results when the slightest changes are made in the initial variables. To show this, the models can be mapped onto two dimensional pitch/time event plots in MIDI sequencer "piano roll" windows. Hence, certain geometrical patterns associated with the musical output became immediately apparent which exhibit stretching, folding, divergence and attraction. In Figure 4, musical flows are shown for the models in Figure 3.

Figure 4: pitch/time event plots for musical flows in two and three dimensional iterative models



4 The Computer and The Creative Process

While the preceding implementations of the models and their pitch mappings are simple, the compositional issues they highlight are not trivial. As a composer who uses these algorithms for pieces written for traditional acoustic instruments played by human performers, the mapping into pitch spaces and their connective flow in time is of crucial interest. The successful use of the models depends in large part upon the composer's ear. Though the specific output of the dynamical models change quite sensitively according to initial variables, the models exhibit consistent meta-behavior, including absence of large scale closure, emphasis on process, and a highly charged periodic rhythmic surface with deeper levels of slower harmonic rhythmic. While these characteristics point to the wonder and force that these models hold, they also highlight those areas where the composer best incorporates artistic judgement based upon more linear thinking. The willingness to circumvent algorithm as the ear suggests is all important in the rendering of them: an approach decidedly non-purist since the algorithms are approached as procedures which suggest potential paths, not prescribed paths.

The use of the computer in the realization of these mappings is analogous to improvising at a musical instrument since MAX allows for real time interaction with the model as it outputs streams of MIDI data. What is different is that what is created with the computer calls into question traditional notions of invention, musical identity, and inspiration. For example, when working with dynamical models such as the logistic map or the Lorenz attractor, I have had the sense that what I was hearing was an object "out there", occupying a preexistent Platonic realm which is impossible to quantify or locate (nor is that so important), but which resonates "in here", at the composer's center, but quite apart from that which is merely personal and subjective. There is more a sense of discovery than of creation in the traditional sense of that word. What I hear is not the result of my projecting my own musical personality into the musical landscape, it is rather more like taking the first steps of a journey into a musical landscape that I could not have imagined before. That landscape seems to me to exist both in time and out of time: I am a visitor to a terrain that yields secrets as I walk through it in time, yet its forms seem to me to have been there all along and will be there again in the future given their deterministic nature. Also contributing to this sense of "otherness" about which I am speaking is that dynamical systems often produce musical output whose richness of design far exceeds what is put into it at the outset. Very simple iterative functions yield trajectories characterized by increasingly complex, self-referential patterns. For example, the subharmonic cascades created by bifurcation, the universal principle behind transition phases towards more turbulent states via period doubling, are viable as source material. Strange attractors yield musical flows that fire the imagination and are applicable across scales in both macro and micro elements of musical design. With MAX, one may experiment live with musical processes set in motion by the algorithm, thereby affecting the evolution of a piece. So the journey through the dynamically modeled musical landscape (rather than the landscape itself) alters according to ones interaction with it.

In my work, the initial decision to restrict the musical output to a largely monochromatic palette of timbres is intentional in order not to detract from the geometry of the system, which in my mind has been of primary interest. However, music is not geometry, and it is clear that timbre and synthesis is an area where the application of chaos algorithms warrants deeper exploration and in fact one in which there has been comprehensive research already [eg. Truax, 1990; Lippe, 1993]. In the case of the models presented here in MAX in a MIDI-based system, there have been some interesting results obtained through the mapping of the models onto the control of operator and envelope output levels, wave sequences, and microtuning by using the "sxformat" object. Since "sxformat" can take output of "expr" objects as arguments for system exclusive data bytes, synth modules and samplers can be made to dynamically interact with the models to create a richly varied palette of timbres.

5 Conclusion

Throughout these preliminary encounters with dynamical models and mathematical chaos, I have found myself thinking about a conversational exchange between the composers John Cage and Earle Brown in 1961 [Cage, 1961]. Cage and Brown were discussing the statement by Coomaraswamy that the function of the artist is to imitate nature in its manner of operation. This led Cage to the opinion that science and art are intertwined. As science expands its understanding of how nature operates, artists are enriched and change as a result. The mathematical models which express dynamical chaos hold particular fascination and potential because they express profound truth about the manner in which the natural world operates around us and within us. Cage was able to embrace indeterminacy out of regard for the manner in which he understood nature to operate. Since then, much territory has been explored on the subject of chaos where indeterminate elements mix with deterministic ones. The principles embodied by these models speak across disciplines and composers have embraced them as a powerful new paradigm for musical design.

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A User's Guide to the Electronic Cliché

Delle Maxwell (Independent)
Annette Weintraub (The City College of New York)

Come on down! Embark on a search for new esthetic possibilities at the frontier of the digital revolution. Journey to the "Edge," the place where art, science, entertainment and industry meet. See the Zone ruled by net cowboys, outlaws, digital revolutionaries and data surfers. The new breed of cyber-artist is exploring how mere images can be transformed into art—unique art. All with the aid of radically new tools! Stake your claim in cyberspace and help capture the imagination of the Entire Planet!

> ***Net Surf!*** **Skateboard to Cyberspace!**
> **"Where Electronics and Art Converge. Entertainment enters a new dimension. And companies don't want to miss out." [1]**

If only myth and reality coincided. You may recognize this breathless hype as the cheerleader surrogate of the datasphere. It surrounds our interactions with electronic art, science and the computer industry. These verbal formulas have visual equivalents as well. It's now almost a cliché to state that electronic art is clichéd. Everyone agrees. What does this mean?

Digital art has a "perception problem." It promises much more than it delivers. Witness the science-fiction extrapolation about its boundless potential for "changing the way we think." Ads create false claims about new aesthetics which spring into existence in barely a nanosecond. Electronic tools, with their highly specific "effects," spawn their own sets of clichés. Not yet able to grasp a vision of the electronic datasphere, artists unknowingly map new images into old formats and old images into new formats. This peculiar combination of cutting-edge technology and familiar images leads to cliché. The close connections between art and industry complicate this mix. Installations inadvertently function as marketing demos of new techniques; scientific illustration passes for both art and science. Image is mistaken for art.

What are some clichés in the context of electronic art? Why is this such an hospitable breeding ground for cliché? Oddly, cliché is a term that has its origins in technology. Cliché and stereotype are words related to the creation of casts or blocks for the printing process. They later came to mean copies from an original matrix; cliché also became a description of the snapshot. By the mid-1800's cliché and stereotype had become synonymous with the formulaic, with uncritical judgment, or an oversimplified opinion or commonly agreed-upon response. With origins in mechanical reproduction, cliché is likely related to the speed of technological innovation, overexposure and obsolescence. Nowhere is that speed of change more apparent than in electronic art. Artists working in this area struggle to merge content, tools and formats as the ground beneath them shifts continually. When these components are mismatched, the results are problematic.

Here are some of our favorite formulaic representations, uncritical judgments, and over–simplified opinions in 2D art, animation, interactive art, virtual reality, and scientific imagery. The subject is vast. Instead of cataloging every offense, we've looked at some of the broad patterns, and defined the underlying issues.

CLICHÉS IN 2D ART

> **"Gogh Crazy!"**
> **Create "Dazzling Artisitic Effects" and "Feel a Creative Explosion!"**
> **"...takes a scanned bitmapped image and turns it into Art"**

Promising infinite malleability at the touch of a mouse, paint and image processing programs offer the seductive promise of speedy, efficient, clean creativity, with a nod toward the scientific and up-to-date. Artists are seduced by their toolsets, which promise total fluidity and control. With so many effects, what else could possibly be needed?

> **"Chalk and Charcoal, Chrome, Craqueline, Dark Strokes, Dry Brush, Emboss, Film Grain, Fresco, Graphic Pen, Mosaic, Poster Edges, Ripple, Smudge Stick, Spatter, and Watercolor"**
> **"The possibilities are infinite!"**

One type of 2D cliché involves conventional figurative imagery used without any awareness of contemporary modes of representation. This figuration is barely evolved beyond the parrots and tropical sunsets genre of hotel art. You get the Jeff Koons look without the irony. It swings between the polar opposites of blissful ignorance of contemporary figuration to slavish replication of various old masters modes. In this hierarchy Impressionism ranks high on the list of favorite styles. This genre wears the latest fashions in toolsets, but its iconographic development stopped before modernism.

> **"...Refines the Art of Design" ...instant Rembrandt**
> **"Impressionism. It's Fast, Fun and Easy!"**

It's now possible to replicate most traditional painting and photographic effects with a variety of simulated paper or canvas textures. Instead of emerging as a byproduct of the process of making the work, or of its concept, visual effects can be applied globally to give the work a particular appearance. One can even purchase libraries of surface appearances called "looks." Take a photo, apply the impasto filter and some chiaroscuro, and voilà! For an instant Old Master, take an original photograph by Joel Meyerowitz and do a Rembrandt makeover. (Why did Meyerowitz permit this use of his work?) While presented as almost-advertising art with a fine arts pedigree, this image is a demonstration piece of the 2D cliché. A familiar style is recycled as new, and is distinguished by its connection to technology and to two famous artists.

Why this tremendous emphasis on tools and effects? Richard Wright has observed that "The future of art is required to settle into the form of an unbroken stream of new expressive tools...Thus the aesthetics of tomorrow are constantly pre-empted by the latest technological commodities and brought forward into today." [1] The perpetual discussions among some electronic artists of what tools they use carry the assumption that the tools *do* determine the art. The possibilities for making art increase with every improvement to the tool set. Or do they? It's even become common to list hardware and software on exhibition labels, in the assumption that this information elucidates the work. Wrong. It might tell you how to copy the look of a particular image, but it reveals nothing about content, process, or the artist's intent. When you know how it's done, what's left?

Art is usually the outcome of a specific material process which results in a tangible object. Or, in the case of printed art, it is seen through the filter of mechanical reproduction. In contrast, electronic art can be liberated from this status as object and from materials themselves.[2] This liberation could lead to an expansion of the domain of art, or perversely, to its diminution. The traditional art world sees the computer as an enabler of imagistic promiscuity and mindless creation. The processing speed that is so essential to graphic designers working against deadline is perceived in a fine art context as leading to the facile and slick.

> **"Creating art with a computer can be like squeezing blood from a rock"**
> **"Turn any picture into a brilliant painting—automatically"**

Advertising hype suggests that the art-making process has been so simplified (or at least should be) that anyone can do it with the latest software plug-in. Armed with your scannner and filters, the world becomes your database, and you can appropriate ten times faster than any conventional artist! The ease-of-creation myth of electronic montage is already a well worn cliché. This claim is cynically reinforced in advertising as a way to sell software. In fine art, this myth feeds into other prejudices against collage. While it may be technically easy to assemble images using these tools, making a meaningful image is as difficult to achieve in this mode as it is in others.

Critics of electronic montage recapitulate past complaints against photography. Digital work is criticized for being technological and therefore not "artistic." It's too fast; too easy; too mechanical. You can even solarize, posterize, collage, composite, dissolve, fade and create vignettes without being trapped in the darkroom for hours. (Ironically, manipulation of photographs is as old as photography itself). And while 2D electronic art has been poorly received by critics, nothing comes in for more abuse than electronic collage. In a review of the *Montage 93* exhibitions, Viki Goldberg writes that, "In Rochester, collage is mercifully treated with restraint...most computer collagists have apparently come to the keyboard innocent of art history—they repeat every maneuver ever performed with that tool of a primitive technology, the scissors. With delirious ease, they patch in bits of digitized art on a computer..." [3] Obviously, compositing in the darkroom is preferable to using scissors, and electronic "scissors" are the worst of all.

Electronic or not, montage has always carried the burden of being "trick" photography. [4] Tricks are shortcuts; they provoke accusations of facility and have an aura of dishonesty. The forms of collage and montage have always been popular and pervasive, appearing as advertising art, "high art," crafts and folk art. Objections to collage, and electronic montage, hinge on its democratic nature (anyone can do it), and its (deceptive) ease and speed of creation. This new seamless and fluid form of collage raises interesting questions about the veracity of photographs and is responsible for a change in our essential relationship to the photograph as a record of reality. Photographs suffer other indignities as well. Ubiquitous in mass media they are now just so much raw material for montage. They are devoured and mutated by the omnivorous scanner, which speeds their devaluation as distinct images. So easily reprocessed, they are recycled to myriad uses with various levels of success.

Photography once borrowed the look of painting. Later film borrowed the techniques of photographic montage. Now computer image processing appropriates the vocabularies of both. Still based on photography's idioms, electronic montage still has some way to go to develop its own vernacular.

ANIMATION

Welcome to "worlds never before seen"

Advances in hardware and software have unleashed a progressive sophistication in effects, simulation, visualization and other forms of experimental computer animation. Early vector drawings progressed to checkerboards, transparent spheres gave way to even more complex shapes in increasingly accurate simulations of material and atmospheric conditions. Infinite zooms, particle animations, artificial evolution, human motion simulation, morphing and dizzying magic carpet rides through inner and outer space are a few techniques in the animation repertory. These amazing effects wash over the viewer with more visual pandemonium than an Andrew Lloyd Webber production. The emphasis is on constant motion and transformation, on visual and aural overload. Ironically, the more clever the effect, the shorter its lifespan. It's applied indiscriminately, and is then forever associated with its most clichéd uses. The effect is forgotten in favor of the latest new buzz. Do you remember morphing? Cars changed to sleek tigers, women to men, men into shaving-cream-covered cubes, frogs became princes.

See horny toads morph into rock stars...

Even the most marvelous special effect can be dulled by persistent overexposure. Wide-eyed awe turns into a fixed glassy stare as the point is hammered home. The vertiginous synthetic kinesis induced by computer-generated camera motion is truly amazing, but how many tunnels do we have to fly through to appreciate it? How many heads can be exploded into clouds of particles?

Experience tunnel vision
It was fun the first time in "Particle Dreams" but ... "Lawnmower Man?"

In early computer animation festivals, the cheers that greeted effects, demos, experiments, and flying logos gave way to yawns. Audiences and animators wanted more meaning and story. But again, there is a mismatch of innovative technology with overly familiar or predictable content that falls into the "old wine in new bottles" category of cliché in narrative animation. Anthropomorphism in the Disneyesque manner has now been nearly perfected, eliminating disturbing signs of "otherness" or unfamiliarity. Timeless, saccharine love stories are now enacted between adorable blobby entities. Boy gets girl. Boy doesn't get girl. Who really cares? To keep the audience awake, another more daring twist on this timeless theme combined with new effects has brought us the inevitable: the bouncing breast animation! While the breast motion is a truly strange mixture of realism and algorithmic regularity, the face has all the liveliness of a blowup sextoy.

Barbarella returns to SIGGRAPH '93 in "Sister of Pain"

The breast is not the only body part pressed into action. There's an amazing new category of phallic cartoon character. This little guy has learned to dance and stand up tall. Why is the breast simulation realistic, while a naturalistic, animated penis attached to its owner is not to be seen?

"Joram" a suggestively human-like character
"Mindblender" exploits another timeless theme

A stereotyped view of sexual politics is not limited to the casting of characters, but emerges in the narratives as well. In Peter Gabriel's "Mindblender," we have the fractured fairy tale of the ugly frog pursuing the beautiful girl in a chase scene with overtones of harassment if not rape. To complaints voiced after its showing at SIGGRAPH, the animator (a woman) replied irritably, "that it was not about rape, but about a blow job." What a defense of content!

"Lawnmower man" —the future of sex?

Far from liberating us from sex and gender roles, these images reinforce them. What then may we expect from teledildonics? Sex is still an attention getter. But substantive commentary on the consequences of the simulation of the body, and on sexuality and gender is slow in coming.

"Enertopia, "Starquest Adventure," and "Luxor Dream Sequence"—three from SIGGRAPH '93. Man's energy consciousness meets the Universal Life Force

Once the mysteries of sex have been cut down to size, the nature of life comes in for review. On a grander scale, appropriate to a tool with such infinite possibilities, are animations about the mysteries of the universe, replete with planets, starfields, new age music, and emerging life forms. The awakening cosmic consciousness is just background. The yearning for substance is laudable, but the symbols of mystery don't automatically supply meaning. Assembled as pastiche, they are just so much visual elevator music.

Critics of cinema are fond of disparaging special effects as an "unfortunate sideshow." [5] But most would agree that effects' sophistication far outranks the quality or innovation of the old-fashioned narratives with which they are paired. So what do we do? Tone down the effects and update the stories? Or demand vision and innovation from the more experimental forms of animation which explore the unfamiliar rather than visualizes the already-seen? Artificial life and evolution algorithms and visualization animations when explored without recourse to sentimental anthropomorphism may provide a glimpse into the future. New narratives may then emerge.

EMERGENT INTERACTIVE VIRTUAL TELEPRESENCE

"Is passive experience with outdated art forms no longer relevant to your work?"
WARNING: participation may not guarantee satisfaction!

If quiet contemplation doesn't work for you, then try participation and interaction to pep up tired art forms. Delle Maxwell worked on such a project at the Sky Art festival in the early 80s at MIT. "I was working with a group receiving slow-scan images of artists using with inflatables, kites, and other skyborne objects. Our instructions were to 'do something' with the images and send them back to other nodes. The idea of collaboration was exciting, the reality was something less than hoped. It was very hard to do 'anything' except play with the images given the short amount of time allowed. The result was mostly pictures that had words added, were altered with digital paint programs, or had the images processed in one way or another, but without much rhyme or reason. We heard later that some of the other artists were mad about their images being trivialized. Viewers at the event found it tedious too." Unless an interaction is structured as performance, spontaneous real-time exchanges are not by nature exciting to watch, and don't engage the viewer. Many network exchanges have all the drama of waiting for grass to grow!

Participatory work at its worst just puts the viewers through an assembly line. Each one is patiently waiting to have their short interactive experience, and maybe to get a snapshot or souvenir of the visit to take home. The Disney experience is cloaked in high technology for the upscale audience. This art typically congratulates itself for being more democratic. It includes everyone, and promotes involvement rather than passive "looking" or "simple" appreciation. But is it really democratic? Or is this involvement highly pre-programmed, structured and routinized with very limited autonomy for the participant? Who says smiling and waving is real participation?

With so much happening in cyberspace, some conclude that static images no longer have a role in contemporary art. Interactivity and participation is becoming an end in itself, a requirement for anyone claiming cutting edge status. Artists who buy into this belief system travel along an inevitable path from 2D to 3D to moving images to stereo images to virtual space, following the flavor of the month. But when lacking any other motive than avoidance of the passivity of static images, participatory and interactive pieces reveal a very narrow set of concerns.

"Wave to the camera," Hi, Mom!

Playing to the baser desires of the audience is a cliché of participatory art. But it works. In the quest to capture audience, nothing sells better than the self. Interactive projects often incorporate some aspect of tele-narcissism as an "attraction loop" or hook, to get them over to your hardware. See yourself on TV; Hi Mom! Is there much difference between this naked appeal to egocentricism and seeing yourself on a video camera outside the discount electronics store? Narcissism sells almost as well as sex. Some artists say, "The viewer is required to complete the work." This is a useful stance, for you can demand creativity on the part of the viewer of a work, rather than on the part of the artist. Viewers want to be in the work so artists turn the camera around on the them. It's the electronic art version of a talk show.

Installation design for interactive art is critical in getting and holding audience. Although a very new form, conventions have already developed their own predictable mystique and rules for display. Shoehorned into trade shows, or difficult spaces, designers have adopted interesting presentation strategies. Favored are Dark Rooms. They enhance the sense of mystery, and keep people from knowing How It Was Done for a little while longer. Satellites in an inky universe, the individual exhibits beckon us with their CRT's. The mysterious darkness isolates the exhibits, and emphasizes the weightlessness and spacelessness so appropriate to Cyberspace. Like a Las Vegas casino, there are no cues to the outside world, no sense of time passing. The darkness puts a spin on a cliché of mainstream contemporary art, the minimalist white room.

No talk on clichés is complete without mention of cyberspace and virtual reality. From military simulators to children's toys to imaginary venues for stereotyped sex, virtual reality and cyberspace have captured the imagination of the hypesters and the hyped. Verbal clichés of the "emergent interactive virtual telepresence" are regularly disseminated in *Mondo 2000*, with no affirmation too bold and no assertion too extravagant for publication. Coiner of cyber-neologisms par excellence, *Mondo* extends the anarchistic, anti-authoritarian, paranoid rants of cyberkitsch to discourse on a wide range of topics. Over-heated prose is pumped out to an audience of believers eager to surf the edges. In this future-crazed environment of bionic body parts, smart drugs, cyborgs, and cybersex, serious issues are sometimes lost in the trappings of techno-fashion.

Surfing the Edge requires a fine sense of timing. Only recently, Billy Idol adopted cyberpunk to update his image. Too late, he missed the wave! Cyberpunk has already been declared dead by a number of Authorities. Even *The New York Times* noted that "cyberpunk has some critical and political content, and a viewpoint about social and technological change, but is being reduced to the borg look—a fashion statement." After cyberpunk, cybersex, cyborgasm, cyberculture, and cyber-kitsch comes cyber-burnout. Death by ubiquity, almost as bad as fractals. A cyber-joke.

> **"VR makes you appreciate the real world even more?" [2]**
> **"Computer realities gives you greater appreciation for the real things you walk around in." [3]**
> **"...It's a way to help us see what's around us all the time, again, anew." [4]**

Can the reality of virtual reality survive the hype? Instead of selling it as escapism (the common cliché about VR) one strategy is to promote it as helping you to appreciate the real world more. Think of it! Now we have a basis of comparison for reality!

> **"Experiential Advertising is one of the most innovative applications for virtual reality technology on the market today. For the first time consumers will be able to enter —and more importantly, interact—with a corporate marketing message. The possibilities are endless!" [5]**

When science invents new worlds, commerce is not far behind. And art can be used to bridge the gap. Besides creating a demand for the VR experience itself, simulation art can stimulate desires for the real things you can buy once you leave cyberspace.

SCIENCE AND ART

Do you believe that Chaos theory combined with the power of digital computers can explain everything from the movement of sub-atomic particles to the organization of human consciousness with pretty pictures as proof?

> **"Can the flap of a butterfly's wing stir up a tornado in Texas?" [6]**
> **"...a butterfly stirring the air today in Peking can transform storm systems next month in New York." [7]**
> **"A roulette ball in Las Vegas wouldn't spin exactly the way twice because another leaf falling in Yellowstone Park had disturbed the air differently than the one before." [8]**
> **"Just as a butterfly, lazily flapping its gossamer wings in faraway Japan, can inaugurate a tiny zephyr that will one day become a mighty typhoon, so evrey credit card holder in these United states, by splurging that bit extra at the store, can strike the keynote of a vast, soon-to-be, consumer-led recovery..." [9]**

Fractals and chaos images are cited as well-known examples of the merging of the visual, math–ematical, and the computational. They have been promoted as mathematical and aesthetic objects and as art for our time. Although these objects may resemble works of art, as aesthetic objects containing a wealth of meaning, they remain art primarily for a scientific subculture. These images are seen by some scientists as an "inner connection, a bridge, ...between rational scientific insight and emotional aesthetic appeal." [6] They fit the classical canons of beauty. "Our feeling for beauty is inspired by the harmonious arrangement of order and disorder as it occurs in natural objects—in clouds trees, mountain ranges or snow crystals." [7] The relation of disorder to order in natural phenomena is complemented by the relation of Chaos Theory to Fractal Geometry. The authors of "Chaos and Fractals, New Frontiers of Science" explain: "When we examine the dev–elopment of a process over a period of time, we speak in terms used in chaos theory. When we are more interested in the structural forms which a chaotic process leaves in its wake, then we use the terminology of fractal geometry, which is really the geometry whose structures are what give order to chaos." [8] The icon of chaos and fractals is the Mandelbrot set, which "...can be interpreted as an illustrated encyclopedia of an infinite number of algorithms. It is a fantastically efficiently organized storehouse of images, and as such it the example par excellence of order in chaos."[9]

The ability to model natural forms such as coastlines or snowflakes with mathematical models seems a "union of opposites." The balance between order and chaos, process and structure, image and algorithm, the endlessly recursive micro and macro reversal of scale, and the combination of the bounded with the infinite, contribute to this nearly-perfect multilevel symmetry. Fractals even have their sonic counterpart in music—the images can be "played." The time-and-spacelessness suggested by their existence within the computer, suggests a transcendental, out-of-body quality which also contributes to their mystique.

This notion of beauty and symmetries, intertwined with science and nature, is a reassuring and old fashioned ideal of Art. Why are these qualities out of sync with mainstream art? Contemporary art as well, tries to reveal the world as it really is, and is not always concerned with beauty. Nor is it very reassuring. In addition, the symmetry that is so satisfying to a scientist or mathematician does not always translate well into art. George Bernard Shaw was reputed to have said, "...symmetry is the enemy of art..." This same symmetry can also be read as a maddening sameness—infinity as tedium—and as a desire to impose too much order and conceptual closure.

The idealization of Beauty and Nature also led to the progressive transformation and romanticization of the fractal images themselves. At first, some of the abstract images were given sentimental titles, evocative of landscape—"Islands" or "Dark Canyon." The next logical step was to merge scientific realism with visual realism. The abstract model of nature was forced to assume the appearance of nature, of clouds, trees, and mountain ranges, adding another level of recursiveness and symmetry. This new landscape takes the form of 19th century romanticism.

Caspar David Friedrich visitis a Fractal Landscape

We see a Caspar David Friedrich, but without the lone figure enveloped in the mist, gazing towards the horizon. Does the lone figure gazing upon Beauty now reside on the outside of the computer screen? In such romantic and sentimental imagery, there is a pairing of today's mathematics with yesterday's art history. Ironically, these images lose the original purity achieved by the elegant integration of algorithm and visual result.

"Put Some Chaos in Your Life!"
"Fractals Everywhere"

The same surfeit of meaning and connectivity that inspired these romantic visual experiments no doubt contributed to the popular appropriation of chaos as an explanation of natural and social phenomena. [10]. Some insist on a resemblance between fractal patterns and those induced by hallucinogens. [11] This, along with the mandala-like centered images and mystical associations evoke the 1960's. The presence of Timothy Leary as celebrity spokesmodel and the re-emergence of Peter Max in digital art would seem to complete the revival.

With such universal appeal, it's not surprising that fractals appeared everywhere—on mouse pads, T-shirts, videotapes, and computer screens. It is hard to find anyone who hasn't seen them. It is even harder to find someone who admits to still being crazy about them—it's almost like saying that one still likes Pachelbel's Canon. Again the ubiquity of the idea and image serves to deaden its impact. It becomes just another pattern-generating formula. The strange hybrids produced by misunderstandings between art and science and mathematics show that cliché can be produced with the most modern means and ideas.

"Cellmates or Soulmates?"

Science and art share other peculiar territories as well. In visualizing synthetic organisms, scientists have, perhaps not inadvertently, appropriated the visual languages of science fiction and Surrealism. If chaos and fractals open our eyes to a dry airless world, then artificial evolution plunges us into a realm of wet and wild biomorphic fantasies. Where fractals and chaos strive towards a type of pure beauty, science fiction hallucinations of biological surrealism depict the grotesque.

Unbounded by mathematical theory, this experimental discipline combines biological ideas with a kind of "automatic programming" with the computer as "medium." These images share some of the characteristics of fractals and chaos such as symmetry, and a mandala-like centering on the screen. But add the third dimension. With multiple light sources, busy surface patterning, and a penchant for disembodied eyeballs and muscular tentacles, the viewer is thrust into the realm of out-of-control metastatic organic blobs.

Surrealiism revisited: The Eyes Have It

Continuous metamorphosis through millions of iterations might produce some interesting forms. Artificial evolution may yet have an impact on art when it finds its own language, and doesn't rely on the anthropomorphic. But so far, The Creators seem to have an inordinate fondness for eyeballs and other artifacts of the Jungian unconscious. Yet unlike some of the subtle, evocative and dreamlike images of surrealism, these forms fail to make the leap from organic raw material to fully assimilated images. As undigested images, they wed the biological to the abstract in a literal patch. They succeed in the paradox of making the unseen and phantasmagoric seem extravagant and predictable at once. Eyeball to eyeball with another bowling ball-shaped scungilli, the iteration-weary artlover has to say, "If you've seen one...you've seen them all...."

IF CLICHÉ IS THE DISEASE, IS CONTENT THE CURE?

Table of "Content"

Some say the missing link is content. "Content" has been recognized by an art community which has only recently shaken off the constraints of formalism. Replacing formalism, minimalism and the other isms of the 60's, 70's and 80's, content is the holy grail of the 90's. Media critics have proclaimed its absence in electronic art. They say we've got it backwards: amazing new techniques arrive, then works are created to employ them. The means are matched to the meaning as afterthought. It's the content conundrum.

Some art is driven by the technology coming out of the marketplace rather than by aesthetics, personal vision, or meaning. The hard-sell glitz of the demo is absorbed into the work, and art becomes an extension of the marketing campaign. Is technological innovation the content? It can be, but is can just as easily be the handwaving that conceals the absence of content. Artists are squeezed from both sides. What the mainstream art world sees as a superficial novelty, the computer community dismisses as passé. The effects of the moment widely recirculate—this year's pet rock. When it's noticed that there is something lacking, discussions about content begin. Can't the content just be poured in, since the technological form has already been built?

"It's the content, stupid. It's not the dazzling technique." [10]
But beware "The False God of Content" [11]

While everyone laments the dearth of content, in some venues, too much content is a bad thing. Chris Crawford [12], a well known designer of interactive games spells out the dangers of content overload. "The worship of content can lead to shovelware—hastily created titles with only a thin veneer of interactivity." An obsession with content can lead to "highly polished productions that are impoverished due to a lack of interactivity." From that perspective, interactivity is demoted to the role of "an electronic page flipper." Crawford call this the expository delusion: the designers don't permit the user to engage in dialogue with the multimedia installation. The user experiences a lecture, not a conversation.

And watch out: "Information is the ammunition. Your mind is the target."

The wrong amount of content can create other problems as well; one difficulty is information overload, or as Richard Saul Wurman calls it, "information anxiety." [13] Design (and art) are supposed to help us filter information so that information has context, and meaning can be integrated and assimilated. That filtering process is the true domain of the artist, who gives shape to information, idea and emotion. When that integrative role is sidestepped, the coherence of intent, meaning, context and means is broken. Cliché is a byproduct of that rupture.

The relationship of content to image serves this integrative function. It is the bridge that connects us with the broader realm of art history, aesthetics and ideas; the motivation to develop a body of work which expresses a strong personal vision; and the substance that engages in critical dialogue with other works of art. When art reflects intent, the tools are given purpose and meaning.

CAN CRITICISM POINT THE WAY?

The mechanism for responding to art doesn't change just because the tools do. It's up to the viewer to look and compare. Listen to your visceral response. Make an emotional connection. Think. Even a wildly negative response is telling you something. Comparisons can be instructive. Let's look at some examples of success and failure.

"Another Day in Paradise" was an installation by Victoria Vesna seen in the *Machine Culture* show at SIGGRAPH '93. In this piece three large preserved palm trees provided a natural focus of attraction. For viewers who took a closer look, the attraction stopped there. One monitor played a continuous video loop showing the story of a Vietnamese PhD. student at UC Irvine. A second palm held a video monitor which reflected the viewer's image, captured by a surveillance camera. The third monitor (also embedded in a tree) was interactive and played a videotape with footage of daily life in Vietnam. With the impact of a point-of-purchase display in a mall, the palms dwarfed the monitors. Reduced to afterthought, the monitors offered passive viewing, and the chance to "see yourself on TV," with little affect. We later found there were a number of themes scattered through the artist's catalogue summary, but they were invisible in the work. This "idea salad" tossed together disconnected thought fragments that didn't add up: real estate, ecology, shopping malls and the 20-year anniversary of the Vietnam War. This piece demonstrates the dangers of elevated presentation values serving up a pastiche of "current concerns."

An intimate video installation, that makes its points with subtlety, is "Family Portrait," by Luc Courchesne (also seen at SIGGRAPH). An extended meditation on the subject of portrait character, and human interaction, it enables the viewer to "converse" with a group of virtual friends. Not just a bunch of talking heads on TV, the virtual beings are disembodied projections, which magically float in front of us. The forced proximity of the installation, with the portraits positioned facing each other on the four sides of a square, created a room-like environment which further enhanced familiarity. Courchesne has advanced an old and traditional form by extending the possible interactions a viewer can have with a portrait. One of the most surprising things about this installation is the power of the emotional connection with images. Drawn into conversation, one wants to spend time. Why do these virtual beings seem so real? A conversation can halt abruptly, and you wonder what it was you said. This installation, simple in its presentation, initiates an authentic interaction.

Man in Polyester Suit meets Man in his Birthday Suit.

What makes a work powerful? An extreme contrast of opposites is evident when one looks at Robert Mapplethorpe's photograph, *Man in Polyester Suit*, 1980 next to (Art)^n group's "hommage" titled *Mapplethorpe/The Nineties* exhibited at SIGGRAPH '90. The Mapplethorpe photographs are fully resonant with tension. As Germano Celant has said, "There is always a dialectic in these images between provocation and aesthetic harmony. Consciously and unconsciously, Mapplethorpe tries to bridge the gap between opposites—order and disorder, dissent and assent, anarchy and the ideal."[14] $(Art)^n$'s barrier-strip autostereograms, while purporing to engage the same content, are lifeless. Hardly sensual, in this image the technology is distancing. The supposedly daring content might easily be exchanged for any other: a bowl of fruit or a late-model automobile. While the Mapplethorpe image engaged the subject of race as well as sex, the blue color of the stereo image avoids such charged meanings. Its icy surface has the warmth of a medical model or cadaver. Inadvertently, this work speaks of a new weightlessness and disconnectedness from the body without impact or resonance. It wouldn't warrant a visit from the NEA.

If electronic art is to find its place in the mainstream, then this divergence in art and what's admired and accepted by electronic artists must be addressed. Criticism can assist. It's been said that we don't yet have the vocabulary to evaluate electronic art. But considering the amount of newly-minted electronic jargon, adding to the grammar of electronic art may not be the answer. Any evaluation of electronic art needs to recognize the pervasiveness of technology without assuming that it is intrinsically wonderful or suspect. It should not be a shopping list of VRAM, bits, 16.7 million colors or powerful hardware. Critics can raise the level of discourse by going beyond discussions of whether the evidence of pixels in an image is appropriate or whether virtual reality should be immersive or not. Reviews which catalogue tools or provide only technical or methodological description contribute to the propagation of the digital cliché. After all, the work should stand when the technical description is stripped away.

CONCLUSION

"But is it Art? Is it Good Art?

No one likes the perception that cliché and formula have become the signature of electronic art. This already well-established perception has stigmatized an entire field; the same few genres of clichéd imagery are pointed out repeatedly, and much electronic art that does work is ignored. Because some computer clichés are so visible, it becomes easy to dismiss most electronic art without examination. This blanket indictment of technological art leaves the thoughtful electronic artist in an ambivalent and defensive position. The problems are obvious, but the solutions are slow to emerge.

It is clear that some electronic art is marked by cliché. This generally occurs when artists use the new tools to reprise familiar forms. Or when a small set of visual effects is indiscriminately applied without consideration of content or process. Or because advertising hype makes impossible claims and overemphasizes special effects. Or when the art/science union is forced to create mystical meaning. Each category of electronic art has unfortunately developed its own set of formulas, as artists try desperately to keep pace with technology. Should this invalidate these emerging forms?

It does help to look at these clichés and not dismiss them without examination. This review of clichés is not meant to merely enumerate them, nor to focus on failure. Clichés are inadvertently revealing. As a subtext, they signal the difficulties artists have in merging form and content with the new tools. When faced with rapidly evolving modes, it's all too easy to fall back on familiar formulations. Faced with too many choices and too much change, it's tempting to take the unbearable "infinite possibilities" and cut them down to size. But rather than limiting our vision, we need to expand it.

Arthur Danto, in his December, 1992 Artforum review of "The Hydrogen Jukebox: Selected Writings of Peter Schjeldahl," insists on the highest expectation for works of art. He says, "It is my sense that those who have not had the meanings of their lives put into question by works of art have not participated in the critical transaction that alone justifies the existence and experience of art. Nothing else—not pleasure, information, political truth, quality, or visual excitement—is a substitute if the whole point and meaning of works of art is that they should move the souls of those who are present to them."

Clichés may reveal inadvertent truth, but they are by definition limiting. If electronic art is to develop its own forms we need to recognize them and move on. If we have high expectations for electronic art, then movement beyond the conventional and routine is essential. Ironically, the reliance on formula, technical determinism, or the acceptance of aesthetic novelty actually allows us to avoid our own cry to "change the way we think." Computer clichés are the refuge of the reactionary to the dizzying speed of change. Take comfort in them at your own risk.

[1] Wright, Richard, "Soft Future," *Visual Proceedings, SIGGRAPH 93* (August 1993), p. 173.
[2] Warren, Charles, "Seize the Apparatus," *Tema Celeste* (Spring 1993), p. 45.
[3] Goldberg, Vicki, "A Brave New World of Electronic Art and Images," Photography View, *The New York Times,* Sunday August 25, 1993.
[4] Sharf, Aaron, *Art and Photography, (*New York: Penguin Books), 1974, p. 109.
[5] Bukatman himself is not one of those critics. He believes that special effects hold an important place in the development of the language of cinema, and is merely making about about current critical thought.
Bukatman, Scott, *Terminal Identity*, (Durham: Duke University Press), 1993, p. 13.
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Cellular Automata Music Composition: a bio-logical inspiration

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composer, electronic music expert, artificial intelligence and music researcher

1. Introduction and motivation

Music has always been an interesting domain for the application of new scientific discoveries inviting composers to combine artistic creativity with scientific methods. "Today it is becoming increasingly common for the composer to turn to the sciences to supplement his or her compositional model" [9]. On the other hand scientists also seem to show interest in the organisational principles found in music (see [9] for a discussion).

We are particularly interested in promoting such interdisciplinary activities. Our motivation is twofold. On the one hand it is believed that scientific models carry an important component of human thought, namely formal abstraction, which can be very inspiring for music composition. On the other hand we would like to raise certain questions like: "What can be the justification for using science as a compositional tool?", or "Which aspects of science are applicable to music and how it can be done?". Obviously there are no simple answers for these and indeed we do not intend to provide any here. We believe though that each artist should be able to make her or his own judgements. As far as these questions are concerned, the work introduced in this paper is to be regarded only as a contribution for empirical experimentation.

Our research work [11][12][13][14] attempts to identify correlation among different disciplines such as biology, crystallography, and computing, in order to investigate the possibility of composing music inspired by a framework of interdisciplinary knowledge.

We have selected a class of mathematical models known as *cellular automata* (CA) to play the central role in this research due to the fact that they have been used to model a wide range of scientific phenomena. During the past three decades scientists have been investigating and developing CA [21]. Although very simple they can provide models for a wide variety of complex phenomena in physics (eg. dynamic and chaotic systems), biology (eg. genetics), and chemistry (eg. chemical reactions and crystal growth) [23].

This paper introduces an experimental system for cellular automata music composition (CAMUS, for Cellular Automata MUSic). It begins with a brief introduction to cellular automata basics and shows how we attempted to map their behaviour into musical aspects. Then it defines the underlying concepts of the system and introduces its functioning, illustrating its operation and musical aspects through an example composition. The paper ends with conclusion and further work.

Other systems have been designed in order to investigate the use of CA in music ([10][7][1][8] to cite a few). Unfortunately it is not the scope of this document to review them. However we recommend the study of these alternative approaches.

Before we begin, we would like to remind the reader that this is a speculative work. That is to say that we are aware that most of the assumptions made below in order to define what we called "cellular automata music" are pragmatic and subjective.

2. Introduction to cellular automata (CA)

CA are mathematical idealisations of systems in which space and time are discrete and quantities take on a finite set of discrete values. A cellular automaton consists of a regular array with a discrete variable at each site, referred to as a cell. The state of a cellular automaton is specified by the values of the variables at each cell. It evolves in synchrony with the tick of an imaginary clock according to an algorithm (i.e. a set of rules) which determines the value of a cell according to the value of its neighbourhood [22][21][4]. As implemented on a computer, the cells are rectangles in the screen whose states are represented by different colours.

CA were originally introduced in the sixties by von Neumann and Ulan [3] as a model of biological self-reproduction. They wanted to know if it were possible for a machine to reproduce, that is, to automatically construct a copy of itself. Their model consisted of a two dimensional grid of cells, each of which is in one of a number of states (which represented the components out of which they built the self reproducing machine). Controlled completely by the algorithm designed by its creators, the machine (i.e. a pattern of cells in the grid) would extend an arm into a virgin portion of the universe (the grid), then slowly scan it back and forth, creating a copy of itself.

Since then CA have been reintroduced over and over again and applied to a considerable variety of purposes. Various interesting algorithms were developed along these 30 years. From many different types of CA algorithms in existence nowadays, two were selected for use in this system: *Game of Life* (GL) designed by John Horton Conway (a University of Cambridge mathematician), and *Demon Cyclic Space* (DCS) designed by David Griffeath (of the University of Wisconsin at Madison) [21][4].

2.1. The *Game of Life* cellular automaton (GL)

GL is a finite two-dimensional lattice of squared cells whose states (0 or 1) are influenced by the states of neighbouring cells. Time is also discrete and from one tick of a virtual clock to the next, each cell is either *alive* (1) or *dead* (0) depending on the following algorithm:

i. if a cell is *dead* at time **t**, it comes *alive* at time **t+1** if, and only if, exactly **3** of its neighbours (i.e. fewer than **4** AND more than *2*) are *alive* at time **t**;

ii. if a cell is *alive* at time **t**, it comes *dead* at time **t+1** if, and only if, fewer than **2** OR more than **3** neighbours are *alive* at time **t**.

With this rule acting everywhere on GL's lattice, an initial configuration of live cells may either grow interminably, fall into cyclic patterns, or eventually die off.

CAMUS's implementation enables the user to design its own rules other than Conway's original rule, as we shall see later in our example composition (see §6.2.)

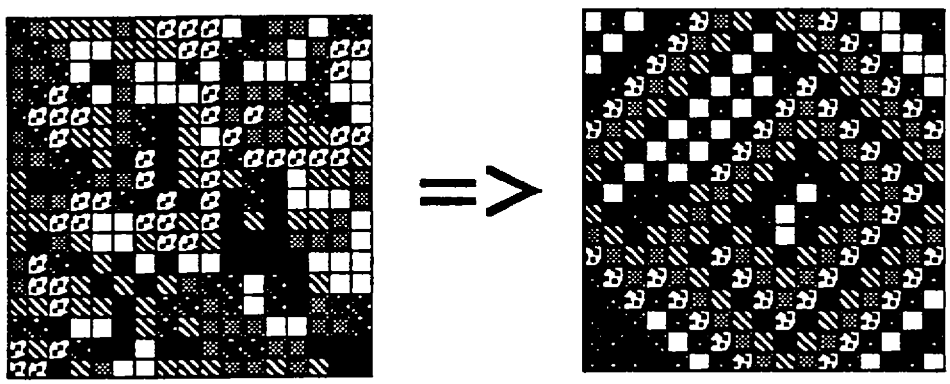
2.2. The Demon Cyclic Space cellular automaton (DCS)

The DCS algorithm designed by D. Griffeath generates a miniature universe of incredible complexity. Initialised as a random distribution of coloured cells, it always end up with stable, angular spirals reminiscent of strange crystalline growths (Fig. 1).

In order to produce this striking phenomenon of scientific interest and beauty DCS relies on a very simple algorithm. There can be any number **n** of states, each represented by a different colour, which are numbered from **0** to **n-1**. A cell that happens to be in state **k** at one tick of the clock must dominate, by the next tick, any adjacent cells that are in state **k-1**. Domination here means a change of state of the adjacent cell from **k-1** to **k**. This algorithm resembles a natural chain: a cell in state **2** can dominate a cell in state **1** even if the latter is dominating a cell in state **0**. But as it is a cyclic space the chain has no end, i.e. a cell in state **0** dominates neighbouring cells that are in state **n-1**.

Both, GL and DCS, cannot be infinitely extensible. Therefore they ought to be modelled as a squared lattice drawn onto a torus (see [11] or [13] for more details).

Fig. 1: Initialised to a random state the DCS cellular automaton always ends up with stable, angular spirals reminiscent of crystalline growths.



3. CAMUS fundamentals

Since CA produce large amounts of patterned data and music composition can be thought of as based on pattern propagation and formal manipulation of its parameters, it is not a surprise that music researchers started to suspect that CA could be translated (mapped) into a music representation in order to generate compositional material. In the following paragraphs we explain how CAMUS does this mapping.

3.1. Geometric representation of triads

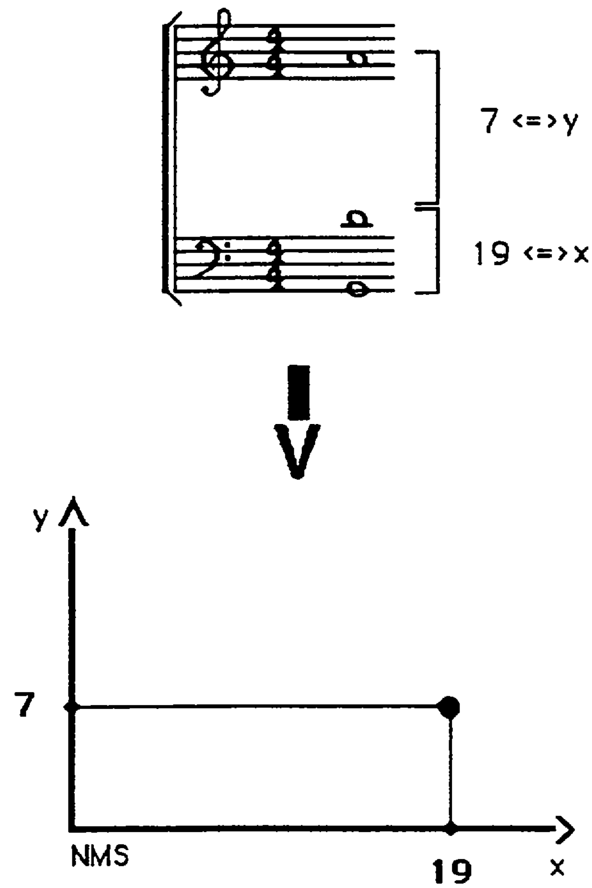
Consider a set of triads, where the term "triad" refers to a sub-set of three elements out of a tune-system set. The tune-system set may be regarded as a discrete framework around which the musical events take place. Its elements (pitches) can be identified as being on a lattice. The tune-system adopted to carry out the study in this paper is the 12 tone equal-tempered system. However other tune-systems may also be used (§7).

The set of all triads having the same interval series is regarded as a transpositionally equivalent class of triads. Any triad in a transpositionally equivalent class may be transformed into another by an operation known as "ordered transposition" (concept borrowed from Allen Forte [6]). This concept is very important for CAMUS because it suggests a geometrical model in two dimensions for representing triads. Each dimension of this model corresponds to a specific order position in the interval series, and is quantified to represent the full range of intervals that could span a pair of pitches in this system (Fig. 2). We named this model for music representation as *von Neumann Music Space* (NMS) in memory of John von Neumann. See [11] or [13] for the mathematical specification of it.

3.2. Mapping CA into a NMS

A Cartesian co-ordinate of a CA cell can be viewed as an address to a point into a NMS.

Fig. 2: The NMS horizontal co-ordinate represents the first triad's interval whereas the vertical co-ordinate represents its second interval.



Consider the following example [3][11][13]:

i. the finite automaton

(SG, sg(0), f)

where

SG = a set of control signals,
sg(0) = the ground state, and

f = local transition function;

ii. the set of control signals

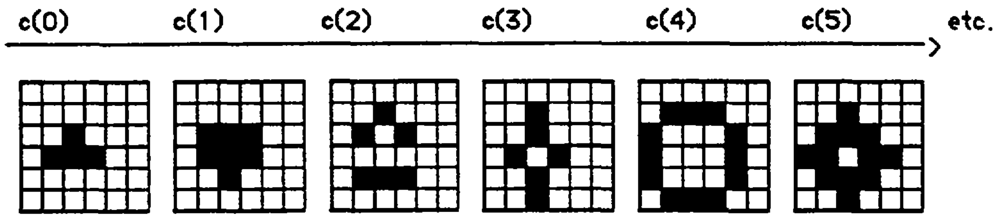
SG = {sg(0), sg(1)}

such that

sg(**0**) = **0**, and
sg(**1**) = **1**.

The above example represents a finite automaton which can assume two states: either a quiescent (0) or a non-quiescent (1) state. A configuration **c: X x Y -> SG** defines a set of cells where the elements are Cartesian co-ordinates of a two-dimensional interval space corresponding to non-quiescent state cells of **c**. A global transition function **F**, also called a *transition rule*, drives the propagation **c(0)**, **c(1)**, **c(2)**, ..., **c(t)**. Each configuration **c** corresponds to a set of triads (Fig. 3).

Fig. 3: Propagation of patterns arising from an initial configuration **c(0)**.



In musical terms, we would say that the propagation of a configuration **c** under a certain global transition function **F** corresponds to the macro-formal organisation of the musical discourse. The micro-formal organisation in turn is defined by the internal organisation of each cell and between cells at a certain time **t**. These concepts were inspired by Xenakis' *book of screens* used as a graphical representation of sonic events in a slice of time [24].

3.3. The musical engine

CAMUS performs two different finite automata simultaneously mapped into a NMS. One is the GL cellular automaton which can assume two states: 0 (dead) or 1 (alive). It is responsible for the aforementioned micro-formal organisation of the composition. Given the fundamental pitches, GL works out a set of triads for each time step **t**. The other is the DCS cellular automaton which can assume **n** states (**n** is specified by the user). DCS is responsible for the orchestration of the composition, i.e. each state corresponds to an instrument designated to perform a cell. These two automata work in parallel (Fig. 4).

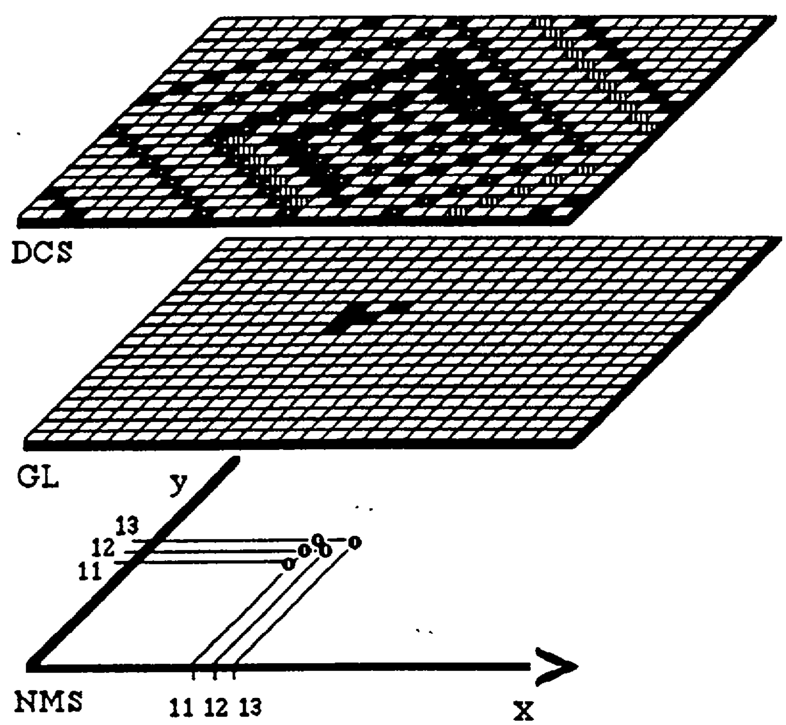
4. Cellular genetic code and temporal reasoning

Each musical cell has its own timing but the pitches within a cell can assume different durations and be triggered at different times. We say that pitches within a cell form a certain abstract shape according to a predefined CAMUS codification which is explained below.

4.1. The cellulAr geNetic coDe (AND)

Inspired by the DNA molecule in the cell's nucleus, whose symbols, drawn from an alphabet of four different chemical bases (Adenine, Guanine, Cytosine, and Thiamine), form strands coiled up into a helix, the "genetic" information of a musical cell is formed by a string (in the form **Tgg -> Dur**) whose symbols have temporal meaning. Like the nucleotide pair, the AND string (also referred to as "cellular typology" in [11] and [13]) has two components: **Tgg** (trigger component) and **Dur** (duration component). Each of these components has a certain *temporal code* which can be one out of 10 possibilities (Fig. 5).

Fig. 4: The musical engine of CAMUS consists of two different finite automata, namely GL and DCS, simultaneously mapped into a NMS.



As an example, consider the following AND: **[dna] -> a[dn]** (Fig. 6). To understand how AND has temporal meaning, imagine the above example in a time domain representation (Fig. 7). The first AND string's component, **Tgg**, stands for the trigger values, and the second, **Dur**, stands for the duration values.

Fig. 5: There are 10 different temporal codes. The combination of two forms the cellular genetic code.

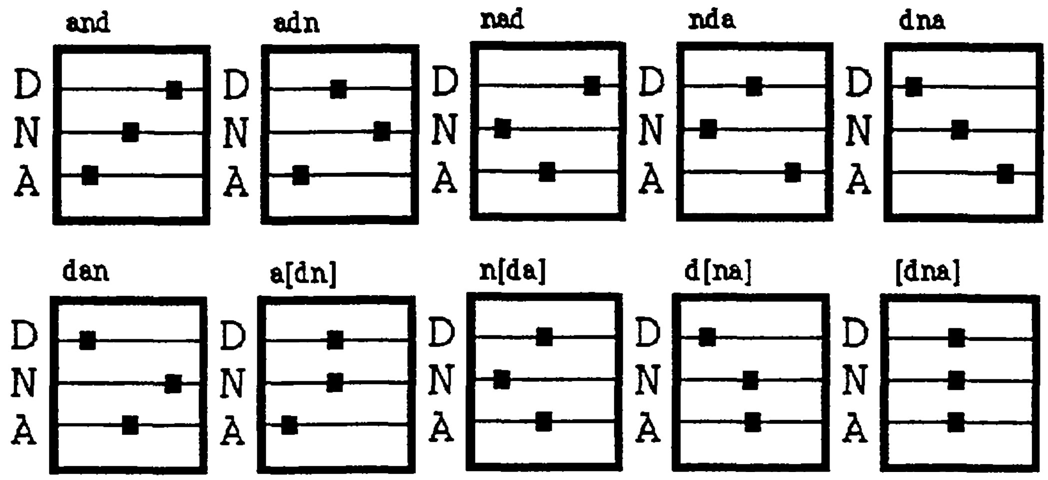


Fig. 6: Example typology [dna] -> a[dn].

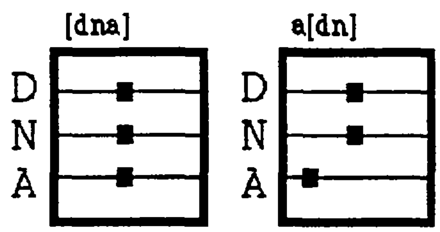
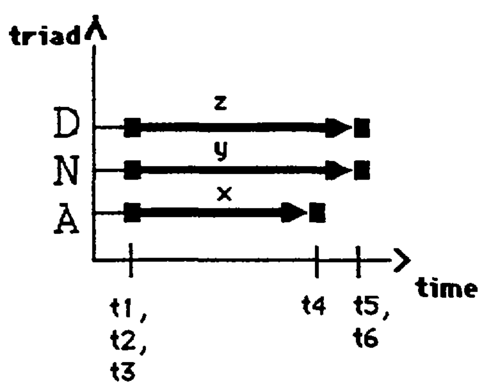


Fig. 7: Time domain representation of [dna] -> a[dn], where Tgg={t1, t2, t3} and Dur={t4, t5, t6}.



4.2. Finding out the AND

AND is deduced by the GL cellular automaton. Considering that each cell to be performed corresponds to a GL's non-quiescent cell mapped to a NMS we now propose a mechanism to find out the AND string.

Assume a 4-digit binary codification as follows:

and => 0101
adn => 0010
nad => 0111
nda => 1011
dna => 0011
dan => 0110
a[dn] => 0000
n[da] => 1111
d[na] => 1001
[dna] => 0001

Then the **Tgg** and **Dur** components are defined by:

Tgg ::= abcd | dcba
Dur ::= mnop | ponm

where **a, b, c, d, m, n, o, p** $\in$ **{ 0, 1 }.**

A cell's AND is specified by the neighbouring cells (Fig. 8). Considering the geometrical relation below, the string is calculated as follows:

a = (m, n-1)
b = (m, n+1)
c = (m+1, n)
d = (m-1, n)
m = (m-1, n-1)
n = (m+1, n+1)
o = (m+1, n-1)
p = (m-1, n+1)

Note that the AND in fact represents the abstraction of a shape. The actual numerical values for each individual pitch's trigger (t1, t2, and t3 in Fig. 7) and duration (x, y and z in Fig. 7) are calculated when the cell is being performed. CAMUS calculates these values based on a distribution formula [5] selected by the user.

Sometimes, by chance, there will be cases where one or more pitch durations may overlap the duration of a cell (Fig. 9).

Fig. 8: The neighbouring cells and their geometrical relationship.

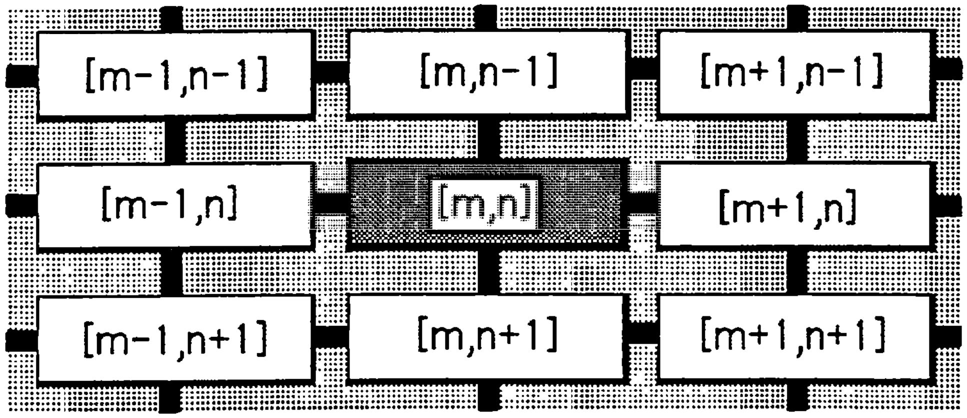
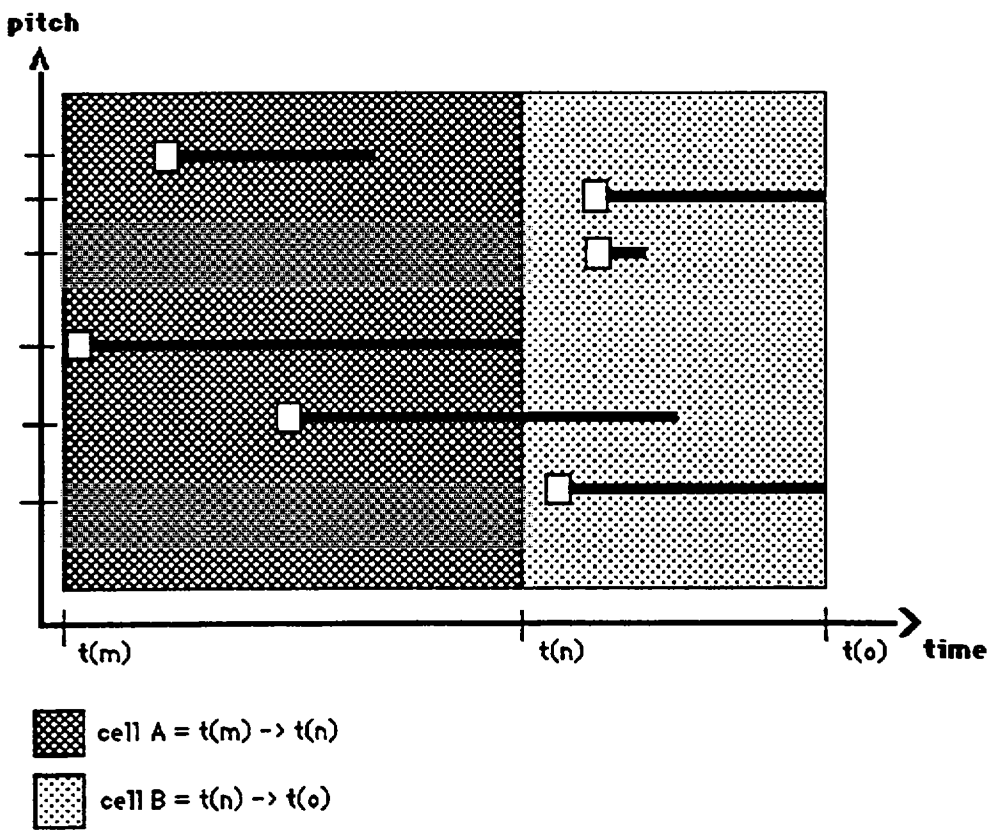


Fig. 9: Sometimes one or more pitch durations may overlap the duration of a cell.



5. The implementation

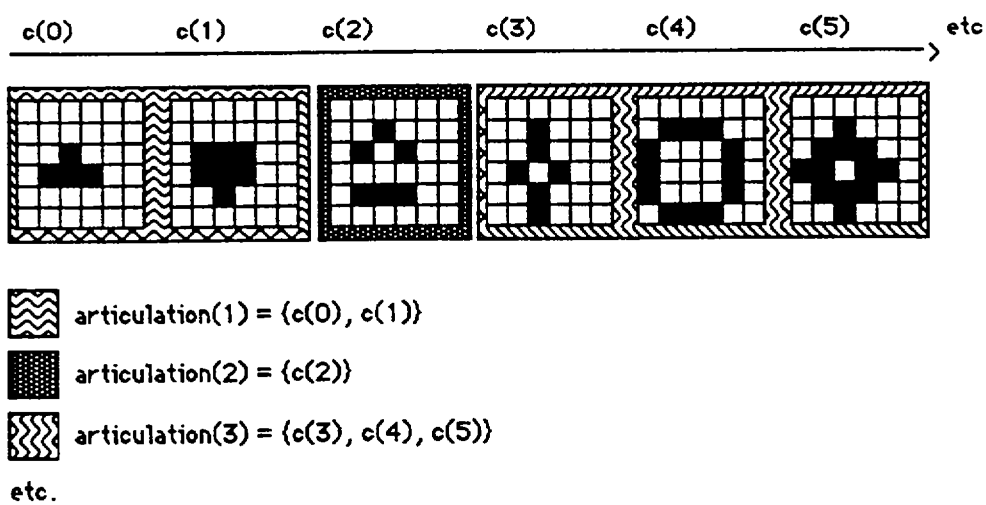
The current implementation (CAMUS V1.0) generates MIDI (Boom, 87) output from the evolution of the musical engine mentioned above.

The GL is responsible for the pitch selection. Each cell corresponds to a triad where the first pitch comes from a predefined sequence of MIDI pitch numbers defined by the user and the remaining two are determined by the corresponding cell's NMS co-ordinates (each co-ordinate corresponds to an interval from the previous pitch). The GL is also responsible for the AND deduction as we have explained before. The default GL algorithm is the one originally designed by Conway (see §2.1.). However other variants may be tried (§6.2.). The user is asked to "draw" the initial GL configuration.

The DCS, which is responsible for the orchestration, determines which MIDI channel will be used to output a cell. The orchestration value, i.e. the number of DCS states, is given by the user.

Different articulations may be specified to take place throughout a certain number of configurations **c(n)**. Articulation here means a group of configurations sharing certain common characteristics. As we mentioned before, each cell of a cellular automaton changes its state in synchrony with a tick of an imaginary clock. In turn, each tick (or step) forms a configuration of cells to be performed. After specifying the articulation loop in terms of number of steps (i.e. how many configurations will be performed within a loop), the user also specifies how many articulations will take place there (i.e. defines groups of steps). Each articulation in turn has to be specified with its own speed (i.e. how fast its elements will evolve), dynamics (i.e. how loud its objects should sound), and fundamental pitch sequence (i.e. sequence of pitches to be used as the basis of "triads") (Fig. 10). Note that bandwidth values are also specified for speed and dynamics. This is to say that actually CAMUS generates a value within these bandwidths for each cell by means of a chosen distribution formula (the same used to calculate the values of an AND, mentioned in §4.2.).

Fig. 10: Different articulations may be specified within a loop.



6. An example composition

In this section we present an example composition using CAMUS.

6.1. Musical thinking in CAMUS

CAMUS works on four dimensions of parametric control: *time* x *pitch* x *dynamics* x *orchestration*.

Time, pitch, and dynamics work according to the user defined setup for each articulation of the piece. The orchestration is defined by the number of DCS cellular automaton states (see §2.2 and §3.3.) where each state corresponds to a MIDI channel.

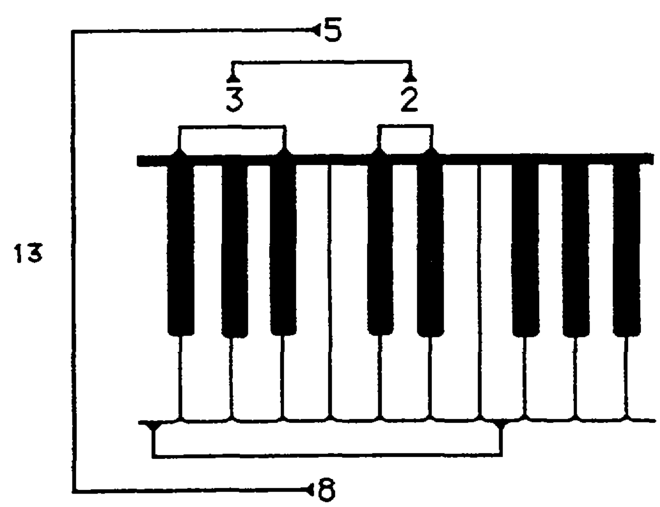
Musical form is also important here. "Form has to do with placing musical materials in time" [15]. It is possible to identify 2 levels of formal control in CAMUS. The lowest level has to do with micro-formal organisation and the highest level with macro-formal organisation. Micro-formal organisation is entirely controlled by the musical engine (explained in §3.3). However it depends on the macro-formal organisation specified by the user, that is the initial CAMUS setup, such as the GL's rules, the initial GL configuration (drawn by the user), the orchestration value, number of articulations, the distribution formula, and so forth.

6.2. *Quadratura Circuli*

Quadratura Circuli is a CAMUS aided composition for 3 instruments.

A numeric phenomenon suggested by the piano keyboard has inspired the author to figure out the parameters to initialise CAMUS. Fig. 11 illustrates a curious relationship between the piano keyboard layout and the early Fibonacci numbers: 2, 3, 5, 8, and 13. Notice that there are 13 keys within an octave: 8 white keys and 5 black keys. The black keys in turn are divided in two groups of 3 and 2 keys respectively.

Fig. 11: Relationship between the piano keyboard and the early Fibonacci numbers.

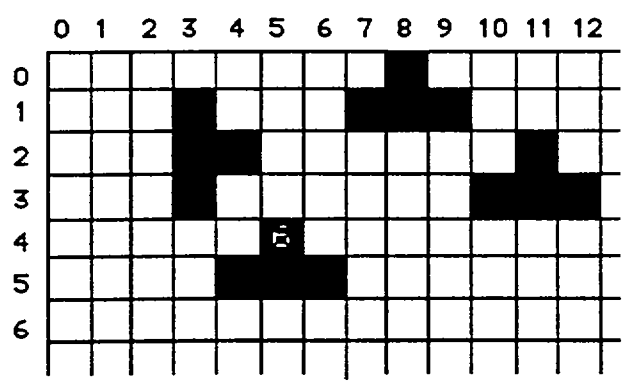


Bearing these numbers in mind CAMUS was set up for *Quadratura Circuli* as follows:

1. loop length = **5** configurations
2. no. of articulations = **2** (one of 2 configurations and other of 3 configurations)
3. life rule = fewer that **5** AND more than **2**
4. death rule = fewer than **2** OR more than **3**
5. orchestration = **3** (MIDI channels 0, 1, and 2)
6. distribution = uniform
7. articulation 1:
   - 7.1. start time = configuration **1** (i.e. c(0))
   - 7.2. end time = configuration **2** (i.e. c(1))
   - 7.3. speed = **8532**
   - 7.4. speed bandwidth = **1323**
   - 7.5. dynamics (MIDI key velocity) = **85**
   - 7.6. dynamics bandwidth = **32**
   - 7.7. fundamental pitches (MIDI numbers) = {**22, 32, 38, 52, 53, 23, 33, 28, 58, 55, 25, 35**}
8. articulation 2:
   - 8.1. start time = configuration **3**
   - 8.2. end time = configuration **5**
   - 8.3. speed = **8813**
   - 8.4. speed bandwidth = **882**
   - 8.5. dynamics (MIDI key velocity) = **82**
   - 8.6. dynamics bandwidth = **35**
   - 8.7. fundamental pitches (MIDI numbers) = {**53, 52, 55, 85, 82, 33, 32, 35, 25, 83, 23, 22**}

Fig. 12 illustrates the pattern given for the initial configuration **c(0)** of the GL cellular automaton algorithm.

Fig. 12: The initial GL configuration of *Quadratura Circuli*.



6.3. A micro-analysis of the generated score

Fig. 13 shows the 4th bar of the generated score which has the 6th and 7th triads (or cells) of the initial configuration in it. We will examine the 6th cell in detail.

Fig. 13: The fourth bar of *Quadratura Circuli.*

6th

CAMUS processes the cells of the lattice (Fig. 12) from top-down to left-to-right. Thus the 6th cell corresponds to the NMS co-ordinate (5,4). The fundamental pitch of this cell is B1, i.e. the 6th MIDI value of the sequence specified for articulation 1. Consequently the second pitch is E2 (i.e. five semitones above B1) and the third pitch is A2b (i.e. four semitones above E2:

fund(6) = **B1**, i.e. MIDI(23),
x(6) = **E2**, i.e. MIDI(28)<= 23+5,
y(6) = **A2b**, i.e. MIDI(32)<= 28+4.

The Tgg(6) and Dur(6) values (see §4.2.) are 0100 (**adn**) and 0101 (**and**) respectively. Therefore AND(6) = **adn** -> **and**. The **adn** code means that pitches are triggered in this order: **fund(6)**, **y(6)** , and **x(6)** (i.e. B1 -> A2b -> E2). The **and** code states that the duration of **fund(6)** is to be shorter than **x(6)**, which in turn is to be shorter than **y(6)** (i.e. B1 < E2 < A2b).

The DCS cell in the co-ordinate (5,4) is in a state which corresponds to the third instrument (i.e. MIDI channel 2).

Finally, the loudness of each of these pitches (not shown in the score of Fig. 13) oscillates between ***P*** and ***f*** (i.e. MIDI key velocity value between 177 (85+32) and 53 (85-32).

7. Conclusion and further work

This paper introduced an experimental system for music composition inspired by cellular automata. We did not intend to provide a general system nor a language for composition but an implementation of a speculative idea for empirical investigation.

Any systematisation of a technique for composition followed by its computer implementation leads to serious compositional limitations. No doubt CAMUS is limited to a narrow world of musical possibilities, yet despite its limited scope, it worked very well. The musical results sometimes are very interesting. Thus we regard it as a plausible starting point for further investigation.

The author has used CAMUS to compose both musical passages to be used in major works (eg. *The Turning of the Tide*, a live electronics piece reviewed in [18]) and pieces whose materials were entirely generated by the program (eg. *Entre l'absurde et le mystère*, for symphonic orchestra, premiered in Edinburgh in 1992). In the former the author explored other "tune-system sets" (§3.1.) than the 12 tone equal-tempered. In this case CAMUS' MIDI output was mapped to a micro tuned FM module synthesiser (the Yamaha's TX81Z). It also controlled a sampler with large scale sound events (several seconds of complex sounds). In the latter the author used the output score as a source material for a hand made orchestration where pitch classes and shapes provided by the AND were preserved.

At the moment we are expanding the scope of these ideas to sound synthesis. We are working on a version which attempts to implement a model of granular synthesis [16][17][20] by means of CA [14][12].

Acknowledgements

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Interactive Journeys: making room to move in the cultural territories of interactivity.
by Norie Neumark

What happens when a theorist /radio producer and a visual artist journey into the terrain of computer interactives? This is the story I want to tell in this paper, by beaming you up and morphing you over, by navigating you through some of these journeys with me. And, as we go, we'll map the ground for a criticism of computer imagery and techniques in both popular games and in those interactives which lie at the crossroads of art, science, and education practices and paradigms. Along the way we'll be venturing into the broader territory of tv and film computer graphics in order to excavate cultural meanings underlying the dominant aesthetics in these images and interactives and to ask what they do for their producers and users.

My interest in these cultural terrains lies at the intersection of a theoretical project on computer culture and a practical project of working with a visual artist on an informational computer interactive. My theoretical project concerns how computer aesthetics and techniques express and (re)produce subjectivity, in postmodern culture - how they texture the ways that technology operates as "fundamental constraint in the producion of subjectivity". (1) The transition to this culture, in the postmechnical, information age, is characterised by a sort of cultural crisis and accompanying identity crisis or crisis in "identity" and identities. This crisis is experienced and produced at the subjective level, through everyday aesthetic experiences, representational practices, and techniques and accompanying changes in perception and practices.(2) My political concern is in the ground this opens up for different versions and subversions of computer culture, particularly across a spectrum of gender, age, ethnic and racial diversity.

At the practical level I have been working with a visual artist, Maria Miranda, in the context of an educational institution, to produce an informational interactive particularly for teenage girls from non-English speaking and Aboriginal backgrounds. The production process and the interaction with our target audience raised a number of issues around how to interact differently with young people whose diverse aesthetics, pleasures, consciousness, and bodies have been colonized, metallized, normalized by a narrow repitition of dominant computer images and practices. It also brought up questions of how to work within the educational paradigms which focus not on the pleasure and subjectivity of the student but on the end product of knowledge/data to be accessed. Working with science and engineering faculties as we did also brought us face to face with other sorts of institutional practices and knowledge paradigms similarly inclined to bypass the senses and pleasures and plug the 'brain' directly into data bases or texts.

My own journeys in all this have been circular or perhaps spiralling from the political problems of how to open up as much aesthetic space as possible in our interactive project to the general theoretical concerns about computer aesthetics and subjectivity. In some ways, the same journeys with different travelling companions and different baggage.

To traverse the cultural terrain of popular and informational interactives in this paper, I have chosen the metaphor of <u>navigation</u>, to resonate with and interrogate its ubiquity in interactive lingo. Like the use of metaphors in interactive practice itself, this is a risky move, as Brenda Laurel signals. (3) The metaphor risks waylaying the journey, as it develops a trajectory of its own. So I'll try to locate it on firm home ground and minimize its, and my urge, to stray.

It may have to do with living in Australia for 20 years, but when I try to envisage the terrain of interactivity, to map the journeys across it, I picture it like a big island continent, surrounded by water, a country defined as much by time as by space.The journeys across this timescape and landscape of computer imagery can be mapped in many different ways — each map in turn can be read in a number of ways, from different locations and with different perceptions. You are then in a position to navigate variously depending on how you drive - on your drives ; depending on your body and techniques, on how you move. Location is of course a crucial question here materially as well as metaphorically, since it always constrains your reading style of the maps. As Celeste Olalquiaga has pointed out, what's normal style in one neighborhood can be provactive in another.(4) The 'style' of navigation in Olalquiaga's sense, is not of course a matter of arbitrary or pure 'choice'.The question is, as always, strategic and practical - how to find spaces and ways to move on terrains where possiblities are open but not endless, always located within certain economic and historical boundaries.

Each of these navigations, then, maps the journey differently producing a different 'reality' and subjectivity. My method in this paper will be to trace some of these navigations across this landscape of subjectivities, by taking you on series of journeys into the interface, beyond and back again. The paper is in three parts. I want to begin by taking you *into the interface* of popular cultural computer graphics - on t.v., film, and interactive games. This first terrain is where popular aesthetics and techniques are largely molded, where computer cultural subjectivty is significantly shaped. This will be the longest and most (apparently) varied set of journeys. In the second and briefer part, I want to navigate you along some of the paths constructed by scientiests and engineers and educators, located at data bases, built on functionality. Finally, briefer still, in the third part, I want to return you to what was my own starting point, with a revisit to the interface via the crossroads of popular culture, science/engineering, and education. To animate this intersection and enable a productive meeting rather than just passing along the way, we will take along the 'art factor'. I hope that this return will be not so much the end as another beginning, full of possiblities.

The first question, before setting out on your journeys into the interface of interactivity, will be what to wear. The wardrobe choices are neither infinite nor arbitrary and they must of course, more or less fit the constraints of your body - though there are always cosmetic surgical and body building techniques to alter your body to fit the outfit. But as you may know even with morphing your possibilities are formally constrained by compatibility of shape and size and of course the economic constraints of being able to buy the morph program.

Part One: Beam me up, morph me over - some journeys into the interface

These journeys are plotted through popular interactive domestic games and video arcades, films, advertisements, and t.v. computer graphics. Your first journey sees you wearing a rather popular outfit - it's the bright and shiny metallic look which is virtually de rigeur evening wear for the high end popular cultural interface. This look fits a number of different bodies and suits you up for certain generally costly navigational paths on the small screen of tv and the big screen at the cinema.

So,there you are at the interface, wearing your metal outfit, perhaps weighed down by clichee, perhaps smoothly ready for quick and strategic movement. As a landscape, the terrain of popular cultural computer imagery that you can survey and traverse in your metal outfit can be like a desert, not a very rich ground for new life to spring from. But like the desert, the Australian desert anyway, the metallic landscape can also be beautiful and alluring, more complex and rich in the flesh than in its arid metaphor.

Navigating timescapes in your metallic look, you may be reminded of another, past moment. You may experience today as what sci fi in the past told us today would look like. The metal look here risks being so overcoded as yesterday's future that it loses a fantasy edge. It 's as if computers are stuck in a timewarp where they have to look like what science fiction promised and where they are "destining their own future and past", according to Albert Liu. (5) He traces a consistent genealogy from the chrome of the 30s to Silver Surfer to high tech future of post-technological beings, following the tracks of the people who invented rendereing and computer imaging,people who came out of the whole aesthetic of science fiction, and comics.These graphics producers' own SF aesthetic got embedded in the "possilibties of the programs". (6). What holds computer aesthetics in this timewarp is not only the aesthetics of their producers, shaped for both women and men in some measure by a certain male aesthetic, but also of course capitalism. The old tried and true is what is likely to sell (they imagine) and there is the economically irrational refusal to see how much of a market they lose by their limitations. For, although to some extent capitalism has fallen in love with difference (7), it's not a very attentive suitor.

The desert of metallic timewarp gains its SF reflective surface not just from SF and comics aesthetics but also from high design. William Gibson, for instance, is aware of this when he paints his SF desert with the dislocating colours of crystal and metal. (8) And chrome is particularly featured. Many of Gibson's metallic images in the book, Burning Chrome are chrome coloured and chrome is the name and quality of the badguy in the title story . This Chrome is a woman, an icemaiden, whose data bases the heroes invade and burn. It's a rather macho set of sexual relations and desires,though the plot and imagery, as usual, repaints literary SF in computer culture imagery so exuberant and incisive it's hard to resist.

Chrome-a particular sort of metal which can colour the timescape as well as the landscape in this journey to the interface.Again the way Deco and SF imagery merge in Gibson's story is telling:

> TheThirties had seen the first generation of American industrial designers; until the Thirties, all pencil sharpeners had looked like pencil sharpeners - your basic Victorian mechanism, perhaps with a curlicue of decorative trim. After the advent of the desegners, some pencil sharpeners looked as though they'd been put together in wind tunnels. For the most part, the change was only skin-deep: under the streamlined chrome shell, you'd find the same Victorian mechanism. Which made a certain kind of sense, because the most successsful American designers had been recruited from the ranks of Broadway theater designers. It was all a stage set, a series of elaborate props for playing at living in the future.(9)

If chrome reflects the future of the past (Deco) then perhaps when you wear it, the interface is coloured by a retro feeling of safe familiarity, at the same time as seducing with a promise of some fascinating future. And does this retro feeling, a typical postmodern perception and experience work like its referent -Deco- to overrirde cultural differences to the point of loss of visibility? (10)

Chrome. A metal known for its covering of surfaces with its heyday in the era of industrial design when mechanical things became all surface and exterior.Hiding and suggesting. From the 30s modern culture hid the guts and intestines and smells and tastes and workings of things, paying attention to the surface and metaphorizing the insides - thus making/acknowledging them as both desirable and frightening and increasingly a creature of the imagination. Chrome reflects, so that you see everything except the thing itself.(11)

Chrome's reflective surface intensified and represented the modern move to the surface. Not surprising that one of the first animated shorts on a computer was "Chromosaurus". (12) Chrome metallic images in computer graphics continue this lineage of an aesthetics of surface and skin rather than the viscera.(13) Albert Liu has traced an etymological connection between chrome and skin.(14) When you wear your metal outfit, does it feel like a second skin? A skin that enables movement (of a particular sort) or a skin that inhibits breathing or? Are you perceiving a deadening reflection and repetition of metal images all around you and suffering sensory deprivation without other colours and textures? Or are you excited by the glitter and glitz?

Does this metal outfit only shape your body in that streamlined modernist way where form hid function - or does it (also) change function - enabling certain new movements? Does the flat iconic surface of the various screens on which computer graphics occur produce a desire to create the illusion of depth? You'll find that in your metal outfit you're well suited for the gravityless 3d movement, so familiar in computer graphics on tv and film. Backwards and forwards through space, alongside those metallic rendered logos for tv stations. Movements with the potential to giddily float you free and disrupt your point of view, disturbing the staid position of classical perspective. But also perhaps a movement that can re-anchor you in a reality that has not changed - the reality of the corporations which bring you these as if/once dazzling ads — re-anchor you at the point of a "supernarrator" (the tv station, the advertising company, the film distributors), as Judith Barry and Margeret Morse trace:

> 'When logos appear mysteriously on the screen, they seem to pass through our bodies on their way to our field of vision; when they swoop or tumble across the screen in elaborate trajectories, their controlled movements suggest not objects given momentum by some other force, but subjects with their own motive power. In this sense a logo can be thought of not only as the proper name of a station, but as a supernarrator that conveys us through various modes of discourse'. (15)

Judith Barry, following the path of Margaret Morse, tracks these 3d computer graphics as they alter the place of the viewer and therefore subjectivity. She sees animated tv logos as "trace(s) of an absent subject...anthropomorphized like fantasy creatures in fairy tales".(16) While the continuous movement of these (metalloid) figures locates the viewer deep inside space, in several place and planes at once, it is not only movement that gives them their meaning but also speed:

> Speed causes us to lose control, we give ourselves over to its exhilerating (sic) effects. It seems as though we are participating....in this universe of motion control to look is to be caught, not by an image but by something more powerful which delivers you to where it wants you to go.(17)

The terrain you are pulled into here by speed and motion is one of a new sort of perspective, different from traditional cinematic space which was a "believable, inhabitable representation" centred on "monocularly-based systems of perspective" - a space with a centre at which you, the viewer was located and your subjectivity ordered. (18)

What drives the movement and the drunken ecstasy of speed, which allows you to leave your centred and controlled self behind - is it just the engine of capitalism and commodification? Perhaps it can be diverted if the outfit doesn't quite fit - because of sex or race say? Does it make a difference if females dress in metal? It depends on who you are, as well as (re)shaping who you are. You risk feeling like the robot Maria in Metropolis, a representation of both frightening, destructive machine culture and terrifying femininity. A machine age scenario perhaps outdated in our post machine information age? And in any case, an all too classic scenario that does nothing to alter the gender/sex mappings of the terrain.

An even less appealing navigation of that Metropolitain terrain, where frightening machines were coded as female, is the road to fascism.On the fascist road machines have a glamour and appeal, as the modern; and the frightening codes of outsiders were mapped instead onto Communists and messiness.This is a much more straight and narrow path, a regimented road and you play a more deadly game. Here you wear your metal suit to protect and armour your body - for those with a fascistic need for safe boundaries, afraid of losing control, needing to hold messy frightening insides in, as Klaus Theweleit has analysed. (19) Here, where your own hold on reality is slim, the metal outfit bears a fascistic glint, giving you that first hold, not so much an escape from reality as an escape from lack of reality, a grounding in a "reality". On this road the games of war and competition flow along tight lines, violently hewn out of the landscape. From inside this suit you read the metal rendered maps to suit your needs.But such journeys into the monumental/monometal scorched earth of fascism like those into the cultural desert of advertising and commercialism should not be confused with the more everyday journeys into the popular cultural interface. Which we're about to take, after a digression to the most high end articulation of the metal outfit and way to mix it out there with the metal boy pixels.

Here you are wearing a very different outfit than the armoured representations usually associated with metal beings. This one is modelled on the smooth metalloid body of the metalmorph. This metal is worn on the inside and can bring Terminator 1000 delusions or desires. According to Albert Liu, this new generation Terminator exhibits the ultimate phallic boneless rigidity, body without organs - perfectly suited to the flat surfaced computer graphic terrain.(20) And having no insides, being post-machine, it needs no immune system to be invulnerable, immune, which is not a bad quality in the era of AIDS.

The Metalmorph is a strange computer product that is "postcybernetiic " - it is "morphogenetic ...rather than programmed", therefore unable to be deprogrammed or even turned off. It is an image in no way related to computers, according to Liu, and "almost as flexible and illusory as celluloid.... a representation of Filmic Intelligence over and above Artifical Intelligence".(21) It is also an unusual computer metal image because in this "figure of persecution" the material which once held a promising future has now become threatening.(22)

But the metalmorph is also particularly slippery, flexible,flowing and mobile - well suited for travelling . Not only a metal being, but also a liquid metal being, which navigates easily across the border from the continent to the sea, itself a border creature of liquid/solid form, like the pseudopod in The Abyss where its rendering program was first trialed.This program achieved a breakthrough in computer simulation , according to Liu:

> Rendering...since it is capable of simulating a holographic realism unattainable in sculpture - by creating the Metalmorph, returns the human figure to a prototypical, subhuman facelessness, its unidealized anonymity reinforced by realism....T-1000's liquidity incarnates the anticlassical possiblity of Dionysian sculpture. Acccordingly, the Metalmorph marked a moment not in the plastic arts but in the plasmatic (as in *plasmatikos*,'molding') arts. (23)

It's interesting to note this renders a move not only from the classical but also the modern representation of sculpture, in its monumental form, which was so appropriate to the bourgeios ideal of solidity . This postmodern metalmorph is marked by its movement and speed as well as its form/lessness.And the metalmorph is not only a metallic being but also also a morphing being which not only changes form but changes shape and takes on, flows into, other shapes. And with a multibillion dollar film budget you can morph into a lot more exciting things than your more economical home version.

Morphing - this suggests a movement and technique possible at any point on the navigational path, more than a departure point. Morphing - is it a body technique to evade(explore) the identity crisis precipitated by awarenesss of cultural difference in the postmodern west? It's interesting to track the major territorial invasions of morphing to try to excavate its meanings. It is a currently and increasingly popular technique in film and music videos, and particularly in advertising. Frequently its beginning and endpoints play around with racial, gender, even species difference. You may want to read this play as erasing or highlighting differences, homogenizing or exposing the tenuousness of a type of identity which made sense in/of the mechanical age of modern capitalism but no longer does in the post modern age of information. Is it a technique driven by the desire to be other, not just travel to other worlds? Is this a fantastic disruption of 'reality' (that leaves you with the abject queasiness) or an erasure of the significance of difference by tampering with the signs of difference?

It depends in part on your location, in time, space, place, discourse, as the producer or reader of the morph. Morphing could be read in the way similar to that in which Margery Garber reads cross dressing, as the creation of a 'third sex' and as a sign of the 'anxieties of binarity', the 'constructedness'of gender, andthe crisis of cultural categories.(24) To Olalquiaga, morphing can be similar to cross dressing when it is about camouflage, which plays a large part of contemporary culture. Both allow the taking on of different personas, presenting yourself as a spectacle, transforming yourself, being multimorphous, not bound by notions of the essential. Both allow for lots of mobility, irrespective of certain codes of your race or gender. Morphing and cross dressing make sense in this postmodern culture, according to Olalquiaga, because it is so visual and icon oriented and there is the desire to look like the icons we see around us.(25)

Computer imagery lends itself to these iconic presentations which are very surface, lacking depth, and also very mobile and able to traverse a lot of boundaries. Olalquiaga traces the ways that both computer imagery and morphing and crossdressing construct/reflect postmodern sensiblities and subjectivity. However, both crossdressing and morphing can also fail as playful interceptions of the mainstream.In particular, playing round the boundaries of gender is more difficult for women to benefit from than men, according to Olalquiaga.(26) You can see if you look at Lucas Films' multiple users' game Habitat, for instance, that at one level the crossdressing and morphing possibilities are wide open - body parts are interchangeable, you can re-spray your colour, you can change your sex. And you'll find lots of men crossdressing as women. (27) But at the level of the graphics, the imagery and the bodies' design are not particularly transgressive or diverse - they remain classically anglo, cute and 'shapely'.

You might produce other readings and episodes of morphing techniques - as a computer culture version of cosmetic surgery or body building perhaps, as something which fails to disrupt or to dissolve structures? (28) I wonder about the way some of the most stunning versions of morphing involve two of popular culture's most famous examples of body building and cosmetic surgery - Arnold Shwarzeneger and Michael Jackson. Arnold, who built his own body, was fabulouly well paid to be seen travelling round the interface with a morph, even apparently known to try it himself, changing race in a magazine image. Michael Jackson who's turned sort of white in real life through pigmentation alteration and cosmetic surgery had what I remember as some of the earliest examples of morphing across race and species in his music videos.

All this raises the political challenge facing you at each moment at the interface, to analyse what's going on culturally and politically with morphing. A strange dislocation occurred at a Seminar on Computer Graphics and Cultural Diveristy around TISEA 93 when Rejane Spitz showed some Brazilian ads with women morphing into big cats. Some feminists were worried by what they saw as the exploitation of women's naked bodies for advertising. Others, including myself, were excited by this example of cultural difference in reading computer graphics and stunned by an image whose meaning was at the same time overcoded and yet available to be disruptive in certain cultural contexts. This was also the begining of my secret desire to be morphed into my cat Nellie.

Beam me up, morph me over —now that your identity is so disrupted with all this high flying and morphing activity around you, let's go back to the wardrobe,where, like Albert Liu, you might choose scuba gear for the journey into the interface. He sees this as a very approriate wardrobe choice for crossing mediums, which is how he imagines a journey into the interface: a "submerging of the human body in another medium... a way to gain accesss to another ...unnatural, inhuman experience...a human/inhuman fusion". (29)

Or, along with Celeste Olalquiaga in New York City, a city where urban movement is a crucial concern outside the interface and fuels a desire to journey inside it, you could journey into the interface dressed in lycra, gliding on rollerblades.Lycra to cover your whole body because you are submerging into another reality and your body needs to be free to traverse whatever obstacles it finds. She identifies the roller-bladed styles on the streets, a look, which is protective, fluid and.robotic, as reflecting the look on video games monitors. It's a look appropriate to speed and violence. A look that lets you glide in and out of the streets and the interface and realities - in a merging or surfing-like manner.(30) Which recalls again the Silver Surfer, a metallic comic character, and the resonance of computer games with comics in their look and signifcance to urban youth styles.

Or, back in the wardrobe, on the other side of your continent, along with Katherine Hayles you could wear a colourful iridescent body suit, for gliding through the interface. For her, living in L.A., hypersensitive to the pervasive traffic, the journey to the interface is driven by an impatience with materiality and the desire to achieve infinite mobility and the exhilaration of speed. Navigating the journey in this outfit, in this way, shortcircuits the cognitive machinery and appeals more to a kinaesthetic sense. (31) Being held up by traffic is certainly something you escape in the cars at the video arcades.There you drive a car as fast as you want, crashing painlessly. Sometimes you find the crashing as exhilarating as the speed as a moment of release and joy. (32) For the more adept , or those who get their thrills without spills, you strive to improve your technique and move ever faster in pusuit of your goals. And with the perfected techniques of computer games and video arcades your sensory channels are reconfigured.(33) According to Klaus Theweleit, you develop a whole new set of perceptions as you play video games -and generations of youth follow generations of computers, differing in the way they perceive and react to/interact with images, movements and depth. In the timescape and landscape of computer games, the kinaesthetic sense of your phenomenal body keeps up with that of the computer and the younger you are, the faster you see and move.(34)

It is culturally significant that you choose to experience these other realities via a machine, rather than say, through drugs, meditation , reading or any of the other many possible ways in. That is not to ignore that they too are technological but here technology takes a particular form, includes particular techniques and aesthetics and shapes your visit to this landscape of other realities in particular ways. And it is part of the technological drive to produce a machine to extend human capabilities, to gain access to to other sorts of experiences (35)

As you drive into the interface you may find yourself navigating a fine line along a very repetitive road. On the one hand, repetitive image can be important and play the soothing function of giving you something to hold onto in postmodern culture where things disappear so quickly that they leave a gaping emptiness. Too much speed can leave you breathless. This breathless emptiness can be balanced with reptition, according to Olalquiaga. (36) For Hayles, the speed with which the new becomes banal means we have to move even faster to escape the banal which is pursuing us ever more closely.(37) It is no surprise perhaps then that these games in which speed is a crucial part are also incredibley repetitive in their narratives and imagery.

All of which takes us deeper into the question of driving. Depending on how you are driving or how you are driven, you can navigate the journeys into the popular cultural interface in a variety of different ways and directions. So what drives you to set out on these journeys into the interface? Sometimes it is the desire to enter another reality or extend your reality or lose your reality; perhaps even to have a radical experience - to test the limits of experience and the limits of desire.This can be the desire to be in another time or space, or place or medium, as we've seen. It can offer an opportunity to lose your particular perspective in time and space. This happens "when things exist in informational form" at the interface, "where doors open that never could open in material form". (38) Is this what makes doors so popular an image on the interactive interface? For Katherine Hayles, the move into the interface "is a movement from materiality into information" so that "sensory data ... impact on us". As you move from your world into the screen you become fluid and immaterial and therefore not bound by the rules of your world - a movement different from that of film which comes out into your world. (39)

Via the machine you are incredibly absorbed, more so, according to Albert Liu, than with reading where some kind of symbolic faculty is being used. At the interface, you can supercede your symbolic faculties - your senses are stimulated in ways that confuse or obviate the brain.The whole design of computer games... "is to assume a purely passive or automatic position with respect to technology, to allow it to access the senses without symbolic mediation, without going through the sign systems which have governed the production of meaning in our culture, namely language....You enter [the interface] willessly, involuntarily, inconspicously".(40) How this operates for the interacitve interface of Sega computer/video games was perceptively described by one 14 year old girl as an escape from boredom, your mother, using your brain:

> "it takes over your mind and you just get hooked on it til you've finished it...It's an imaginary place where you can just relax and your mind goes free... Your mind gets loose and stuff".(41)

So what happens when you mix it with the tough boy chrome pixels in the old games of violence and competition. Are these games 'fantasies' in the subversive way that Rosemary Jackson discusses?

> A fantastic text tells of an indomitable desire, a longing for that which does not yet exist, or which has not been allowed to exist, the unheard of, the unseen, the imaginary, as opposed to what already exists and is permitted as 'really' visible. (42)

They are certainly fun, an escape, addictive even, but whether they are fantasy or not depends in part on who plays and how, as well as what they play. However, their violence should not necessarily be seen as a signal of 'realism' or recuperation.Violent computer games can enable a violation and subversion of norms which are particularly restrictive for kids under the institutions of family and school. That Danielle, like many (?) girls is not violent but likes violent games because they're the ones 'you can get into', are more 'exciting', you get 'glued to', could make sense in terms of what Rosemary Jackson elaborates in her study of fantasy literature:

> As a literature of 'unreality' fantasy has altered in character over the years in accordance with changing notions of what exactly constitutes 'reality'...From about 1800 onwards, those fantasies produced within a capitalist economy express some of the debilitating psychological efffects of inhabiting a materialitc culture. They are peculiarly violent and horrific.(43)

This can be a sort of using the very codes that bind in order to free those binds. (44) As Bataillle noted, "Those arts which sustain anguish and the recovery from anguish within us, are the heirs of religion.(45) How apt that the ultimate scientific rational machine enables such fantasy encounters - science yet again doing the work of religion?

Just as with fantasy literature, computer games' subversive function resides perhaps in their structure rather than (only) their themes.(46) Computer games play with fantasy is determined at the graphic and technique level more than/as much as the narrative. When its naratives stray from the more fantasy lineage into more 'normally' violent, romantic or realist territories, it is perhaps only their disorienting speed and their low res graphics which save them from performing a normalizing cultural function.

The genres may vary but the narratives of these games can be so familiar that you can follow them with a bit map - and you're still drawn in, despite the low level graphics. Perhaps even these low level bitmapped graphics provide some allure - some room for the imaginations in these well worn narrative and aesthetic grooves. The less intelligible it is, the more we can project fantasies and desire onto it. As David Humphrey suggests:

> A low-resolution image like a badly taken photograph, or an image produced after many generations of cheap copying, has the capacity to solicit the viewer's participation in a production of its sense. That degree of filling-in-the details required to'recognize' or 'define' the low-resolution image draws the viewer closer to the realm of memory and association...these vague images create an increased susceptibility to the unintended or subjective, exercised by the peculiarities of the maker and viewer. (47)

So with or without the bit map as a sop to your drive for imaginary space or space for the imagination, you are drawn into the interface.

The crucial question, at each interface moment, is whether the sexist, racist and overly repetitve content locks you too closely to the codes of reality. At those times it may be role playing games that offer some deeper fantasy involvement. Or perhaps the appeal of role playing games is to kids in (sub)cultures where they've already passed some speed threshold and need the complication of role playing's involvement. (48) According to Alberti Liu, role playing games seduce by producing the sense of yourself being somewhere (else). They produce a sense of subjectivity and selfhood not by a stable fixed point of view or point of reference but precisely by the instability and fluctuating commotion we now perceive as real life or real sensation.(49)

Even in these role playing games, neither the narrative content, nor the movement are necessarily fantastically disturbing of the reality you've escaped from and will return to. As Olalquiaga notes,they co-opt 'styles' with a lot of speed in order to become readily marketable but through the narratives infuse the new modes of reality with traditional values, because of who's producing them - their male point of view. Yet this is not a totally bleak journey because it can be redirected back to the streets where people take on this computer game look as 'style' and, in making it their own, offscreen, they find room to move where capitalism and masculinity have blocked or monopolized the way on screen. 'Style' allows people to play with codes and transform them, alter them, be creatve and active in their response. (50)

This is all very tricky territory you've been on - particularly when you try to work out what's going on with those young girls at the interface.You can try asking them but they speak a different language to describe the visual landscape. And more than that. As the generation which has grown up in the information age, you can find their perception of time, the technquies with which they operate at the interface very different from you own. They move differently and at a different pace. Speed of play and uptodateness of the game (signified by music and graphics) draw them in and move them around. All of this is not to say that the graphics don't have an effect in (re)shaping their aesthetic sense, even if this is not conscious. But this seems not to be a question that concerns the market forces operating at this interface. Nor, unfortunately does it figure much as you journey past the interface, as we're about to do in Part 2.

Part 2: Journeys past the interface: Plotting navigations to the heart of the machine: scientists,engineers, and educators rule okay

In these journeys you aim for the dead centre of reality, bypassing the imagination as much as possible. A movement directed by symbolic urges, which sometimes got detoured as you played around at the interface. There's a high res. road which can take you straight there though there are low res. access roads. And the eye you keep on the road is that of scientific vision in this landscape where engineers rule okay.(51)

No time for cross dressing or other playing in the wardrobe for this journey - What You See Is What You Get. Scientists and engineers are more interested in playing around under the hood of the vehicle than giving it a respray, new chrome finishing.Their relation to the machine's insides follows the paradigm of science - constructing it as something to be conquered, controlled,to exercise power over, to find out its secrets; to have their own power and subjectity expressed in these 'useful' actions. (52) Any style on the outside will do, indeed to the engineer's eye attention to the graphic look can be 'a waste of time', a 'superficial' and 'insubstantial' activity because it is not 'anaytical'. To that eye there is no difference between the active,creative transformation of style and the passive consumption of fashion. Although the cleaner and simpler the interface looks, the better, because its less likely to bedazzle the user away from their main aim of following the well laid navigational paths as quickly and efficiently as possible. The high res. road holds the greatest promise here as the path of smooth, clean functionality - far more appealing to the tech's eye than the dirty, abject low res.approach which appears as a dysfunctional roadblock to their vision. It could distort or disturb the drive around their hierarchicially organized space in which immediate and fast navigation between levels is the top priority, paramount to who or what is on those levels and what it feels like.

Their drive is to detour any possibilities to engage visual pleasures, to bypass the senses and plug the 'brain' directly into data bases or texts. In the engineering faculty at UTS, they took the Mac users off the network because the Macs 'caused trouble' for their IBM traffic - too many pretty or different pixels interfering with the march of the repititive parade of interactive bodies? Functionality is the go on this journey, navigational dexterity is where it's at. Relating is as superflous as visual pleasure. No need to relate to the user, just track their movements through the visual desert where your data base is right at home.

If an educator guides you on these journeys, your path can often be pretty much the same as if you go with a scientist or engineer. The difference is that as travelling companions, they're generally more interested in what you have in your suitcases and your final destination than in how the path takes you there. So long as they can track your movement and you reach the proper destination, they're happy. And what does tracking as a technique of relating to the user do to the producer and the user? This question doesn't seem to delay many engineers and educators - and it's certainly not protocol to let the users know. Tracking could look to you very much like the commercial and government surveillance uses of computer -though dressed up for this journey in the educational guise of 'for your own good'.

Of course the navigation of the journey will differ depending on which scientist, engineer or educator you travel with - where they've come from, how they like to travel and where they want to get to. There are engineers and scientists whose perceptions exceed the boundaries of the knowledge system they work within, enabling them to see the significance of the graphic imagery interface rather than rush straight through the tunnel vision to the 'heart' of the machine function. And educators sometimes get derouted from their institutionally driven goal-orientation - they can stop and recognize the practice and pleasures of the user. Still, this is not normal practice and many of the educational and informational interacitve interfaces reveal the low level of awareness of the significance of aesthetics and show the limitations of the institutionalised nature of their knowledge.

The effects of the engineer's eye and the educator's ear are very evident at the interface even if not consciously. Lack of concern with the graphics, music, and speed factors tell teenage users that they're there for an educational rather than entertaining ride. Which brings me to the end of this section and back to my beginning - with the question of how differently to travel to an interface where diverse young people can operate differently than in the usual educational or popular cultural mode, though with some of the pleasures and benefits of both.

A Return to the Interface - a journey at the crossroads of art, science and education.

As we return to the interface after that brief visit to the heart of the machine, a number of questions remain unresolved from our first series of journeys through it. Can there only be tough chrome boy pixels and fluffy pretty girl pixels, marching in the repititive parade of interactive bodies? 'Are all the pixels white'? Can art be available to new bodies/subjects and new bodies/subjects available to art through images resonating with cultural and aesthetic diversity? To examine these and other querstions, it's useful for this revisit to the interface to take an artist along and introduce the 'art factor'.

Art Factor is one of those travelling companions I never like to quiz too much about who they are for fear. of scaring them off. Art has her own constraints on her own turf, where historical, market and institutional forces constrain her movements. On this territory here, though, she may be a bit freer of those constraints and able to add both a critical edge to the technique as well as an aethetically pleasurable dimension to the landscape. Art Factor enters the terrain of educational and informational interactity to make reality strange. With her paintbrush and technique, scientists, engineers and educators can loosen the deadlock grip of "reality" on imagination and the imaginary. In the process, 'reality' itself can be disturbed and experienced differently.

So Art Factor makes room for possibilities to engage visual and aural pleasures at the educational/informational interface. How to do this is tricky because the techniques are not necessarily the same as those she likes when she's on her own turf. There, one of the popular strategies is to take the low res. road to the interface to challenge the tying down of meaning. What David Humphrey says about the value of the abject quality of low resolution in art in general can also apply to computer art specifically:

> Low resolution...translates as languid irresolution. The dumb simplicity of the dissolving gestures registers a low-intensity resolve to simply mark the surface without the burden of representation. (53)

Other computer artists working on their own turf take the high res road. For instance, they see possiblities to disrupt meaning and "implant the visceral in the technological "with more high res techniques, though they are constrained by the economic possibilities of going as far along the high res. road as they'd like to do. (54)

While there's a far greater diversity to approaches by Art Factor on her own turf that I can track here, as I come to the end of my story, I'll just note that these questions of high and low res. roads,and cultural diversity, articulate differently when you stand at the crossroad of art, science, and education. My own ongoing project,with artist Maria Miranda, at that crossroads, has been to create a 'real' world familiar/strange enough to excite curiosity, pleasure, and engagement. We constructed paths which suited our target audiences' desire for the 'game' factor, for surprise and challenge. The data came last, not first; it was audience - driven not menu driven.The information was designed to fit the aesthetically pleasurable interface. The look was painterly, a lush, non-'realist' world inhabited by culturally diverse bodies. A real' world (domestic and exterior) was animated expressively and fancifully; and an informational territory was infiltrated with the critical, 'inconsistent' edge of the 'art factor'. When your funding is limited and you have engineers, scientists and educators to keep happy, then to transgress 'reality' and 'realism' and speak to the aesthetic sensibilities of a culturally diverse audience of 15 year old girls, is a happy end, and beginning, to the story of these interactive journeys.

Footnotes

1. Leola Jacobs, "Technological Dreaming: Language, poetics, subjects", paper delivered at <u>Sex/Gender in Techno-Science Worlds</u>, University of Melbourne, 29 June, 1993.

2. Celeste Olalquiaga's work, particularly <u>Megalopolis</u> is a valuable exploration of this cultural and political moment. Celeste Olalquiaga, <u>Megalopolis: contemporary cultural sensibilities</u>; Minneapolis: University of Minnesota Press,, 1992.

3. Brenda Laurel, <u>Computers as Theatre</u>, New York: Addison-Wesley Publishing Company,1991*passim,* esp 7,127-132.

4. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",<u>the listening room,</u> ABC FM, in production, for broadcast January, 1994.

5. Albert Liu, Radio interview for "Journeying into the Interface",<u>the listening room,</u> ABC FM, in production, for broadcast January, 1994.

6. *Ibid.*

7. Adele Clarke, "Modernity, Postmodernity and Reproductive Processes c. 1890-990 or "Mommy, where do cyborgs come from anyway?", paper delivered at Sex/Gender in Techno-Science Worlds, University of Melbourne, 28 June, 1993.

8. William Gibson, "The Gernsback Continuum", Burning Chrome, London: Grafton, 1988, pp. 45-46.

9. *Ibid.*, p. 39.

10. Penny Sparke, Felice Hodges, Emma Dent Coad, Anne Stone, Hugh Aldersey-Williams, The New Source Book, London: Little, Brown and Company,1986, p. 100.

11. Sandy Stone, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

12. Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

13.Francesca da Rimini, conversation about VNS Matrix's interactive "All New Gen", September 27, 1993.

14.Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

15.Margaret Morse, cited in Judith Barry "Eyestrain", Public Fantasy: an anthology of critical essays, fictions and project descriptions by Judith Barry, (ed. Iwona Blazwick) London: ICA, 1991, p. 111.

16. *Ibid.*, pp.111-112.

17. *Ibid.*, p. 112.

18. *Ibid.*, p. 114-5.

19. Klaus Theweleit, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

20.Albert Liu, "Metalmorph", The Abject, America , Lusitania, Volume 1 Number 4, p.131; and Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

21. Albert Liu, "Metalmorph", The Abject, America , Lusitania, Volume 1 Number 4 p.138-9; and Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

22. Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

23. Albert Liu, "Metalmorph", Abject, America, Lusitania, Volume 1 Number 4, p.138, see also pp. 136-138.

24. Margery Garber, "Introduction", Vested Interests: cross-dressing and cultural anxiety, New York: HarperPerennial, 1993, *passim*..

25. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

26. *Ibid.*

27.Alluquere Rosanne Stone, "The Anthropologist as vampire: Transsubjectivity and Transgender", paper delivered at Sex/Gender in Techno-Science Worlds, University of Melbourne, 27 June, 1993.

28. *Ibid.*, For a discussion of fantasy as disruptive of structures, see Rosemary Jackson, Fantasy: the literature of subversion, Methuen: London and New York, 1981, pp.72-3; 77-8, 174-80.

29. Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

30. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

31.Katherine Hayles, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

32. Alluquere Rosanne Stone, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

33. Katherine Hayles, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

34. Klau Theweleit, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

35.Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

36. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

37. Katherine Hayles, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

38.*Ibid.*

39. *Ibid.*

40.Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

41.Danielle Tuwai, conversation, September 25, 1993, Sydney.

42. Rosemary Jackson, Fantasy: the literature of subversion, Methuen: London and New York, 1981, p.91.

43. *Ibid.*, p.4.

44. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

45. cited in Rosemary Jackson, Fantasy: the literature of subversion, Methuen: London and New York, 1981, p.18.

46. *Ibid.*, p. 175

[redacted]

47. David Humphrey, "The Abject Romance of Low Resolution", The Abject America, Lusitania, Volume 1 Number 4, p. 155. A similar point is discussed by Alluquere Rosanne Stone, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

48. James O. Jackson. "Vidkids everywhere", Time Austraila, September 27, 1993.

49. Albert Liu, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994. See also Rosemary Jackson, Fantasy: the literature of subversion, Methuen: London and New York, 1981, p.35, where she notes: "Subverting unitary vision, the fantastic introduces confusion and alternatives".

50. Celeste Olalquiaga, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

51. Scientific vision is something Donna Haraway investigates most usefully in her Primate Visions: Gender, Race and Nature in the World of Modern Science, New York: Routledge, 1989, see especially chapters 1 and 9.

52. Leola Jacobs, "Technological Dreaming: Language, poetics, subjects", paper delivered at Sex/Gender in Techno-Science Worlds, University of Melbourne, 29 June, 1993; and Alluquere Rosanne Stone, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

53. David Humphrey, "The Abject Romance of Low Resolution", The Abject America, Lusitania, Volume 1 Number 4, p. 155. A similar point is discussed by Alluquere Rosanne Stone, Radio interview for "Journeying into the Interface",the listening room, ABC FM, in production, for broadcast January, 1994.

54. Francesca da Rimini, conversation about VNS Matrix's interactive "All New Gen", September 27, 1993.

"Scientists Doing Art, Artists Doing Science"

by Trudy Myrrh Reagan
Founder, Ylem: Artists Using Science and Technology

Standing on the ridgetop where one can look both into the fields of art and into technical subjects, one is impressed by the scientists, mathematicians and computer scientists who have made contributions in the field of art. I will survey some 20th century art pioneers who began in science-related fields—ones who did not work in the electronic arts, and who are no longer living. Then, I will discuss two who are still alive and currently using electronic means to bring their science-related expertise into the realm of visual arts: **John Whitney** and **Kenneth Knowlton**.

Coming from the other side of the ridge are visual artists who are doing science with an artist's mind. In the course of their work as artists they have been bitten by the bug of some problem that has drawn them over the ridge into the technical realm. They've made contributions in both art and a science-related discipline using electronic tools.

This is a tribute to both scientists and artists whose careers have taken them to both sides of the ridgetop. These are towering figures whom I wish to honor. I have chosen seven to discuss in detail: **Lillian Schwartz, Helaman Ferguson, Kenneth Snelson, Ellen Sandor, Roman Verostko, Harold Cohen, and Myron Krueger**. I will go subject by subject. For instance, I will treat computer science and discuss contributors, taking note of who were the artists and who were the computer scientists.

First, the pioneers: Beginning in the 1930s, **Buckminster Fuller** was exploiting his remarkable geometric insights by designing geodesic domes and truss structures. His engineering was art, in the spirit of Bauhaus design for everyday objects. And, long before anyone else, he was preoccupied with global needs and resources. Will this prolific genius be remembered more for the geodesic domes on the landscape, or his vision for the future? His 1971 World Game, a group activity to teach people an appreciation of world resources in a new way, was an early *Sim World* ecology game. He knew, before most of us, how much people in the industrial countries squander resources. But he was an optimist. Will his vision of ocean-going colonies help care for our expanding population in the next century?

We are particularly indebted to **Frank Malina,** a space scientist and artist who in 1968 gave voice to artists like ourselves by starting the journal, *Leonardo,* from which sprang the organization Leonardo/ISAST. In countless ways, it has provided validating support for art using science and technology that has been so absent in the official art world. ISAST is one of the organizations that makes the ISEA conferences possible.

How did it come about that the co-founder of Jet Propulsion Laboratory in Pasadena in 1944, and later a director of UNESCO's Natural Sciences Department, became so involved in art that he saw the need for this?

He had moved to Paris to work for UNESCO. In 1953, after completing this work, he began doing art there. *Deep Shadows,* 1954, started with the idea of making moirés with mesh, and ended up being his first piece using electric light. He went on to make light boxes with static and moving elements which, in combination, produced moving patterns. A particularly complex one was *Cosmos,* 1965, using over 100 bulbs and 29 rotors. Diffusers were used to give a soft, lyrical quality. He learned by chance that this was not a completely original idea, and wondered why no way existed for artists to search the literature for predecessors and technical information as there is in science. *Three Masks,* in 1965, explored polarized plastic films that moved past each other to produce a color change. He may have been the first to use this technique, which has proved fruitful for several other artists.

His frustration with the lack of literature caused him by 1965 to contact potential publishers regarding an art journal that would allow artists to speak for themselves in clear language, and to have the articles peer reviewed, as in scientific journals. The aim was to promote sharing of information and contacts with colleagues worldwide. In 1967 he reached an agreement with Robert Maxwell to have it published in England at Pergamon Press.

What else was happening at that time? Also in 1967, **Gyorgy Kepes** founded the Center for Advanced Visual Studies at MIT, and Experiments in Art and Technology, an endeavor started by artist **Robert Rauchenberg** and Bell Labs scientist **Billy Klüver,** had just had its Armory Show in New York the year before. So the timing was very good!

In the early 1960s, physicist **Robert Wilson** was about to take a sabbatical to do sculpture when he was offered the directorship of the proposed Fermilab in Batavia, IL. He insisted that the contract give him discretion to allocate the money, as long as he got the accelerator built within budget. He proceeded to make a great many aesthetic decisions about the building and layout of the lab. The majesty of the great central building is legendary. He felt it was a visual symbol of the great common endeavor that they were engaged in, contributing greatly to group morale. And, of course, the laboratory was peppered with his sculptures that doubled as cheap solutions to practical problems. One was an outdoor hexagonal sculpture covered with an array of boxlike condensers to boost the energy of the accelerator. Most laboratories would have built a small building for this at somewhat greater cost.[1]

Two pioneers of the computer age

Composer **John Whitney** and his brother began in the 1940s to make synthetic music by drawing sine wave variations with a complicated array of pendulums. These appeared on the sound-track edge of movie film, based on how normal sound is coded in this area as a lineal wave-form representing sound harmonics. He combined it with abstract animation, which he had learned to do as early as 1937. Since the advent of personal computers, he has been linking digital sound with digital images, writing software to do this. He believes that a musical experience is one in which harmonic dissonances resolve into consonances through time and resonate deeply in human experience. And, he believes that moving images can be created that correspond to this. But his technical contribution is his realization that music and visual art are all digits now, and can be manipulated in a new way.

Computer scientist **Ken Knowlton** has created many tools for visual art and animation. At Bell Labs he worked with Leon Harmon in 1966 to reproduce scanned photographic images with small symbols for different densities. This was a rough way to obtain grey tones at a time when computer output was very primitive. The curious juxtaposition of overall image and, at close range, unrelated symbols inspired artist **Lillian Schwartz** to collaborate with him. Schwartz' drawings on graph paper became computer graphics. It was with his help that she became a computer artist. Then he wrote BELFLIX (a corruption of Bell Flicks), the first general-purpose program for animation, and a later animation program, EXPLOR, for Lillian Schwartz' use. At SISEA in 1990, he and Katherine Donoghue presented a "Computer Simulation of Calligraphic Pens and Brushes. In his other technical work, he holds 14 patents.

In art, here is how Knowlton has exploited his original idea of symbols to code the density of pixels in a photograph: In one, the dot patterns on 24 sets dominos are arranged to show a man holding a domino. His portrait of Jacques Cousteau uses large and small white shells on a black grid. While working on it, he couldn't see the face up close. He says the lovely expression in the eyes was completely coincidental. Lately, he has been using shells on cultural icons such as Grant Wood's *American Gothic* figures.

Seven Whose Work Crosses Disciplines

In the use of computers for archeological and art history research, artist **Lillian Schwartz** is breaking new ground. As new graphic tools are developed, she has a gift for seeing worthwhile ways to use them. Here is her 1984 computer poster for the Museum of Modern Art called *Big MOMA*. It involved texture mapping (fairly new in 1984). This is just one example of her art using the computer.

In archeology, one of her 1981 projects relating to excavations at Carthage was to find an entrance to the harbor at Carthage described in ancient texts. A contour map of the present harbor was scanned in. Lines between the contours forming a mesh of triangles were added, then data about sea level fluctuations and other historical changes was entered. This made an animation that played backward in time and clearly showed the old entrance. A year later they dug it up!

In art history, her famous comparison of Leonardo and the *Mona Lisa* in 1986 happened quite by chance. Gerard Holzman was working on PICO graphics software, and invited her to try scanning in some images that she had on magnetic tape. While she searched for Leonardo's self-portrait, she came upon the *Mona Lisa* and also scanned her. Remembering the debate about Mona's identity, she thought it would be fun to compare her face with Leonardo's. Leonardo had to be flipped from left to right and resized. Then, the tips of the noses were aligned. The match-up of features was so close it was uncanny! The results seemed to show that Leonardo had used himself as the model. Schwartz exhausted other possibilities, comparing *Mona* with other Leonardo studies for the painting. None of them matched as well.

The *Mona Lisa* gambit was used again to follow the trail of another historical mystery: who was Shakespeare? Here, her discovery was that the face of Queen Elizabeth I fit Shakespeare's best! What this proves, she admits, is a mystery.

Her most recent projects concern frescos by the early Renaissance painter, Piero della Francesco. Here are two of them. Analysis of the face in his painting, *Resurrection*, shows an asymmetry in the nose and ear areas. In fact, one ear seems positively deformed. Note how much character the face has. The cauliflower ear and deformed, or perhaps broken, nose suggested to her that della Francesco's model had been a fighter.

For frescos, Renaissance painters made big "cartoons" (drawings) to transfer to the wall. Holes were made along the lines, and charcoal dust pounded through them onto the wall. To save labor, parts of cartoons were often re-used. As in computer graphics, these could be flipped over or moved. As she logged examples of this rule-based behavior, Schwartz found a way to do a virtual restoration of a damaged patch in the background behind the portrait of St. Julien. The texture in it had been created, she found, by moving the same stencil around at random. She was able to make a facsimile of the basic stencil and move it on the computer image to create a piece that fit. She expects that sleuths like herself can construct restored images in computer memory which may be useful to historians whether or not the funds are found to restore the actual work.

From her study of previous artists and from making art herself with a new-fangled art medium, she concludes: "If the artist captures something essential prior to death, then we remain moved because of the spirit preserved in the artwork. That movement continues to exist because moved because of the spirit preserved in the artwork. That movement continues to exist because the expression is inconclusive, speaking to us as a spark unbound by time and space. The computer also represents a process. But it is a polymorph of mathematical and logical design. What it can do is subject to what we believe it can do for us....the qualitative sensations of the creative act remain the elusive domain of the artist."[2]

Turning now to mathematics, **Helaman Ferguson** marries the Stone and Bronze Ages with mathematics and the Computer Age. His interest in stone began when he was apprenticed in his youth to a stonecutter. He studied painting in college and took graduate-level sculpture courses. His doctorate, however, was in mathematics, which he taught at Brigham Young University for 17 years. Now, he designs new computer-based algorithms for operating machinery and for visualizing data. Scientists, he finds, are buried in an avalanche of data, and need his help in "sculpting" it into something they can grasp.

Concurrently, he does sculpture. And what sculpture! Mathematical relations take shapes never before seen. He molds abstract formulas into something ordinary passers-by can enjoy. The tactile qualities of stone or bronze lend a special warmth to his ideas. He enjoys the adventure of carving the unpredictable stone, concentrating to the same degree as when doing a difficult calculation. His technique is always subtractive, carving away, a more risky process than building up. Finding the right embodiment for the idea must come first, which sometimes takes years of turning the problem over in his mind. Then, he begins to carve, using hand and power tools.

Earlier, he created stone sculpture measuring by hand and eye, but now uses a computer-guided system developed by the National Institute of Standards and Technology. The actual transfer of the pattern to stone is by means of a measuring device not unlike a retractable tape measure that goes from a fixed point at his computer apparatus to the points he measures on the stone. Its measurement of a given point will show up on the computer screen where it can be compared with the desired measurement for that spot. He carves until these match. This is not easier, just different. The computer method has problems of its own!

His *Umbilic Torus NC* was cast in bronze using the ancient lost-wax process. The original was carved in high density foam. Similar to a Moebius band, the shape of *Umbilic* has a peculiar quality: It only has one edge. It is covered with a surface-filling fractal curve. The surface design was inscribed by a computer-driven milling machine. Ferguson enjoys this pattern's resemblance to those on ancient Chinese bronzes and Mayan carvings. He likes to think his marbles and bronzes will last as long.

"I celebrate mathematics," he says. "Among the greatest myths of our age are mathematical equations, their equal signs heros. Today's Atlas holds up a world of aircraft; he is the equal sign in the Navier-Stokes equation; airplane designs are simulated by equations before they are considered safe to bear humans aloft. I regard mathematics as a design language for vital images."[3]

In physics and chemistry, we have sculptor **Kenneth Snelson** who is making models of electron orbits around the nucleus of the atom. Snelson has made his mark in the world with his enormous tensegity sculptures. He invented compression-tension structures while a student of Buckminster Fuller's in 1948. When Fuller saw the idea, he named the concept Tensegrity, refined it, claimed it as his own and patented it—not one of Bucky's finer moments.

We need to know a little more about the atom to know what Snelson is doing. Allow me to oversimplify! The atom has a hard, dense core, made of protons and neutrons. The nucleus is more in the realm of nuclear physics, which does not concern us here. Around the nucleus circulate

Electrons have too many puzzling properties to enumerate here: for example, are they particles or waves?. Therefore, the famous logo of the atom that shows electrons whizzing around the nucleus like beady little planets is misleading. Physicists prefer to describe properties of electrons mathematically and not to think of them visually at all, or to portray them as a swarming "electron cloud."

However, chemists do try to visualize groups of electrons. The underlying basis for the Periodic Table of Elements, they believe, is that electrons are arranged in "shells" around the nucleus (figuratively speaking). If the outermost shell is full, the atom is like an inert neon atom, not reactive with other elements. An atom naturally possessing one more electron would represent a different element with an additional shell, a new element on the Periodic Table. Atoms with incomplete outer shells react with other atoms. Some atoms, like chlorine, are very reactive for this reason.

Snelson, yearning for a balance of forces to account for the apparent solidity of the atom, hit upon a concept of halo-like domains on a shell, not running around its equator, but rather like circles drawn on the surface of a balloon. He sees the halos as pressing like stones in a spherical arch, attracted toward the nucleus by its electric charge, but restraining each other in place. He has read much on the subject and has made models with many materials. One type, made out of circular magnets, turned up an odd relationship. Circular magnets can make shapes, but only certain numbers of them will make spheres. With one exception, these numbers match the number of electrons that can occupy shells, according to the Periodic Table. Using his idea, he can represent the atoms of all elements.

He always felt that his physical models didn't capture the beauty of his idea. On his SGI computer he has done a prodigious amount of work to render his models of the atom. His work has been shown at places where scientists could see and discuss it. Scientists don't feel the models meet their concerns, and quarrel with them somewhat. To date, no one has made a discovery using them. Their "uselessness" keeps them in the realm of art, which suits Snelson just fine. His computer graphics are deep and rich computer art.

But, tensegrity, which he thought of in 1948, is being used more than forty years later to show the "close cooperation of proteins" inside and outside of cells![4]

Now we turn to scientific visualization. **Ellen Sandor,** who also started as a sculptor, has recruited and led a team that created a new way to display scientific computer graphics. These displays, called PHSColograms (for PHotography, Sculpture and Computers, pronounced SKOL-o-grams) represent a new medium for artists as well.

In 1981 she made a big 3-D triptych for the wall of an office on Wall Street. Two years later, she recruited a team that called itself $(\text{Art})^n$. It created a huge camera studio to make barrier-strip autostereograms. Autostereograms, so-called because a 3-D illusion can be seen with the unaided eye, were invented around the turn of the 20th century. A big still-life or diorama was photographed several times (usually nine), each time from a different angle. The film being exposed was covered with a "barrier screen," a black film with thin, transparent vertical lines—so that each image reached it only from a particular angle.

When one views an autostereogram, one moves past it. Another screen on this strange photograph allows each eye to see only one of the nine images at a time as you move by. The two eyes each see slightly different images, which the brain translates into three dimensions. Autostereograms are very difficult to make. Exposures are long. Moving the subject and the barrier film must be done precisely. One mistake ruins a day's work.

The resulting project combined these images with other media for a colorful 20' high installation in the lobby of a Chicago office building. They called it *PHSCologram 1983*. The ones that followed were often of sculptures and scenes with exaggerated perspective made especially to be photographed by the process. After seeing *PHSCologram 1983,* Dan Sandin, of The University of Chicago's Electronic Visualization Lab, understood the implications of it for scientific work. After he joined $(\text{Art})^n$ in 1985, computers were used, greatly simplifying the mechanics and making possible PHSCologram of synthetic, computer-generated, completely imaginary objects. **Donna Cox**, at the National Center for Supercomputing Applications in Urbana, IL, has used the PHSCologram technology to model three-dimensional projections of four-dimensional objects. (She is another artist who is making a contribution to science by helping scientists to be more effective in visualizing their data). The $(\text{Art})^n$ team includes, besides Dan Sandin and Donna Cox, **Stephan Meyers, Jim Zanzi, Randy Johnson** and **Ron Nielsen.**

A breakthrough, the Stealth Negative technique, was introduced by American Printers and Lithographers in 1988. This allowed $(\text{Art})^n$ to by-pass the labor of physically making a photographic negative. The computer generates the barrier screen design and 13 different views of the subject. It creates a file which can be read by the computer of a prepress scanner, the same used in the printing industry to make four-color separations for printing plates. The output is transparent, in black-and white. Each of the four transparencies is exposed to the appropriate color of photographic film, and all are sandwiched together to make the four-color image, which is then contact printed onto Cibachrome film. The Cibachrome is mounted on the backside of a sheet of clear plastic. The computer also prints the black-and-white barrier screen, which is mounted on the front side of the plastic. Lit from behind by a lightbox, it produces the colorful 3-D illusion.

At the moment, these displays make wonderful science exhibit pieces, but are too expensive to be used routinely to help scientists visualize data. However, $(\text{Art})^n$ anticipates that PHSCologram capability will be used in laboratories when small computers become more powerful.

Ellen Sandor is eager for artists to avail themselves of the technology. The artist in her also responds to the science images as art. She says: "For someone who is not a technical person, I have fallen in love with visualizing the invisible."[5]

In the realm of artificial intelligence (AI), **Roman Verostko, Harold Cohen,** and **Myron Krueger** have made contributions that are very intriguing for what they tell us about the emerging human-machine symbiosis. Symbiosis is when two species live intertwined, each supplying what the other lacks.

A personal art concept has led **Roman Verostko,** director of this conference, to explore computers for art. The tension between control and uncontrol are his subject, pursued for many years in drawing and painting using the Surrealist technique of "automatic" painting (i.e. making marks with no attempt to edit in order to access other realms of the psyche).

In 1970, Verostko learned to program, and in 1982 began writing a program to create art. A concept that fascinated him was epigenesis, that is, how a seed (genotype) unfolds into a mature being (phenotype). The computer program is a genotype that he creates. By its output (phenotype) he learns more about the logical structure he has created. It reveals something about computer logic that interests him. Sometimes, a bug creates an aberration. If it is lovable, he retains it. Taking cues from feedback like this, he modifies the program. As this process has developed over the years, he has created a program, Hodos, rich enough for other artists to use for their own art concepts.

His original fascination with control and uncontrol, the tension of opposites, is still observable in his present work. Hodos randomly repeats a line theme in many locations and rotations. Verostko has enabled the computer plotter to draw the line motif large with a Chinese brush. He inks and hands the brush to it when prompted by the computer program. That's symbiosis! Verostko's teaching a computer to make expressive lines, says Roger Malina, is "like teaching dolphins to talk to us."[6] Verostko says: "Software, in an uncanny way, appears to have a life of its own. The artist's role is to humanize it."[7]

Artist **Harold Cohen** has given great attention to the marks humans make and why. In his curious quest, he has not only extended what we understand artificial intelligence (AI) to be, but has ventured into cognitive science, the psychology of knowing, as well: What does it mean to draw, to look at a drawing and understand it, and what is it possible to tell a computer about generating one?

In 1966 Cohen was a visible success: at the Venice Biennale he had been one of five painters to represent Britain; but his career soon made a right-angle turn. An abstract painter, he was wrestling with the Abstract Expressionist dogma that really pure and good paintings had no meaning beyond the beauty of the painted surface. So, he experimented with making marks that looked like they *ought* to mean something more. From whence came the glimmer of meaning? From the viewer. This dialog was the basic issue in his work for many years.

Discontented with the big-time art world, he accepted a one-year invitation to the University of California at San Diego in 1967. He ended up staying, because he stumbled upon something new. Jef Raskin, then a graduate student in music and later one of the developers of the Macintosh computer, persuaded some of his non-technical acquaintances to learn programming—in spite of the fact that early manuals and rudimentary computers made this difficult.

Six months later, it struck Cohen that programming decision structures and the decision-making process in painting bore some similarity. (If...then...else...) routines were a branching structure that created unpredictable outcomes. This is called a *contingent* system, in which rules and feedback, plus randomness, (deterministic plus non-deterministic factors), create a result that is unanticipated—but usually comprehensible.

Could a drawing create itself, using a computer? What rules would it need? The computer's rules would instruct its pen plotter to draw. It would become a tool for describing and testing Cohen's hypotheses about the image-making activity of the brain. His work converged with artificial intelligence (AI) research because he assumed that the symbol-manipulating computer could be treated as functionally equivalent to the brain.

He gave his program, called Aaron, rules and feedback. With feedback, Aaron could avoid messing up the drawing it had already done. And, it would know when to stop. *Three Behaviors for partitioning Space,* 1972, was an early result. Beyond a few rules about where to place lines, what else would Aaron have to know to give the impression that these are marks that convey *intention,* a drawing, not simply some process like erosion leaving its trace?

The next year in a remote spot in California, he saw petroglyphs. Once they had meant something to someone. They looked to him as if they *ought* to mean something, just as his old paintings had. Cohen concluded that all humans recognize and can use outlines, or closed figures, to represent objects. Could a computer draw such a closed figure, a blob? What other elements in the petroglyphs suggested what Aaron should know? Repetition, division, a sense of the overall use of the space. By 1977, his drawings had reached "preschool," with a groping, wavering line (deliberately avoiding splines, the computer's slick look), and a space populated with significant-

looking forms.

He was immensely pleased. These appeared to have a meaning that was really absent. They elicited from the viewers the meaning-generating response that he felt refuted the reductionist dogma of abstract expressionism. Also, Cohen had made a tool for further exploration.

Also by 1977, he was beginning to do installations with Aaron churning out drawings. (Particularly difficult with computer-shy curators and technical troubles). Before Cohen's name was on the wall at the San Francisco Museum in 1979, a European critic walked into his installation and remarked that the work looked like paintings he had seen before by...Harold Cohen! Like Verostko, he had made the computer the tool for his own vision, a vision based on a concept that produced a distinctive-looking result.

However, Cohen had reached a plateau. He couldn't think of any more "primitives" like blobs to teach it. The next step was to teach it something about the real world—knowledge representation, as it is known in AI. First, pictorial space: Our mind's strategy to judge spatial relations is to detect when one object hides another. Programming Aaron to imply hidden objects was an extension of Aaron's knowing where the others were already drawn: suitable lines between existing objects could work wonders.

Secondly, recognizable things: Aaron learned to make stick figures. Cohen conceived a clever idea: The computer scribbled or made stick figures, but held them in memory, did *not* output them to the plotter. These were outlined, the way children sometimes do. The program only plotted the outline. He also gave Aaron some simple rules about four-legged animals.

He really crossed over to figuration in 1985. Someone challenged him to do the Statue of Liberty. Aaron needed simple anatomical rules: what limbs connect to what. Outlined scribbles evolved into plant life, and the statues evolved into figures in his *Eden* series by 1987.

Recently, Cohen has tackled facial features, solving the problem of putting details inside of objects. Arms and hands are in complicated spatial arrangements. When a figure has crossed arms, which is "forward," hiding the other? Consider what he had to tell Aaron about *that*. The figures must now exist in 3-space with x,y,z coordinates. He has had to invent rules for hidden-line removal entirely different from CAD system ones. It illuminates what *we* know to in order to draw.[8]

Cohen began doing computer art nearly 25 years ago. It took several years to get any results. For years, art professionals couldn't imagine computers in the same compartment as art. However, when computer graphics came on the scene, most programmers were busy creating a synthetic reality of a different sort, based on light and perspective, as in the last 500 years of Western European art and photography. Most computer artists were busy using the equipment as paint-boxes, image enhancers or controllers. Few realize what Cohen has accomplished.

Cohen believes the business of the highest-level art in every period is to rethink what art is. I believe many of us here are engaged in this, in our own way. As we begin to think globally, the Western art-historical tradition will recede into proper perspective. Cohen's investigations can be seen as part of a general movement to identify what is universal in art-making. They also suggest another way artists and machines can build upon each others' work, symbiosis.

Finally, we have **Myron Krueger,** a computer scientist who became an artist. By so doing, he has learned much about virtual reality, artificial intelligence *and* about human behavior.

We are acquainted with virtual reality (VR), the head-mounted display and DataGlove, which grew out of flight simulation. Myron Krueger's vision of VR is much more comfortable: it is a space that surrounds you, not a suit of gear.

In 1969, as a graduate student in computer science, Krueger was invited to join a collaborative art project called *GLOWFLOW*. It was a computer-controlled immersive environment. Phosphorescent liquids pulsed through horizontal tubes around a darkened room, the flow interactively controlled by people stepping on pressure sensors in the floor. The artists in charge didn't want the meditative mood disturbed by people playing with the cause-and-effect of the interaction, so a delay was deliberately built in. Krueger strongly disagreed with this, feeling that real-time interaction was the fundamental gift the computer offers the arts. He became an artist to create what he called *responsive environments*.

In the first, *METAPLAY,* a video camera displayed a person's image on a big screen. A computer tracked body movements and offered a computer graphic response. Computer graphics drawn by a live artist were superimposed on the participant's live image. Krueger still remembers when a participant drew a picture in the air with his finger, causing a computer graphic outline to flow from his "finger" across the screen—unplanned, but a logical extension of the setup. Krueger has become a student of behavior in order to factor it into the programming for his pieces.

His next piece, *PSYCHIC SPACE,* was based on the assumption that people are problem-solvers. It presented a maze on a big screen to the participant, with a clue about where he or she stood in it—but not just any maze. If one tried to leap the boundaries, the lines stretched! After each maze was solved, the person was "trapped" in yet another. Provoking! Krueger programmed 40 different responses. Often, these countered people's normal expectations, poking fun at those taking it too seriously.

In the mid-1970s, Krueger conceived *VIDEOPLACE,* which was "nowhere," in what we now call cyberspace. The silhouettes of people at different locations were juxtaposed on the same image. A person, finding his or her image on the screen with the moving image of another person, found it irresistible to interact. People seeing their images touch reacted as if being physically touched.

CRITTER took this a step further: The silhouette of a person could interact with a cartoon bug that had a big repertoire of responses. Chase it, it fled. Stand still, it climbed up. When it reached the top of the head (victory!) several things could happen, the final one being that as it jumped up and down, the image of the person disappeared. People were so identified with their image on the screen that many looked down and checked their body as this happened!

A recent piece, *VIDEODESK,* has practical applications. Hands of people from several locations can be projected onto the same virtual desktop and point to text or graphics without a mouse while working together.

Like Verostko and Cohen, Krueger uses the branching structure of his computer programs to activate a variety of scripts. Krueger changes these, not only in response to what he notices about them, but about the behavior of people playing in his environments. The object of the artist always is to toy with expectations and hold a viewer's interest. With so many variations, people cannot exhaust the possibilities in one session. Moreover, the program can accumulate experience. Ultimately, it will be able to create new interactions. This is symbiosis!

Being ahead of one's time can be fascinating, but not very remunerative. Especially at the beginning, obtaining funding was hard. Using the low-budget equipment of that era, the problem was for the computer to keep up with people. Krueger overcame this by teaching himself electrical engineering and chip design to add special-purpose processors. According to Howard Rheingold, author of *Virtual Reality,* "Krueger has logged more hours building artificial spaces and putting them through their paces than anybody else in the VR world."

Beyond this, to his delight, he has exposed unexpected behavior in people. In 1977 he prophesied: "We are incredibly attuned to the idea that the sole purpose of our technology is to solve problems. It also creates concepts and philosophy. We must more fully explore these aspects of our inventions, because the next generation of technology will speak to us, understand us, and perceive our behavior. It will enter every home and office and intercede between us and much of the information and experience we receive. The design of such intimate technology is an aesthetic issue as much as an engineering one. We must recognize this if we are to understand and choose what we become as a result of what we have made."[9]

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5. Harold Henderson, "Art or Science?" *Reader*, Vol. 20, No. 45, Aug. 16, 1991, p. 18.
6. George Boole, *Derivation of the Laws of the Symbols of Logic from the Laws of the Operations of the Human Mind*, with computer illustrations by Roman Verostko and preface by Roger Malina (Minneapolis: St. Sebastian Press, 1991).
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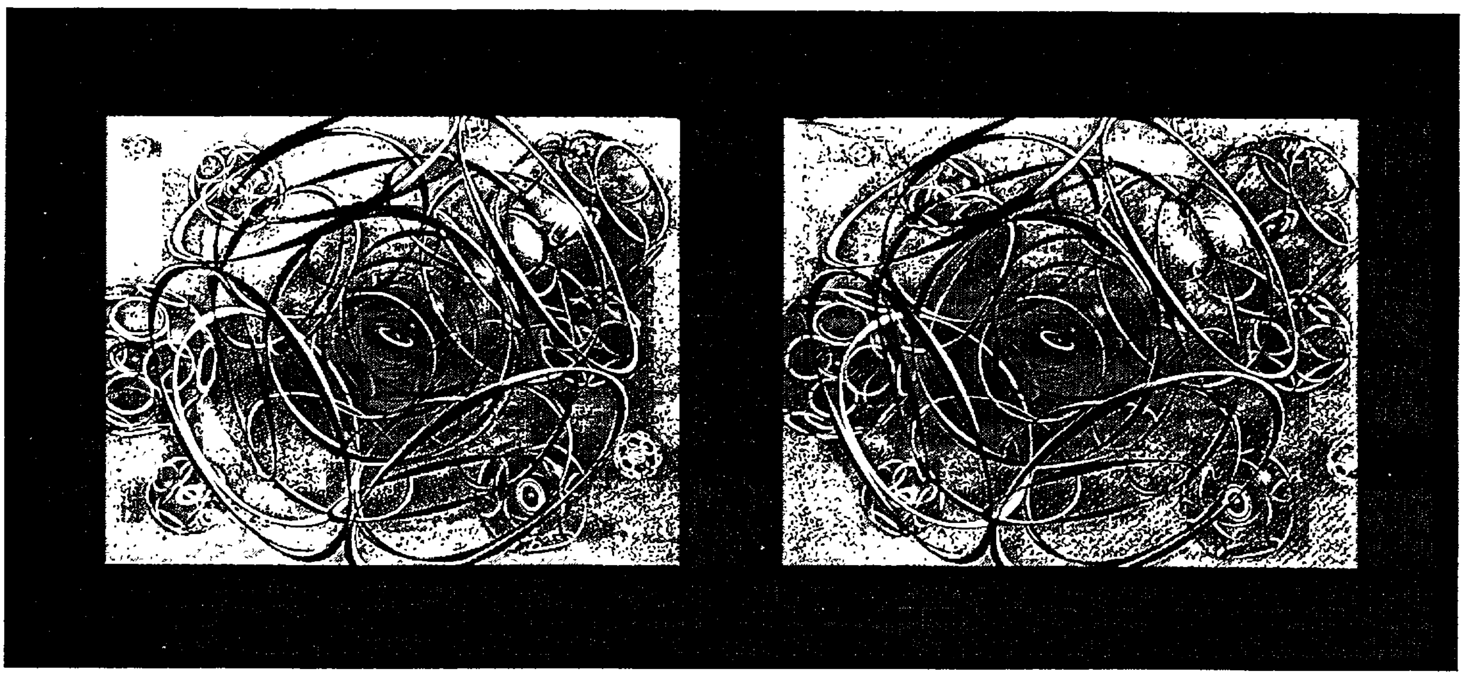

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The Semiotics of the Digital Image

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Contemporary art criticism is deeply rooted in modernist and postmodernist theories. Modernism, which drew on the formalist theories of critics like Ad Reinhardt and Clement Greenberg, was a period of art-for-art's sake that called for "pure painting" that was free of "illustration, distortion, illusion, allusion or delusion" [1]. For Clement Greenberg, the physical dimensions of the medium defined "pure painting" and "pure sculpture." Artists stripped their paintings of three-dimensional illusions and embarked on academic studies that emphasized "the flat surface, the [rectangular] shape of the support, the properties of pigment" [2]. Greenberg's formalist theories sought to establish objective criteria for the evaluation of art based on this interaction of form and medium. Modernist theory, however, was highly deterministic with only one approach to evaluating the aesthetic quality of artwork.

As formalism reached a peak in the 1960s, body, performance, pop, and conceptual art rejected the modernist doctrine and ushered in the era of postmodernism which challenged all restrictions on form and aesthetics. For many theorists, the fragmented pluralism of postmodernism led to ". . . depthless styles, refusing, eluding, interpretation" [3].

Out of this aesthetic chaos, new forms of artwork emerged including artworks that use computer graphics as an integral part of the design process. However, much of this art is criticized for its lack of aesthetic quality, with critics maintaining that the work merely imitates earlier art forms. In many instances, the critical theories of modernist and postmodernist discourse define these evaluative criteria. Reminiscent of the modernist doctrine, many writings highlight characteristics of the digital medium such as kinetics, interaction and networking, simulation, virtual reality, and numerical analysis as the principle criteria for defining and evaluating the aesthetics of digital art. Critics often misinterpret works that do not exhibit these attributes as artwork that could have been done in another medium without the use of electronic technology.

This approach to evaluating digital art overlooks the semiotics of the digital image in which symbols become interpretations of symbols, and multiple levels of graphic encoding take on discursive characteristics similar to linguistic syntax. As this conceptual environment of symbols and text replaces tactile and kinesthetic interaction with the artwork, new forms of creative expression codify form, space, action, and time into diverse levels of abstraction. Unlike the fragmented visions of the postmodernist period, these works merge discrete concepts into fluid, integrated statements.

This paper examines the semiotics of the digital image within the context of philosophical developments in mathematics and physics. In these fields, causality and deterministic logic have been replaced by "descriptive" mathematics and scientific theories of relativity and quantum mechanics. The concepts behind these new scientific models of reality are also an integral part of the semantic-syntactic structure of the digital image.

The Visual Logic of Descriptive Geometry

Geometry is one of the oldest branches of mathematics and the architectural framework for computer graphics. The term *geometry* is derived from the Greek words meaning "earth measurement," and early Euclidean geometry used deductive methods to study flat surfaces (plane geometry) and rigid three-dimensional objects (solid geometry). These linear, static methodologies were based on sets of unproven assumptions called axioms that were derived from perception and experience.

Mathematicians gradually realized that these intuitive assumptions should be replaced by abstract terms devoid of preconceived meaning. This type of formal system would provide a more flexible structure for evaluating spatial relationships. In 1637, Descartes used algebraic equations to visualize points, lines, and forms, thus raising the study of geometry to a new level of abstraction by detaching it from its perceptual base. However, Cartesian geometry, like Euclidean geometry, was still founded on deterministic logic and deductive reasoning.

The 1800s brought new philosophical and scientific inquiries into the relationship between optical truth and interpretation. Mathematicians reevaluated traditional assumptions about space. New theories evolved that further underscored the need for geometric systems that were not based on the intuitive perception of space and time. In 1854, for example, a German mathematician named Georg Riemann postulated that space could be curved--a theory that Einstein later used to develop relativity. Riemann's research, along with the work of other mathematicians in the nineteenth century, required new methods of defining and visualizing spatiotemporal concepts. The linear determinism of Euclidean geometry was slowly replaced by mathematical models that described multidimensional abstract relationships. The dynamic interaction of these spatiotemporal descriptions was reflected in new mathematical terms such as *betweenness*, *projective*, *translation*, *reflection*, *hyperplanar*, and *inversive*.

In the 1960s, with the help of computer graphics, mathematicians bridged the gap between symbolic descriptions and perception by using patterns to visualize logical processes and simultaneous relationships. Mathematician Lynn Steen describes mathematics as a "science of patterns" with abstract levels of visual encoding in which "theories emerge as patterns of patterns" [4]. In this new descriptive geometry, perceptual references symbolize dynamic processes and interrelationships that change over time. Logical analysis is augmented by the perceptual, holistic synthesis of visual patterns. According to mathematician Jacques Hadamard, images are important to provide a "simultaneous view of all the arguments" [5].

The *visual logic* of descriptive geometry enables mathematicians to understand the structure of a problem and then reconstruct and improve their intuitive understanding of numerical relationships. Multiple levels of perceptual encoding create a model for describing "those aspects of visual modes of thought that appear to lie beyond the analogy of mere sight" [6]. Mathematicians can analyze the syntactical components of geometric space and then synthesize those relationships into an integrated system.

Metastructural Models in Physics

Like early Euclidean geometry, classical physics was built on deterministic logic and reductionist theories that limited the interpretation of physical forces to strict causation. Newtonian mechanics, for instance, was built on the reductionist theory that time and space were rigid and constant. Newton described time and space as follows:

> Absolute, True, and Mathematical Time . . . flows equably without regard to any thing external. . . . Absolute Space, in its own nature, without regard to any thing external, remains always similar and immovable [7].

In classical physics, reality was an objective truth, and the scientist was a passive observer looking on. However, in science like mathematics, theories of indeterminism eventually replaced Aristotelian logic. With the introduction of relativity and quantum physics, a new scientific model of the world emerged in which dynamic interactions replaced static, linear forces.

In his theory of relativity, Einstein demonstrated that space and time are not absolute. Both space and time are multidimensional forces that defy the limitations of perceptual interpretation. At lightspeed, for example, time encompasses both the present and the future. In effect, time ceases to change because it contains all change [8]. Spatial representations also merge at high speeds. As space is compressed, multiple views of objects are possible from a single perspective because planes and volumes become one [9].

Quantum physics continued to develop this pluralistic and highly abstract model of spatiotemporal interaction. Traditional observations about the physical world broke down in the microscopic world of quantum mechanics. Scientists needed new theories to explain the indeterministic and highly interactive nature of subatomic units. In 1926 Niels Bohr developed the theory of complementarity to describe the antithetical duality of physical forces [10]. Light, for instance, is *both* a wave *and* a particle. However, light reveals only one attribute at a time, and the scientist determines that attribute by the type of measuring device used in an experiment. Scientists also learned that multiple forces such as gravitation, nuclear forces, and electromagnetism can operate simultaneously in the same place [11]. In this multidimensional model, physicists discovered the "quantum leap," the fact that electrons can move between orbits and simultaneously appear in another orbit without traversing the intervening space [12]. The linear dimensions of strict causation that characterized classical physics were replaced by a matrix of interactive relationships.

The world of quantum physics raised as many questions as answers. There was no longer any such thing as "objective" reality. Relationships were defined by the participation and interpretation of the observer. Like the mathematicians of the time, scientists learned that they could no longer rely on intuition and experience to define physical forces. They needed to build a flexible, abstract framework for a virtual world with tentative truths.

The Semiotics of the Digital Image

Mathematicians and physicists demonstrated that we cannot rely on our perceptual interpretations of reality. Instead, we must raise our intuitive knowledge of space and time to a higher level of abstraction that defines the dynamics between perception and reality. Once we identify these interactive forces, we can create multidimensional models that integrate mathematical laws and interpretation into virtual extensions of the physical world.

Psychologists call this process of redefining perceptual knowledge "reflective abstraction." Computers have made it easier for mathematicians, scientists, and artists to use this process to visualize and construct new knowledge beyond the boundaries of logic and expectation. In art, the results are a new visual aesthetic that echoes the philosophical perspectives of modern mathematics and physics in the following dimensions of digital semiotics:

- Metastructural Dynamics
- Cognitive Mapping
- Visual Logic

This paper discusses each of these points and cites examples of representative artwork. Due to space restrictions, it was not possible to include illustrations of the many works of art that are mentioned. However, the reference list at the end of the paper includes sources for the cited works [13].

Metastructural Dynamics

In computer graphics, terms like *three-dimensional model*, *rendering*, and *simulation* suggest an artificial retreat from reality. However, artists are actually using these techniques to visualize scientific interpretations of reality by creating metastructural environments that expand the intuitive dimensions of space and time into abstract models of a dynamic, virtual world.

Using an architectonic system of mathematically defined forms, colors, compositions, and perspectives, an artist can control the hierarchy of geometric relationships and redefine the geometric syntax of experiential space and time. The use of geometric coordinates to specify spatial relationships has shifted the artistic focus to linear and surface projections rather than perspective projections. Working with subtle changes in the attributes of lines such as width, color, texture, and position, artists transform the planar dimensions of linearity into volumetric extensions of space. This type of "linear space" is an integral part of works by artists such as Eudice Feder (*Separation*, 1980; *Permutations*, 1980; *Wind-Warn*, 1985), Herbert Franke (*Serie 1956*, 1956; *Grafik I*, 1956), and A. Michael Noll (*Ninety computer-generated sinusoids with linearly increasing period*, 1965). These artists use precise, geometrically controlled lines to create multiple levels of perceptual space. Tony Longson adds a physical dimension to this concept of linear space by creating line and "tonal" drawings on multiple panels of Plexiglas and then overlapping the panels to create three-dimensional constructions (*Group Theory Grid*, 1968; *Square Tonal Drawing #2*, 1980).

For other artists, surface rather than linear projections shape the metastructural dynamics of space and time. In works by Manuel Barbadillo (*Untitled*, 1975) and Vera Molnar (*Hypertransformations*, 1973-6), geometric progressions define randomly shaped, interlocking planes of color with ubiquitous perspectives and spatial orientations. In these works, the two-dimensional space becomes all-inclusive and folds into itself much like the curved space of modern geometry and physics.

The medium of light in computer graphics also transforms the spatial dimensions of lines and planes. For example, in works by Ben Laposky (*Oscillon 40*, 1952; *Oscillon*, 1956) and Kathleen Dolberg (*Gossamer*, 1984), transparent filaments of light create flowing shapes that engulf the surrounding space and blur the perceptual boundaries between lines, surfaces, three-dimensional space, and infinity. The medium of light also defines different levels of linear and surface space in the "virtual sculptures" of Michael O'Rourke. These two-dimensional images juxtapose definitive geometric lines and objects with diffuse areas of modulated colors. This visual interplay between light and space is sensually articulated in O'Rourke's backlit transparencies such as *Manhattan Invitation* (1988).

The reflective and refractive qualities of light also enable artists to visualize the spatial relationships *in* and *between* objects. In the animations of Yoichiro Kawaguchi (*Origin*, 1985; *Ocean*, 1988), reflective and transparent surfaces transform the organic forms into mirrored visions of space within space. The images embrace space and time from all directions rather than limiting the vantage point to a unique perspective. Like the works of Barbadillo and Molnar, space becomes all-inclusive and nonlinear.

Time, in particular the spatial representation of time, establishes a conceptual link between the physical and virtual dimensions of these metastructural models. Time is defined as an infinite extension of space and form through the mathematical abstraction of lines, angles, and curves. The geometric syntax of the fractal image is an excellent example of this temporal link between the physical and virtual dimensions of reality. In other artwork, such as Kawaguchi's art, time is defined by reflective and transparent objects that visualize the passage of light through space. In these images, layers of visual data define multidimensional arrays that visualize simultaneous and sequential levels of spatiotemporal perception.

The metastructural dynamics of the digital image integrates structure and control into a spatiotemporal continuum that defines an infinite, virtual space. This visual dichotomy is especially evident in artwork that juxtaposes the definitive geometry of three-dimensional objects with subtle gradations of texture, color, transparency, or reflection. The computer paintings of David Em (*Redbal*, 1980; *Zotz*, 1985) and my own artwork (*Rhapsody in Time*, 1986; *Coloratura 100*, 1988; *Kaleidoscope*, 1992) represent this type of visual model (see Figure 1). In these images, geometric objects anchor the work in the logical dimensions of space and time while perceptual transformations challenge the limitations of experiential reality.

Cognitive Mapping

The mathematical models of descriptive geometry, relativity, and quantum mechanics emphasized interactive webs of sequential and simultaneous events. In many forms of digital art,

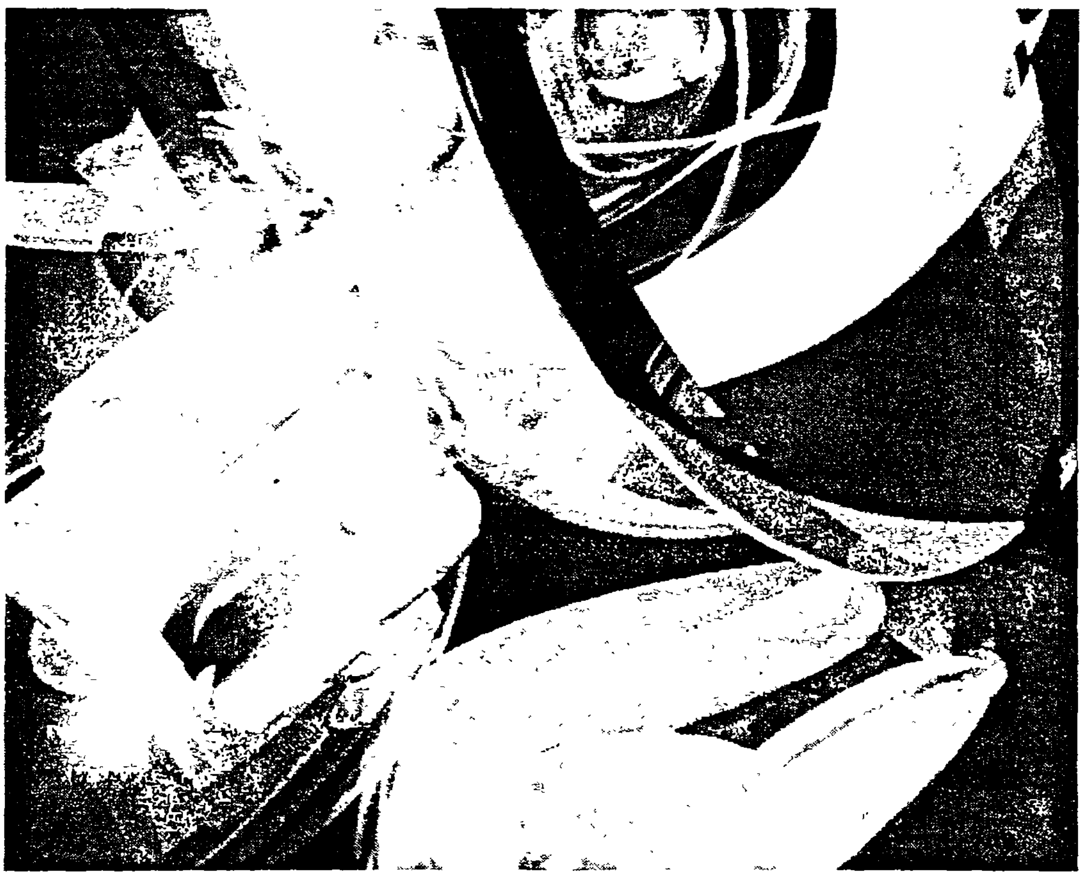

Figure 1. *Kaleidoscope* by Patricia Search integrates geometric structure and control into an abstract, virtual space. (Copyright 1992 by Patricia Search. All rights reserved.)

perceptual and cognitive processes define a matrix of temporal relationships, resulting in a complex network of associations.

In some artwork, this multidimensional structure visualizes the geometric syntax of space and time. Bruce and Susan Hamilton, for example, use computer graphics to create conceptual drawings for sculptures like *Tetrad* (1984), *Metamorphosis III* (1987), and *Scarab* (1990). In these works, mathematically defined proportions create a geometric balance between lines, planes, textures, and color. The mathematical syntax of these sculptures not only visualizes logical, sequential processes but also provides a syntactic filter for simultaneously mapping multiple perspectives in space and time.

Other artists use a dynamic, visual-linguistic syntax to construct interactive webs of associations. In *Random Ranson* (1986) and *Indicted Invited* (1988), Tom Leeser extracts images and text from their original sources and integrates them into a "media archeology" that challenges their original meanings and context [14]. Paul Berger creates digital photographs that visualize the cognitive networks of information in a database. In works like *Print-Out* (1988), Berger uses photocopied lists of database entries as backgrounds for photographic portraits [15].

In interactive works of art, narrative intention increases the complexity of cognitive mapping. The viewer expects to construct meaningful relationships and must continually redefine the webs of interaction between expectations and reality. Abbe Don explores these issues in *We Make Memories*, an interactive program that allows viewers to create stories by experimenting with the associative links between content, structure, and context [16].

In the digital image, a semantic-syntactic network of images, text, and sound directs actions and expectations. The viewer constructs a system of relational codes that becomes an integral part of the interpretation of the work. Multiple levels of perception and cognition may exist within individual symbols. Jim Johnson, for instance, creates bookworks with symbols that integrate visual and linguistic semiotics. Using computer graphics, Johnson has designed a "Skeletons" font that is derived from silhouette drawings of skeletons. In the book *Dead Air* (1991), he uses this font to form words that complete phrases beginning with the word "dead," phrases such as *dead wrong* and *dead last* [17].

The work of artist Jim Rosenberg adds another level of inquiry to these visual-linguistic maps. He uses "word clusters" to experiment with the syntax of words that occupy the same point in logical and physical space. In his interactive program *Intergrams* (1990), a group of phrases is indecipherable when the phrases overlap each other in the same space. However, moving the computer mouse over the cluster discloses individual phrases and hides the remaining ones, revealing the meaning of the cluster [18].

The use of symbols to map perceptual and cognitive associations is an important dimension in the semiotics of the digital image. Like the recursive patterns in mathematics, symbols become interpretations of symbols. Thorne Shipley conducts theoretical research in "pattern and matrix vision" [19]. His work investigates the different levels of perception and cognition that are defined by visual patterns or textures in linguistic messages. Unlike Johnson who maps synonymic associations between words and images, Shipley is exploring what he terms "heterological message duality" or "message multiplicity" [20]. He illustrates this concept using words that are typographically constructed from other words. For example, in one of his illustrations, the text for the word *yes* is repeated in a pattern that forms the shapes of the letters in the word *no*. Similarly, the text for the word *you* forms the shape of an *I*, and the word *will* creates each of the letters in the word *won't*. When these typographical constructions appear in phrases like *No, I won't*, the visual patterns within each word communicate a secondary message--*Yes, you will* [21].

Future research and investigation will expand the semantic-syntactic dynamics of these types of cognitive maps. As artists expand their use of interactive multimedia in artwork, they will find new ways to add levels of sensory interaction to the layers of relational encoding. Artists will also learn how to integrate the linguistic patterns of user interfaces and programming languages into these visual symbols, adding still another interpretive link to the semiotic structure of these cognitive maps.

Visual Logic

Just as writing fostered the development of abstract thinking with the implementation of symbols and sounds to designate thoughts, the mathematical syntax of computer graphics defines another level of abstract thinking called visual logic. However, unlike writing that separated data from interpretation, this new abstract symbolism uses visual perception to synthesize data and interpretation into an integrated whole.

Artists, like mathematicians and scientists, use visual patterns to improve their intuitive understanding of logical and perceptual relationships. Many artists, for example, use computer graphics to investigate the logical and intuitive dimensions of design. The grid, which postmodernists rejected as a symbol of structural control, has resurfaced as an intuitive symbol of the underlying structure of spatiotemporal procedures. Daniela Bertol's collage *Bending and Twisting: Hypothesis #3* (1988) uses a twisted geometric grid to visualize the algorithmic structure of space and time. The grid is also an integral part of Andrew Glassner's *Celtic Knot* series (1987), black and white drawings that investigate the geometry and form of Celtic knot weaving. In these works, Glassner uses an invisible grid to create a visual pattern that symbolizes the spatiotemporal relationships in the perception and comprehension of this intricate weaving procedure.

Some artists use design techniques to create a multidimensional syntax that articulates the interaction of perception and cognition. For over twenty years, Manfred Mohr has been using computer graphics to analyze the relationships of lines in the cube (*P-26/2 Inversion Logique*, 1969; *P-155 Cubic Limit*, 1974-6; *P-306 Divisibility I*, 1980-3; *P-370-P Divisibility II*, 1985). Mohr uses the twelve lines that make up a cube to create a new visual language that "disrupts the symmetry of the cube" [22]. In his prints, individual lines, which form discrete units of information, create a visual syntax that signifies the sequential steps in the perception of geometric forms and space. At the same time, his designs form an integrated whole in which black and gray lines establish contrasting layers of perceptual events that disrupt the sequentiality and order of the mathematical logic.

Artists also use the visual logic of computer graphics to explore the intuitive synthesis of logical events. By juxtaposing text and images that symbolize procedures or actions with images that represent the end results of those actions, the artist constructs an interpretive dialogue that visualizes the temporal transformation of ideas. Colette and Charles Bangert, for example, use computer graphics to investigate how mathematical models visualize various types of forms (*Large Landscape: Ochre & Black*, 1970; *Circe's Window*, 1985; *Katie Series*, 1986-7). The software they have developed explores the relationships between numerical functions and the drawing process:

> At the time the programs were written, we thought of the transforms and the interactions of the instances. Now we think of the whole drawing as a picture of a single line in a high dimensional space [23].

Margot Lovejoy uses mathematical symbols to visualize the perceptual and logical representation of spatiotemporal relationships. In two-dimensional works such as *Azimuth I*

(1983) and *Azimuth II* (1983), geometric shapes, angled lines, geographical maps, and architectural drawings create a visual syntax that signifies the perceptual and cognitive processes involved in the interpretation of two-dimensional representations of space. Lovejoy's three-dimensional installations integrate physical space and time into the visual logic of spatiotemporal perception. In *Azimuth XX -- The Logic Stage* (1988), the artist juxtaposes three-dimensional, geometric forms with linear perspective grids that are projected onto the surrounding walls. Lovejoy describes her work as "the struggle to control, represent, and construct meaning in the 'gap between art and life' " [24].

The visual logic of the digital image is highly modular. Visual symbols can be rearranged to create new syntactical relationships. Digital images assume many characteristics of linguistic syntax but without jeopardizing their perceptual immediacy. The high level of abstraction in this visual system transcends the constraints of verbal language. The visual logic of the digital image shares many of the conceptual attributes of "metaphorms," visual metaphors that Todd Siler creates to describe the temporal and procedural relationships between art and science. Siler describes the power of metaphorms as follows:

> In metaphorming something, we can traverse the constraints of logic and verbal thought, transferring or relating from one object to another a new meaning, pattern, or set of associations. Like the language of pure mathematics, which can describe abstract *n*th-dimensional processes and forms, the symbolic language of metaphorms is also multidimensional. It operates simultaneously on many planes of associations, nuances, and meanings [25].

Conclusion

Modern mathematics and physics demonstrated that we need to develop abstract models of reality that are flexible enough to accommodate the shifting dynamics of a wide range of variables, including the subjective decisions and interpretations of the observer. To understand these multiple levels of interaction, these models must acknowledge differences as well as interactive relationships. Only then can we build a model that is flexible enough to change with new perspectives and observations. As Marvin Minksy points out in *The Society of Mind*,

> We usually like to think in positive terms about how various parts of systems interact. But to do that, we must first have good ideas about which aspects of a system do *not* interact. . . . In other words, we have to understand *insulations* before we can comprehend interactions [26].

For mathematicians, scientists, and artists, computer graphics provides a powerful tool for visualizing the insulations *and* interactions of a multidimensional system. The digital image integrates the structural control of analytical processes with the holistic powers of perception and interpretation. Artworks abandon the predictable, deterministic logic of the modernist period and the eccentric, fragmented pluralism of postmodernism which was characterized by random, irrational infrastructures. In the digital image, the geometry of mathematics and the logical syntax of programming languages create a conceptual framework for synthesizing complex webs of interactions.

In the future, new technology will alter the semiotics of the digital image. High-definition television, for example, will modify established perceptions in space and time. High-resolution displays will place an added emphasis on detail and text and increase the prominence of background imagery. As digital displays acquire the scale of actual walls, the syntactic structure of the image will become an integral part of the surrounding architectural space. In addition, the electronic dissemination of art, coupled with interactivity and collaborative networking, will increase the temporal dynamics of the digital image.

All of these developments further mandate the need for a new design discourse, perhaps based on an interactive audiovisual language, that reflects the dynamic structure of the digital image. Artists, mathematicians, and scientists are no longer concerned with a single view or interpretation of reality. Instead, the emphasis is on using digital technology to modify perceptions and restructure information. Models of reality, defined by abstract descriptions of tentative truths, are subject to constant reevaluation. This dialogue between logic and perception leads to an eternal quest for new perspectives--a quest that Minsky describes as the interaction of two types of complementary knowledge:

> We search for "islands of consistency" within which ordinary reasoning seems safe. We work also to find and mark the unsafe boundaries of those domains [27].

The semiotic structure of the digital image visualizes these complementary forces and helps us understand the limitations of perception and reason, thus enabling us to transform those "unsafe" boundaries into new knowledge and insights about the complex world around us.

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Live Interaction Applications for Real-time FFT-based Resynthesis

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Introduction

The Fast Fourier Transform (FFT) is a powerful general-purpose algorithm widely used in signal analysis. FFTs are useful when the spectral information of a signal is needed, such as in pitch tracking or vocoding algorithms. The FFT can be combined with the Inverse Fast Fourier Transform (IFFT) in order to resynthesize signals based on its analyses.This application of the FFT/IFFT is of particular interest in electro-acoustic music because it allows for a high degree of control of a given signal's spectral information (an important aspect of timbre) allowing for flexible, and efficient implementation of signal processing algorithms.

This paper presents real-time musical applications using the IRCAM Signal Processing Workstation (ISPW) [Lindemann, Starkier, and Dechelle 1991] which make use of FFT/IFFT-based resynthesis for timbral transformation in a compositional context. Taking a pragmatic approach, the authors have developed a user interface in the Max programming environment [Puckette, 1988] for the prototyping and development of signal processing applications intended for use by musicians. Techniques for filtering, cross-synthesis, noise reduction, and dynamic spectral shaping have been explored, as well as control structures derived from real-time signal analyses via pitch-tracking and envelope following [Lippe & Puckette 1991]. These real-time musical applications offer composers an intuitive approach to timbral transformation in electro-acoustic music, and new possibilities in the domain of live signal processing that promise to be of general interest to musicians.

The FFT in Real Time

Traditionally the FFT/IFFT has been widely used outside of real-time for various signal analysis/re-synthesis applications that modify the durations and spectra of pre-recorded sound [Haddad & Parsons 1991]. With the ability to use the FFT/IFFT in real-time, live signal-processing in the spectral domain becomes possible, offering attractive alternatives to standard time-domain signal processing techniques. Some of these alternatives offer a great deal of power, run-time economy, and flexibility, as compared with standard time-domain techniques [Gordon & Strawn 1987]. In addition, the FFT offers both a high degree of precision in the spectral domain, and straightforward means for exploitation of this information. Finally, since real-time use of the FFT has been prohibitive for musicians in the past due to computational limitations of computer music systems, this research offers some relatively new possibilities in the domain of real time.

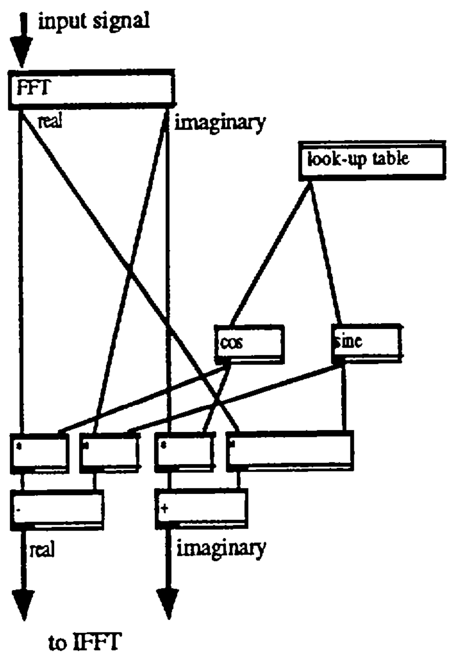
Programming Environment

Our work up to this time has been focused on real-time signal processing applications involving the spectral modification of sounds. (We hope to attack the problem of time-stretching at a later date.) Since we are constructing our signal processing configurations in Max using a modular patching approach that includes both time-domain and frequency-domain modules, we are able to develop hybrids, discussed below, that combine standard modules of both types. Development in the Max programming environment [Puckette, 1991] tends to be simple and quite rapid: digital signal processing (DSP) programming in Max requires no compilation; control and DSP objects run on the same processor, and the DSP library provides a wide range of unit generators, including the FFT and IFFT modules.

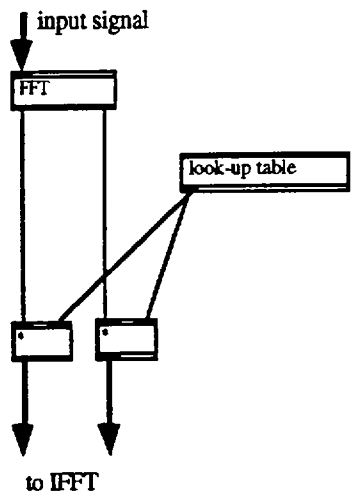
Algorithms and basic operations

All of the signal processing applications discussed in this paper modify incoming signals and are based on the same general DSP configuration. Using an overlap-add technique, the DSP configuration includes the following steps: (1), windowing of the input signals, (2) transformation of the input signals into the spectral domain using the FFT, (3) operations on the signals' spectra, (4) resynthesis of the modified spectra using the IFFT, (5) and windowing of the output signal. Operations in the spectral domain include applying functions (often stored in tables), convolution (complex multiplication), addition, and taking the square root (used in obtaining an amplitude spectrum); data in this domain are in the form of rectangular coordinates. Due to the inherent delay introduced by the FFT/IFFT process, we use 512 point FFTs for live signal processing when responsiveness is important. Differences in the choice of spectral domain operations, kinds of input signals used, and signal routing determine the nature of a given application: small changes to the topology of the DSP configuration can result in significant changes to its functionality. Thus, we are able to reuse much of our code in diverse applications. For example, though functionally dissimilar, the following two applications differ only slightly in terms of their implementation.*see figure below.*

phase rotation



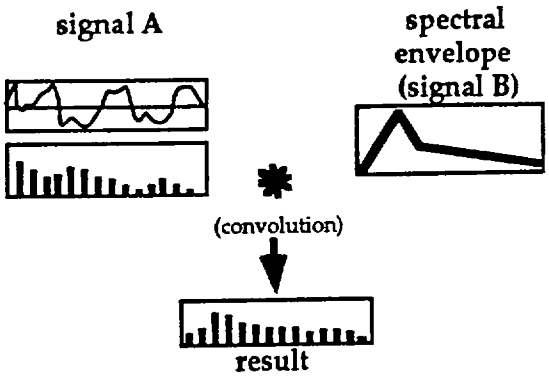
filtering



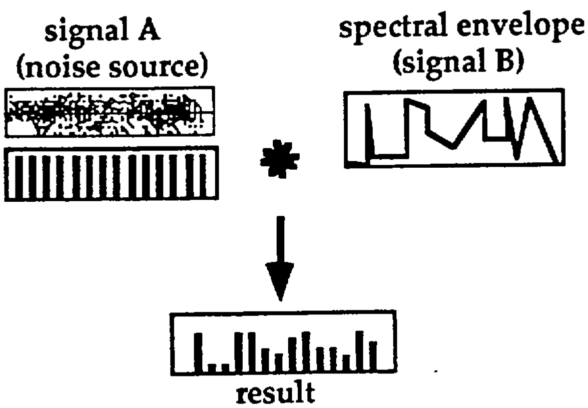
Applications

High-resolution filtering
Highly detailed time varying spectral envelopes can be produced and controlled by relatively simple means. A look-up table can be used to describe a spectral envelope in the implementation of a graphic EQ of up to 512 bands. The spectrum of the input signal is convolved, point by point, with the data in the look-up table, producing a filtered signal. Because we are able to alter the spectral envelope in real time at the control rate (up to 1kHz), we may modify our spectral envelope graphically or algorithmicaly, hearing

the results immediately. *see figure below.*

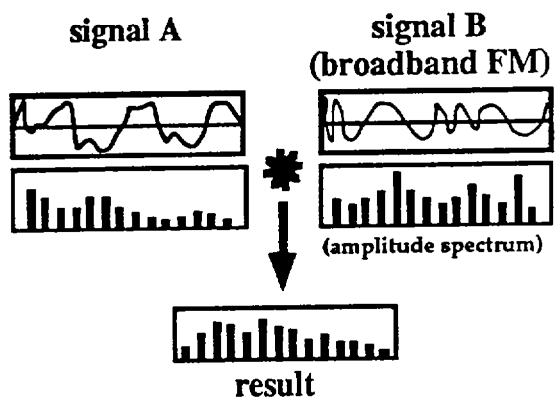


Using a noise source as the input signal, it is also possible to do *subtractive synthesis* efficiently. *see figure below.*



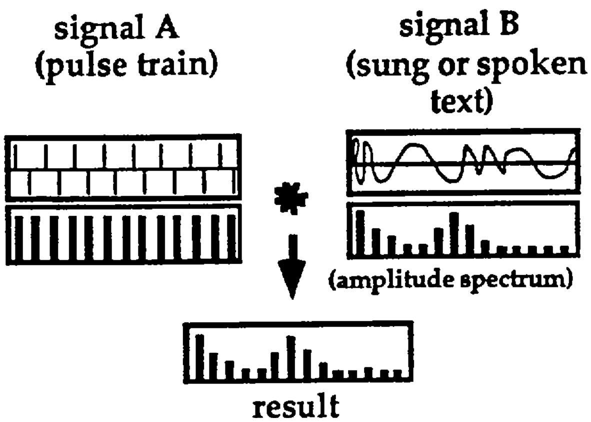
Low dimensional control of complex spectral envelopes

The spectral envelope used in the above filtering application can also be obtained through signal analysis, in which case a second input signal, signal B, is needed. Signal B is analyzed for its spectral envelope, or amplitude spectrum, that describes how signal A will be filtered. Obtaining a spectral envelope from an audio signal offers several interesting possibilities: spectral envelopes can be "collected" instead of being specified, and can change at a very fast rate (audio rate), offering a powerful method of dynamic filtering. Also, audio signals produced by standard signal processing modules such as a frequency modulation (FM) pair (one oscillator modulating the frequency of another) are of particular interest because they can produce rich, easily modified, smoothly and nonlinearly varying spectra [Chowning 1973] which can yield complex time varying spectral envelopes. These spectral envelopes can be modified using only 3 (FM) parameters: carrier frequency, modulator frequency, and modulation index. Likewise, other standard signal processing modules such as an amplitude modulation (AM) signal generator, an additive synthesis instrument, or a band-pass filter bank offer rich varying spectral information using relatively simple means with few control parameters. One of the advantages of using standard modules is that electronic musicians are familiar with them, and have a certain degree of control and understanding of their spectra. *see figure below.*

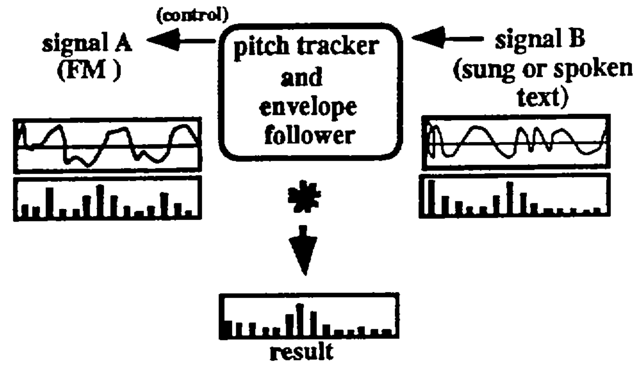


Cross synthesis

In this application two input signals are required: signal A's spectrum is convolved with the amplitude spectrum of signal B. Thus, the pitch/phase information of signal A and the time varying spectral envelope of signal B are combined to form the output signal. Favorable results are produced when Signal A has a relatively constant energy level and broadband spectrum, and when signal B has a well defined time varying spectral envelope. For example, when wishing to transform spoken or sung text, we assign the text material to signal B while specifying a pulse train, noise source or some other constant-energy broadband signal to signal A. Since the frequency information (pitch, harmonicity, noise content, etc.) of signal A is retained in the output, unusual effects can be produced when frequency related changes occur in signal A. In the following example of a *vocoder*, text can be decoupled from the speaker or singer's "voice quality", allowing one to modify attributes of the voice such as noise content, inharmonicity, and inflection, independently of the text material. *see figure below.*

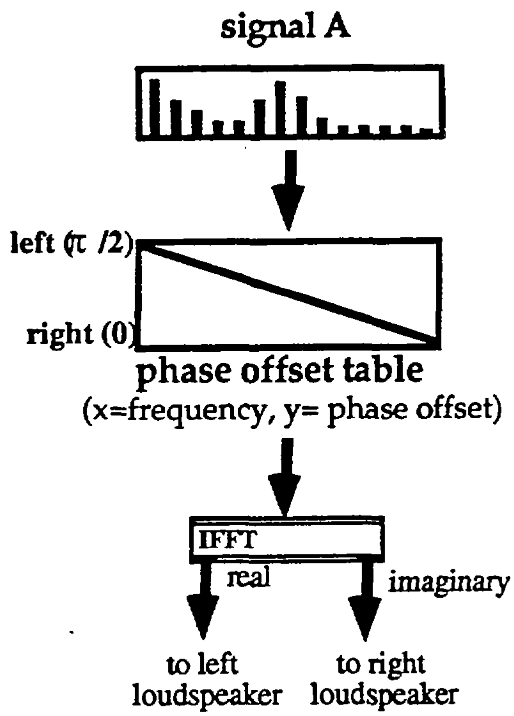


Mapping qualities of one signal to another
A simple FM pair may be used to provide an easily controlled, constant-energy broadband spectrum for use in cross synthesis as signal A. Musically, we have found that in some cases, the relationship between signal A and signal B can become much more unified if certain parameters of signal B are used to control signal A. In other words, real-time continuous control parameters can be derived from signal B and used to control signal A. For example, the pitch of signal B can be tracked and applied to signal A (FM) to control the two oscillators' frequencies. Envelope following of signal B can yield expressive information which can be used to control the intensity of frequency modulation (FM index) of signal A . In experiments incorporating the above, a mezzo soprano's voice was assigned to signal A, while her pitch and intensity were mapped onto signal B (FM), producing striking results akin to harmonization and frequency shifting. *see figure below.*



Finally, it should be noted that interesting transformations can be produced by simply convolving signal A's spectrum with signal B's spectrum. In this case, the phase (frequency) and spectral envelope information from each signal figures in the output signal. Transformations of broadband sounds, akin to, but more pronounced than flanging, can be produced when convolved with the signal of a high index, inharmonically tuned FM pair, whose frequency parameters are controlled by the pitch of the first signal.

Frequency dependent spatialization
In the spectral domain, the phases of a given signal's frequency components can be independently rotated in order to change the component's energy distribution in the real and imaginary part of the output signal. Since the real and imaginary parts of the IFFT's output can be assigned to separate output channels, which are in turn connected to different loud-speakers, it is possible to control a given frequency's energy level in each loud-speaker using phase rotation. The user interface of this application permits users to graphically or algorithmically specify the "panning" (phase offset) for up to 512 frequency components. *see figure below.*



Frequency dependent noise-gate
In the spectral domain, the energy of a given signal's frequency components can be independently modified. Our noise reduction algorithm is based on a technique [Moorer & Berger, 1984] that allows independent amplitude gating threshold levels to be specified for each frequency component in a given signal. With a user-defined transfer function, the energy of a given frequency component can be altered based on its intensity and particular threshold level. This technique, outside of being potentially useful for noise reduction, can be exaggerated in order to create unusual spectral transformations of input signals, resembling extreme chorusing effects.

Future Directions

The authors are currently working on alternative methods of sampling that operate in the spectral domain. Many interesting techniques for sound manipulation in this domain are proposed by the phase vocoder [Dolson 1986][Nieberle & Warstat 1992]. Along with the possibility of modifying a sound's spectrum and duration independently, we would like to perform transposition independent of the spectral envelope (formant structure), thus allowing one to change the pitch of a sound without seriously altering its timbral quality.

Conclusion

With the arrival of the real-time FFT/IFFT in flexible, relatively general, and easily programmable DSP/control environments such as Max, non-engineers may begin to explore new possibilities in signal processing. Though our work is still at an initial stage, we have gained some valuable practical experience in manipulating sounds in the spectral domain. Real-time convolution can be quite straightforward and is a powerful tool for transforming sounds. The flexibility with which spectral transformations can be done is appealing. Our DSP configuration is fairly simple, and changes to its topology and parameters can be made quickly. Control signals resulting from detection and tracking of musical parameters offer composers and performers a rich palette of possibilities lending themselves equally well to studio and live performance applications.

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CREATIVE PROBLEM SOLVING AS AESTHETIC EXPERIENCE*

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In this paper I will outline some ways in which we can better appreciate computer-based interactive art by placing it in the context of the psychology of creativity and problem solving. I will use examples from my interactive art works, which are themselves artistic and conceptual statements of perception and cognition. Within these works I view the physical environment as the art object, and the process of interaction as the art work.

All art objects can engage the viewer in active forms of perceptual selection. We choose to look at a part of a sculpture, or do a structural analysis or an interpretation of a painting. Traditionally this is done as part of the detached contemplation often associated with the aesthetic experience - the phenomenon of aesthetic or psychical distance (1, 2). Interactive art, in contrast, requires that viewers become behaviorally involved with the object and directly manipulate it, creating a new art work within the constraints of the environment created by the artist. It is thus a dynamic processes that changes over time and includes a high level of personal involvement with the work. In this process, interactive art is an extension of the ability of the viewer to analyze and interpret the work, but it is closer to the task of the traditional artist in which creative expression and problem solving are explicit parts of the process.

In my own work, relatively simple hand or body movements by the viewer activate photocells or other sensors which then, through a computer interface, change the sound or visual environment. Viewers usually do not develop a high level of technical competence. Some critics might argue that whatever the tool, the traditional brush or the interactive hand movements, some level of mastery is required to be creative. According to this argument, the lack of skill of the first time viewer and manipulator of an interactive art piece would preclude the possibility of any meaningful or creative result. But I would suggest that this confuses craft and art, where craft determines the object and art is the process of the experience.

One dimension that distinguishes my interactive art from other computer related interactive activities such as video games, is the openness of the work or the extent to which the nature of a desirable outcome has been defined. Video games have well defined outcomes where the goal is to avoid being eaten, to get points, etc. They often result in highly compulsive and competitive behaviors on the part of the participants. Loftus and Loftus (3) have developed a theory to explain these behaviors based on well-established

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psychological concepts of partial reinforcement schedules and cognitive dissonance. In interactive art, on the other hand, the outcomes are more defined by the viewer, although there are always constraints imposed by the art objects and the particular computer program. My goal as artist is to create a situation that minimizes constraints, and this seems to eliminate much of this competitive behavior. In the problem-solving literature, interactive art would be referred to as an ill-defined problem, while video games are well-defined problems. I will come back to this later.

Creativity. The term creativity has been used in a variety of ways. Traditionally a distinction has been made between the artist as creator, and the viewer or audience as the consumer or appreciator of the work already completed by the artist. In interactive art this distinction is blurred since the work is never complete and the art experience depends quite explicitly on the viewer's behavior. The activity of the viewer becomes part of the art work itself. The viewer becomes creator in this restricted context. Therefore it is necessary to make the distinction between creativity in a specific situation and long term creativity associated with a lifetime of work.

One of the recurring issue concerning creativity is whether it represents a set of special abilities or is an extension of normal cognitive abilities. Coupled with this issue is the validity of the romantic idea that true creativity is the result of great and sudden leaps of insight of which ordinary people are incapable. Weisberg (4) argues that creativity is most often the result of a long, slow, incremental process that is based on previous work. He makes this argument based on experimental studies and the analysis of well documented cases in which there is a clear creative output, e.g. Picasso's **Guernica**. Weisberg's view is consistent with the idea that interactive art can help the viewer develop the less formal aspects of creativity, namely personal expression and informal problem solving.

Irving Taylor (5) some years ago defined different levels of creativity. At the most basic is expressive creativity in which spontaneity and freedom are the dominant characteristics. He suggested that expressive creativity serves as the necessary foundation for higher levels of creativity, all of which are forms of problem solving. He distinguished among technical, inventive, and innovative creativity on the basis of the conceptualizations required. At the highest level is creativity resulting in a new conceptual framework for a problem area.

I will be primarily concerned with two aspects, creative self expression and creative problem solving within the specific situation of interactive art. I also assume that nearly everyone is capable of being creative in this situation. Only indirectly will I address the issue of the creative personality or the processes involved in creating masterpieces.

Interactive Art Works. In order to make the discussion more concrete I will describe some of my work. Over the years, I have constructed interactive sculptures and transformed a number of galleries into interactive spaces. I have done installations using existing environments, such as a collection of junk at Ars Electronica, an ornate Victorian staircase, and a large outdoor bell tower. All were interactive reinterpretations of existing parts of the environment, and served as statements about the perceptual nature of reality. Two specific works will be described in some detail: 1) a gallery space, **Doorways of Meaning**, and 2) a large willow tree at an outdoor arts festival, **Mayfair Network**. I will use them to illustrate some preliminary ideas about creative self expression and creative problem solving and the relationship between these two processes.

Doorways of Meaning, was shown recently at the Galerie Rene Blouin in Montreal, Quebec, Canada. The room, approximately 16 x 20 feet, was hung with red and green cord networks that created spaces and doorways between the spaces. Around the boundary between the floor and the walls were eight photocells embedded in shredded paper. Light from red and green spotlights in the ceiling shone on the photocells so that viewers moving in the room cast shadows on the photocells and changed their resistances. The microcomputer was continually monitoring the photocells and when changes occurred, it was programmed to send MIDI signals to a sampler, a drum machine and a synthesizer. The audio outputs from these devices were then mixed for the speakers in the room. The sampler was loaded with eight voice samples that spoke to the nature of experience and the metaphor of doorways as ways of perceiving and knowing reality. Half of the voice samples were in English and half were in French, as a tribute to the bilingual city of Montreal. Half were male and half were female.

People moved around and through the cords, creating shadows on the walls and individual sequences and patterns of voice, percussion and electronic music. For example, by moving rapidly, a babel of sound could be created which could fade out to a single voice when the viewer stopped. A number of people varied their speed and moved their arms. Others moved very slowly and meditated. While all seemed to understand that their movements caused the sounds, several tried to work out certain regularities in the pattern and tried to understand how it worked. Some expressed the belief that moving the cords caused the sound. Others seemed to just accept the relationships between movement and sound and developed their own expressive experience.

For **Mayfair Network** I used a large willow tree 35-40 feet high with a low wall, made of logs, around the tree, about 15 feet from the base of the tree, and about 3 feet high. This formed an inner circular path under the boughs of the tree. This inner path was further defined by pieces of red rope which were tied to the high tree limbs and rested on the logs. Photocells connected to a small computer-controlled sound system, were placed around the circular path. Walking through the openings in the wall and on the path activated the photocells which caused sounds in four speakers in the tree and four among the logs.

The piece was for me a somewhat playful commentary on the inner-outer nature of perceptual experience. The inner circular path, with the viewer activated and controlled sound, reflected our somewhat nonspatial inner world over which we have some direct control. Beyond the wall and red ropes was the external world of light and sound, only indirectly under our control. The response to the piece was mixed. Some people saw the inner-outer metaphor right away. Others treated it as a piece of playground equipment, suitable for climbing, sitting and swinging. In both cases, many people wanted to know how it worked. Some correctly understood the relationships of the photocells to the sound, while others thought that pulling on the red cords caused the sounds, and shared this information with others. This idea seemed to arise from a form of superstitious behavior in which people pulled on the cords and sounds were produced in the proper sequence for an apparent causal relationship. However the sounds were produced by others who happen to be inside activating the photocells at the time.

Creative Self Expression. These examples of interactive art certainly generated self expression, in which individuals were quite spontaneous and had a certain freedom of action. This was clearly present in the creative exploration of **Doorways of Meaning**, which seemed to promote free exploration. Part of this may have been due to the voice forms of free verse that were heard, since most tried to listen to the words as they moved in the space. The room was talking to them as the moved. The free play of climbing and swinging on **Mayfair Network** seemed much different and was directed at the logs and the space around the piece. This may have been due to the festival atmosphere, the large number of children, and the physical construction of the piece.

In creative self expression there is creativity as a process which may not produce tangible objects. Most of the creativity research has dealt with products, such as drawings, which are judged by independent evaluators. Much has been done to determine the conditions under which more creativity has been displayed in these products. For example there is experimental evidence that intrinsic motivation, an internal desire to do the task just for self-satisfaction or enjoyment, leads to more creative output than extrinsic motivation, doing the task for external rewards, such as money or prizes. However, external praise can be effective in increasing creativity if perceived properly by the subject (6). In my interactive works, there are no external rewards, and so the conditions would favor whatever intrinsic motivation that the viewer brings to the piece.

These data clearly support an earlier theory of Taylor (7) in which he developed the core idea of a transactional system. He made the distinction between responsive, interactive and transactional systems for understanding the personality-environment relationship. In the responsive system the determining source of energy is the environment, while in the transactional, the source is the individual, and in the interactive system the drive emerges from both. He argued that true creativity results from a transactional system. This raises the question as to whether interactive art is or should be transactional art? My own tentative answer is that interactive art allows for transactional processes, particularly to the extent that intrinsic motivation may be involved. Appropriately Taylor (8), drawing upon others, argues that the characteristics of the individuals that are related to transaction include openness, internally developed systems and resources, and internal control with a kind of courage. In applying his model to interactive art we need to make the distinction between stable personality characteristics that contribute to creativity and environmental processes that foster creativity in us all. The extent to which the art museum/gallery environment is open and promotes the expression of these personality characteristics may be the extent to which interactive art becomes transactional art. This situation should also provide a favorable climate for developing creativity in problem solving behavior.

Creative Problem Solving. Creative problem solving is defined as cognitive processes that produce a solution that is novel or new to the individual or society (9). Since there is such a large psychological literature on problem solving, I will only point in some directions. Some of the following material about problem solving and mental models is an extension of my other work (10).

One of the important dimensions of problem solving is the extent to which a problem is well-defined or ill-defined. Newell and Simon (11) in their classic work formalized an approach for well-defined problems, which they proposed might also be appropriate for ill-defined problems (12). The idea of a problem space is central to their formulation. Within that space there are 1) the initial state for the problem solver, 2) a goal state defining what is to be achieved, and 3) rules and strategies for moving from the initial state to the goal state. Sometimes the rules are well defined, as in a game of chess, and sometimes they are heuristics, which are rule-of-thumb strategies that may or may not lead to a solution. Some strategies that can operate are problem solving by analogy and working backward, among others.

This formulation has been challenged as being too limited and too removed from the everyday world of problem solving (13). This kind of critique suggests that it may be difficult if not impossible to define the problem space because it is so subtly and differentially influenced by context. This context includes personal, social, developmental, and moral factors. Furthermore it is often unclear to the individual in everyday situations if there is a problem, what constitutes a solution, if there is one solution, or what means are available for approaching the situation/problem (14).

It is obvious that I can not deal in this short space with all of these and other related issues. But acknowledging them, I will sketch some likely scenarios that illustrate how a problem solving model might work and how some of these factors can be conceptualized as operating in interactive art.

If the goal is to experience the art work, the viewer might move to the art object and stand passively looking at it. This would be analogous to the typical approach to traditional art works. Since the two works require the viewer to enter either the room or area under the tree, no sound will occur unless the viewer or someone else is in the space. In both cases, the viewer would initially have a very minimal experience. This may be as far as some viewers go, depending on their levels of curiosity, age, and past social experience, as they interact with the social constraints of the environment. For example, the public nature of the festival for **Mayfair Network** or the elite quality of the art gallery environment for **Doorways of Meaning** may inhibit further exploration and thus limit the mental representations or models of the work in the viewer's mind.

But for other viewers, movements by themselves or others might cause some sounds to occur. Observing this a viewer could extend the goal of experiencing the work by moving into the space and discovering something about the contingencies between sounds and movement. The motivation for this may be related to creative self expression described above. In any case the viewer then further develops a model for understanding each work: the work as a room to be explored for **Doorways of Meaning,** or as a piece of playground equipment for **Mayfair Network**. Both analogies work pretty well as ways to proceed. As I indicated particularly for **Mayfair Network** many individuals developed the idea that pulling on the cords produced the sounds, and thus solved the problem of how it works although it was a false mental model. They produced this solution either by trying the cords themselves or by communicating in the social context of the festival atmosphere.

Other heuristics might also be used. Working backwards might be tried for **Doorways of Meaning**. Here the viewer might recognize that every time she moved forward or brushed against a cord, a voice was heard. By asking why that occurred, she might find the photocells, and develop an accurate idea of the way it worked, or by concentrating on the cords, she might develop the false model that brushing on the cords produces the sounds.

In these problem solving examples, there are no specific outputs such as paintings or drawings. Instead there are cognitive models for understanding the piece by the viewers, which we can call functional mental models (15). The term functional is used to reflect the causal and interactive aspects of the art work. The details of these models are different for different individuals depending on their experiences with the pieces and the total context of those experiences. The models may be vague or very specific.

I should make one other point about the influence of my interactive art works on problem solving strategies. In all of my pieces, the relationships between movements and the sounds (or video patterns) are not completely predictable. While they all fall within a general type or quality of stimulation, the details will be slightly different with each activation, even if the viewer makes precisely the same movements, because there is randomness in the programs. This reflects the variability in human behavior and provides a level of mystery and surprise. This kind of program is, of course, different from programs designed to do spread sheets or word processing where predictability is paramount. How this randomness effects the problem solving strategies and resulting mental model is unclear. Several viewers have found the randomness somewhat frustrating and have commented that it would be better to have a piece with greater predictability so that it could be played like a traditional musical instrument. Here they have attempted to solve the problem of how the piece works by treating it as analogous to a musical instrument with part of the resulting mental model including ideas about it being a deficient instrument. It also raises an interesting question about the extent to which interactive art ought to be predictable.

But the creative self expression, problem solving and functional mental models appear to be especially important in understanding interactive art, since they describe the cognitive operations and behaviors of the viewers. And as an artist I include these cognitive processes, behaviors and the associated memories as parts of each process art work.

Measurement Problems. I have described in general terms the kinds of responses that are involved. But there is a serious question about the degree of creativity involved. As a way of determining creativity, some investigators have used judges to rate the creativity of the outputs. But of course this still depends upon the criteria that the judges bring to the task. This approach seems to work best for existing art in which the criteria of creativity are to some extent established, such as poetry, painting etc. But as Weisberg (16) among other has pointed out, what appears as one subject's great creative leap to one judge, may simply be a logical and very small application of the subject's knowledge to the problem. Should the creativity of the solution be based on the individual or the total context? And how is context defined for everyday problems?

In my earlier work I was not as concerned about recording output. However with the computer it is possible to record responses. Yet, it is still difficult to know under what conditions the responses occurred. I am currently working on more sophisticated systems that will guide viewers through certain experiences and be able to collect reactions in more controlled ways, although we are still dealing with viewers in the relatively uncontrolled art gallery environment. With this sort of situation there is always the problem of the measurements interfering with the art. If the viewer knows that his or her responses are being recorded and analyzed, will the behavior be the same? Some informal interactions with viewers suggests that this could be a problem. On the other hand, it would be very helpful to have more systematic data on these issues. And then there is the question of whether I am making art or making experiments; or can I do both at the same time?

Summary. In this short paper I have tried to sketch very briefly how we might conceptualize interactive art within our psychological understanding of creativity and creative problem solving. While we obviously need better models, especially for ill-defined problems in everyday situations, this unique conceptualization provides an added layer of meaning to the aesthetic experience. Further, the application of a creative problem solving model to the process helps to understand the nature of the interaction. Some interesting questions revolve around the relationships between levels of creativity, and the extent to which experience at the level of self expression influences abilities at more complex problem solving levels, and then how that will work within the context of different individuals operating within the total environment.

Interactive art clearly extends the boundaries of art by involving the viewer in the creation of art works, a role traditionally reserved for the artist. It also extends the definition of art to suggest that the object becomes a means of producing art works as mental processes. Electronic media play a critical role in this kind of extension because they are clean, flexible and fairly transparent media that invite participation. Using these electronic tools, creativity becomes art.

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Qualitative, dialectical, and experiential domains of Electronic Art

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"The wheel's hub has thirty spokes
Utility depends on the hole through the hub.
The potter's clay forms a vessel.
It is the space within that serves.
A house is built with solid walls
The nothingness of window and door alone renders it usable,
That which exists may be transformed
What is non-existent has boundless uses."
- Lao-Tse

Perhaps there has been a time when men in all cultures handled rather similar objects, which demanded similar skills and were used for the same sort of tasks. Seen in today's perspective - when technological developments are rapidly and enormously increasing the differences among societies - this egalitarian view sounds absurd and naive. Countries have been mainly categorized in terms of their technological stage, in spite of their natural resources, their territories, their people or their cultures. Because of technology, the world has been divided into the First and the Third.

The expansion of the use of computer technology poses serious problems for developing nations, and makes us reconsider the idea that technology is always a synonym for progress. The modern way of living of the consumer society - a model originated in the First World - forces the adoption of a unique model on both developed and developing countries. This model jeopardizes or, in most cases, destroys the possibility of generating differing technological alternatives, according to the cultural, social and economic parameters of a given context.

Different groups may give different solutions to the same problem. In India, camels are still vastly used in many cities as a transportation means. In Thailand, millions of motorbikes were transformed into three-wheeled machines with a coverage, which are known as *"tuc-tuc"*. A sort of rickshaw - pulled by a person riding a bike, is another largely used means of transportation in many Asiatic countries. Horse coaches and oxcarts are commonly seen in Brazil, in rural areas. And bikes - of all sorts, sizes and shapes - are the most popular means of transportation in China. Creativity, inventiveness, the power to adapt and adequate to each group's needs, are these devices' common denominator. But cars look basically the same in India, Thailand, China or Brazil, as in Europe or North America. This is not a result of the international widespreading of an optimum product development, which prevails over other product designs for its inherent qualities. It is a consequence of technological dominance.

But although cars, fridges, motorbikes and telephones look pretty much the same around the world, computers undoubtedly represent the most threatening example of technological and cultural dominance of our time. As an intellectual tool, the computer is an environment that has many values and biases associated with it [1]. In essence, computer equipments reflect the predominant logic, attitudes and views of the First World. Alternative technological solutions do not easily emerge from computer research groups in developing countries, mainly due to economic reasons. As an inevitable result, a basic computer technological model is spreading all over the world.

The continuing growth of the use of computer-related technologies in developing countries - in which illiteracy often reaches high figures and represents a major social problem - is leading towards a very critical situation. Unlike other technologies, such as the radio and the TV - which are very popular among illiterate people in these countries - computers are still highly based on written, verbal communication. Up to now, the use of computers in the Third World is mainly confined to industries, offices and universities. But the scale of technological development seems set for inexorable growth. It is predicted that in the near future people in these countries will need to interface with computing devices for most of their daily tasks, as it already happens in the developed nations. According to Nicholas Negroponte, in "the modern world" every person uses at least 12 computers a day, from fax machines to cooking equipments [2].

This prospect brings the issue of computer literacy to light. As Freire discusses in his book "Pedagogy of the Oppressed" [3], literacy is not a question of being able to read and write, but of being able "to say someone's own word", as a culture generator. It is the significance of the message contents that counts in a intersubjective dialogue, not merely the mechanical repetition of words. One may ask then what "computer literacy" means Is it related to the pressing of keys and icons, or to the grasping of the underlying logic of computers as symbol processing machines? Is it measured by the level of someone's mastering of computer devices and jargons, or by the level of conscious interaction with the equipment, as in an intersubjective dialogue?

In most developing nations, we are witnessing the advent of what can be called "double illiteracy": people who are already on the fringe for not sharing the codes of a reading and writing society, and that now might be out of the system for not mastering the use of computers.

After banks have introduced magnetic cards and automatic cashier machines - aiming at making the client's life easier - things have become more complex to many of their users, in developing nations. One can observe a high degree of difficulty when illiterate or semi-literate people have to interface with a computer - even when what is required is simply entering their code number in a 12-button keyboard or finger-pointing on a touch-screen monitor the numbers relative to the amount of money they want to cash. Although even illiterate adults frequently master the use of numbers, and can perform simple arithimetical operations in their daily routine - such as giving the right change at the street market, using the telephone dial, or choosing the right bus to catch - for some reason it seems more complex for them to deal with this new devil's machine. If interactivity is considered to be the core of computer-related technologies, then it is necessary to analyse the implications of an interactivity primarily based on verbal written communication in countries where a great portion of the population is illiterate or semi-illiterate.

As a technology that can only manipulate explicit data and symbols according to formal, syntactical rules, computers tend to legitimize those types of knowledge that fit into their framework and delegitimize other types of knowledge. Epistemological methods such as interpretation, intuition, introspection and dialectical synthesis of multiple and contradictory realities are not legitimated by computer technology. Streibel emphasizes that the more computers are used as intellectual tools, the more this process of legitimization and delegitimization takes place: "The more we rely on the formal characteristics of knowledge, the less we rely on the tacit and interpretative dimensions of knowledge." [4].

If, on the one hand, the expressive facet of computers has greatly improved by the advent of multimedia resources, on the other hand computers' capability of receiving human inputs is still very limited. Most of the time our emotions and ideas are funnelled and restricted to the pressing of keys or to moving a point-and-clicking device.

Computers still do not recognize the user as a specific individual: the human is treated by the computer as a generic type, not as the actual person. Although human-computer dialogues aim at resembling interpersonal conversations, Bork [5] points out that these dialogues are a form of behavioural technology where dialogical interactions are controlled by an author who is not part of the actual interaction. While interpersonal interactions have a conjoint control as their essential component, interactive computer programs only permit the user to make decisions from a pre-defined set of choices. "The existence of interactive systems doesn't automatically imply a democratic turn, a redistribution of power from "the producer" to "the consumer", or a reorganization of the information traffic." [6].

One of the major challenges we face today is to create computers that have a degree of good sense and comprehension. Computers have no understanding about the information units they process. If the communication channels could recognize the information contents, personalised systems that could filter and generate information for a one-person audience could be developed. Darley [7], says that if new technologies are to enable "egaliatarian, more democratic, constructive forms, offering new kinds of interaction, knowledge, and understanding", these possibilities have to be sttruggled for.

Under this scenario, we ask what should be our responsibility as electronic artists. How can artists interfere in this process, so that human, social and cultural aspects are considered in the development of computer-related technologies? Is the role of the artist who uses emergent technologies in the Third World different from the role of those who deal with Electronic Art in the First World?

These issues encompass two different perspectives, that are, however, strongly interlaced. The first one concerns the governing rules of the development and implementation of computer-related technologies. The second perspective is related to the interdisciplinary dialogue between artists and scientists.

In the first perspective, it is important to consider computer technological development as an international issue. Operating on a global scale brings problems related to the topdown transfer of technology - from First to Third World countries - and exacerbates the issue of cultural dominance. Kaplinsky [8] focuses on aspects of potential conflict in the transfer of technology and mechanisms which are used to enforce the control of the dominant group. He says that any set of complex relationships between different individuals or groups is likely to lead to some misunderstanding and conflict. In the case of the transfer of technology, however, "conflict does not result merely from misunderstanding others' motives and intentions, but it is fundamentally built into the nature of the transactions." According to him, the reason for that is that the technology which is transferred is a primary input for the generation of surplus. "Control over this technology is thus crucial, not only because it leads to control over the generation of this surplus, but also because it is an important element in the control of the distribution of the surplus.".

Galeano says that the big cities of the south of our planet are exactly like the ones of the north, but seen through a distorting mirror: the copying effect of modernization multiplies the model's errors and defects [9].

These problems also occur on a national scale. The already existent gap in most developing countries between the elites and the poor - in some cases, the top tenth of the population controls nearly half the nation's wealth [10] - is likely to increase as a result of the introduction of computer technologies. The illiterate man from a developing country will suffer the double unfavorable condition of not being a citizen of the First World - with all the technological advantages that this means - and of not being part of the restricted group of the Third World who may have access and therefore will master the computer logic and skills. The introduction of computers in everyday life will even be more aggressive to this 'deprived man', as he will not be able to gradually learn, master or interfere with this new technology. Yet, in the end, computers will be imposed on him.

In his report on the study of pictorial perception among African subjects, Hudson [11] says: "We take it very much for granted that methods which are only moderately successful in our own cultures will prove equally, if not highly, successful in an alien culture. We fall into the error of thinking of the black man's mind as a *tabula rasa*, which we have only to fill with the benefits of our own cultural experience in order to promote whatever objectives we may have in mind. We forget or ignore the fact that the black man possesses his own indigenous culture."

In the light of these problems, we may conclude that the introduction of computer technologies will not possibly lead to an improved social yield in developing nations. But there is still hope. Malina [12] names contemporary artists "technology colonizers" and quotes McLuan, when he says that the artist's role is to explore and spread the new environments offered by technology. We may infer that, as colonizers, artists are expected to explore and establish new territories. Much, however, depends on our awareness of the actual situation, on our understanding of the frontiers and possibilities, and on our participation in technological research.

This issue brings the second perspective into discussion: the interdisciplinary dialogue between artists and scientists. Although the basic approaches of these professional groups usually differ, it is misleading to seggregate human actions into 'art', 'science' and 'technology': new areas of research are emerging as a consequence of collaborative work among artists and scientists. It is a must that the artistic focus be incorporated in the process of new technological developments; without that focus these technologies will not reach their original goal, which is to meet human needs and desires. As artists, we can criticize, interfere in and deviate technological trends from inadequate directions. When the stick is crooked it bends to one side and if you want to straight it, it is not enough placing it into its correct position. You've got to bend it to the opposite side. This is one of the things electronic artists can do with/for emerging technological developments. Technologists working in isolation are far from discovering the intricacies of social and cultural issues, and their view may bend technology to its utilitarian extreme. As artists, we need to bend it to the other, by taking into account the complexity of human-machine relationships in a socio-cultural perspective. As a result of these opposed and complementary views and attitudes, technology may be perceived and used by the general public in its intermediate final shape, as a sum of scientific and artistic perspectives. Human, social and technological areas of knowledge should have never been divorced, as they are complementary parts of the holistic human experience.

If we are to understand the effects that computers have on society, say Winograd and Flores, "we must reveal the implicit understanding of human language, thought and work that serves as a background for developments in computer technology." [13]. In asking what computers do we are ultimately addressing the fundamental question of what it means to be human. Electronic artists are gradually discovering combinations of the expressive potential of human natural languages - which extend over aesthetic, metaphoric, artistic, affective and moral domains - and the objective, quantitative and procedural characteristics of computer technology.

Yet artists and scientists' views are not de-contextualized or isolated from a socio-historical situation. Geographical, cultural, political, economic factors affect their perception and guide their actions. Electronic artists working in the First World greatly differ from those working in the Third World not only in terms of their approaches and resources, but mainly in terms of their access to computer-related technologies' developers. As regards the problem of "double illiteracy" in developing nations, electronic artists in the First World may be able to interfere in a more direct way than their colleagues in the Third World, by actually having the opportunity to take part in the development of new trends in computer-related technologies

Penny [14] points to the advent of a new professional identity - "the interactive media artist, an interdisciplinarian as comfortable with cultural coding as with computer code...". We can make computer technology move into an era of new values concerning cultural issues, as part of the interactive dialogue among humans and machines. Art and science must merge into one single process of cognition. Artists and technologists - from the First and the Third Worlds - may blend their different perceptions and knowledge in order to enable the construction of a qualitative, dialectical and experiential electronic expressive language.

The time is right for the adoption of such an approach. In fact, the main challenge of this decade is to establish a socio-technical commitment capable of addressing problems of both local and global scope. In a world of social, cultural and economic disparities, maintaining a balance between uniqueness and uniformity needs to be the contemporary electronic artists' major struggle. Better times may be on the way.

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THE ELECTRONIC GARDEN

Iain Whitecross - Artist

The Electronic Garden is a cybernetic sculptural environment of light, movement and sound. It is made up of nine freestanding units or 'plants', each consisting of a cluster of similar 'flowers' with the tallest being close to human height. The installation is exhibited in a darkened space of sufficient size to allow spectators to stroll from one plant to another, much as they would in nature. Since the Garden is activated by sound, spectators are encouraged to clap, whistle or sing, or talk to the plants as they would to a pet. Some even arrive prepared with their favorite musical instrument.

The sculptures are constructed of acrylic plastic, (the 'blossom' of each flower) and stainless steel, (the 'stem'). Employing the principles of fiber optics, incandescent bulbs concealed within the opaque 'ovary' of each blossom transmit their light through the translucent 'petals' and 'stamen' causing them to glow and shimmer. The lights are arranged in three separate colour circuits, each responsive to a different frequency, while their brightness is determined by the volume of the input stimulus. At the base of each stem, an electromagnet is positioned so that when activated it exerts a pull upon it. The pulsing of this magnet causes the sculpture to tremble and sway much as does a real flower stirred by the breeze. Finally, the sounds emanating from each cluster are generated electronically and manipulated by the same three frequencies that determine the colour of the lights. This produces small but infinite variations similar to the repetitive yet ever-changing rhythms heard in nature. Activating these responses is the feedback system, whereby the spectator sounds already mentioned are picked up by microphones, amplified and fed to the various switching devices that control output to the lights, electromagnets and sound synthesizers.

Hopefully this brief description is sufficient to introduce the reader to the Electronic Garden and provide a basic understanding of how I made it. In fact this always seems much easier to explain than why, which I find I'm often asked in a slightly skeptical tone of voice as though there was something perverse or contradictory about the concept, that in this world of already ubiquitous technology, a garden surely should be sacred and made of good old-fashioned dirt. I can even imagine myself being ironic, were it not I who had devised it. So it's with some care that I have retraced the path I took that led me to my switched-on garden.

My first brush with the idea of art combining with technology came during a fellowship I received to the Macdowell Colony in New Hampshire. I was working there on a series of large paintings executed with pen and air brush that presented a somewhat surreal interpretation of microphotographs of plants. In a sense therefore one could say that I was already attracted to the new worlds revealed by science, but this impulse was something quite instinctive and unplanned. That was now to change, for while I labored on these inner landscapes of the leaf, I became friendly with a fellow colonist, a Chinese-American sculptor, Wen-Ying Tsai. He was surrounded in his studio by a wall of multicolored gyroscopes, each rotating at a different speed, but I became more often giddy from his talk than from his work, for his convictions as an artist and his training as an engineer made him a most articulate spokesman for the future of a match between technology and art. Once more then in New York, I was introduced by him to a group called Experiments in Art and Technology, or E.A.T., as it was known to its adherents. Founded by an engineer from Bell Labs, E.A.T.'s objective was to bring about collaborations between artists on the one hand and engineers and scientists on the other, not just to spark creative work, but also on a more philosophical level to try to bridge the gap between these two polarities in our culture and in so doing, perhaps help shift technology away from war and weapons and towards more human needs.

Through E.A.T. I was introduced to the person who became my collaborator, a bio-engineer at New York Hospital. He was a most eccentric man, his conversation sprinkled with obscure (to me) meanderings of scientific jargon and a laugh that sounded like a medley of Strangelove and Svengali. He also had two fingers missing and one eye that seemed to my unpracticed gaze as though it might be glass. When I say 'obscure', you must understand that I had no scientific background. Technically I was more or less illiterate, having early given up the science track at school for languages and literature. In fact it was a sort of joke at home that I couldn't even change a light bulb. I suppose my new collaborator found my enthusiastic innocence amusing, at any rate we laughed lot, became good friends and began to work together.

At this point I need to backtrack, to mention two influences that shaped the artistic direction I now followed, both dating from the years I had spent in Paris. They were the monumental stained glass windows of St. Chapelle and the great panorama of Monet's water lily paintings. In both these works there was a mysterious, almost hypnotic quality that haunted me, while on an intellectual level I was still drawn to their involvement with the phenomenon of change. In his water lily series, Monet had captured the passing of the day across his garden pond, while in St. Chapelle, that great band of artist-craftsmen had used the flux of sun and clouds to give their work its never ending life. "What if", I said to my collaborator, "what if I made a lily pond and we used lights and they could change...?" "No problem," said Svengali/Strangelove and laughing launched into a description that took me long to follow. But eventually I did and learned a lot and our collaboration prospered.

Then one day as we worked together I asked my friend about his missing fingers. He gave his laugh and said it was "an accident at work. I was doing research then, control systems for anti-personnel weapons. My project was a bomblet that jumped waist high and then exploded. The design was really elegant but... well, I got some wires crossed and... I suppose you could say I was lucky. When I left the hospital, I thought I really owed them something and since they had an opening, I took it... and I guess that is also why I got involved with E.A.T."

And so our work progressed. Unfortunately, even as it did, so grew the Vietnam War. At first I didn't feel involved, since I was not a U.S. citizen. But contact with E.A.T. and other artist groups I knew, began to change that and soon like many, many others in this country, I grew every day more angry and distracted. When the Christmas bombing of Hanoi took place, something snapped and I broke up the work I had done as a mark of protest. It was a harsh and maybe senseless gesture, though at the time it seemed to me entirely valid. At any rate, it pushed my art in quite a new direction, a series of silk-screen prints entitled "Advertisements for War". They were brutal and ironic, juxtaposing brightly colored scenes of cruelty and carnage with titles drawn from the cheerful advertising slogans that appeared on T.V. like brackets round the daunting nightly news. And so time passed and the war at last was ended. I spent some years back in Europe, began and finished other projects and the shards of water lilies gathered dust. Then one day, once more in Manhattan, I got things out of storage, unscrewed crates, opened files of drawings and decided it was time again to build. And so I did, though now alone, for I had lost all contact with my eccentric engineer.

How and at what point exactly the rebuilt water lilies grew into a garden, I am not quite sure, though I can recall some ideas and influences which slowly yet insistently became the rules of this new game that I had now begun. A guiding force for many years was Arthur Koestler's dictum that creative development, both in art and science, comes most often from the bringing together of existing but previously unrelated matters. In this case, the combining of cool, hard, high-tech materials such as stainless steel and acrylic plastic with the soft, warm organic forms of plants would parallel the joining of technology and art and create, I hoped, a harmonious balance between Dionysus and Apollo. In those forms, there were perhaps some echoes of the sensual flower paintings of Georgia O'Keefe, who I discovered had also been obsessed with St. Chapelle. And there was input too from heat sinks, diodes and transistors, all those tiny electronic parts that now lay round my studio.

As for the sounds, their inspiration came from the creatures of the Adirondacks, that great wilderness to the north of New York State where I spent several summers near a lake called Paradox. But these are details. What of the concept of the Garden as a whole? For that perhaps I owe most thanks to that great visionary artist of the 15th century, Hieronymus Bosch. It is the grand design of his mischievous and inventive Eden that gave me courage to expand my lighted lilies into a cybernetic Garden.

Which brings me to Norbert Weiner, professor of mathematics at MIT in the 1940's, humanist and visionary author, who believed that the thought of every age runs hand in hand with its technique. Thus for him the 18th century was the age of navigation, made possible by clocks and lenses; in the 19th century, it was power with the steam engine at its core; while the 20th, which brought the electron tube, is the age of communication and control, or as Weiner chose to term it, cybernetics. "We have decided," he said, "to call the entire field of control and communication theory, whether in machines or animals, by the name cybernetics which we form from the Greek word for steersman." Successful steersmanship relies on feedback, whereby experience is used to modify reactions. As an example think of a bird chasing a butterfly. The bird's every movement stimulates the butterfly's eyes, which in turn makes the butterfly's wings react, which moves it in a different direction. This changes the signals given by the bird's eyes which lead to new movements of its wings and so on. Insufficient feedback on the bird's part and the butterfly escapes; excessive feedback from the butterfly and its nervous system cannot cope, its flying pattern stutters and it ends up on the ground for lunch.

When all the plugs are plugged and the Electronic Garden is welcoming its visitors, I like to feel that, as an Elizabethan poet wrote:

> My garden chaseth quite away
> All heavy hearts and doleful dumps...

I want it to be fun, of course!

But not just that. I've not forgotten those youthful dreams to inspire technology for peaceful purposes and although sometimes in the intervening years they've seemed impossibly naive, (we Lilliputian artists tugging at the laces of the jackboots of the military-industrial giant), I dare now to think that we were just before our time and that this idea, which lay gathering dust like the pieces of my sculpture, has finally a chance to bloom.

Beyond this hope, I see my Garden now take on new meaning. When I named my flowers, I used their Latin names in deference to the principles of Carl von Linnaeus. Although many of his contemporaries considered this practice elitist and obscure, Linnaeus had quite other motives. He believed that by freeing plants and flowers from their human reference, be it religious, medicinal, or bawdy, he would make it understood that the natural world has its own existence, independent of mankind and must be seen by us accordingly. As Samuel Taylor Coleridge said, "Nature has her proper interest and they will know what it is who believe and feel that every thing has a life of its own." Yet even as we learned to grant this independence, we have become more and more obliged to recognize our mutual dependence, to accept that our relations with the natural world are ruled by feedback and that this feedback is a two-way street, so that indeed there is nothing that we do that does not have effect on what we see.

Thus it is that I have come to see the Electronic Garden as a fragile image of the natural world in the cybernetic age, a natural world that we now know is also very fragile - not just flowers and leaves and birds and trees, but whole species, the soil itself, the water, air, the very light. Much as I love my little Garden, I would not want it to replace the smallest portion of that world. It is no substitute for nature, just a faint reminder of what we stand to lose unless we start to listen far more carefully to feedback and manage to improve our present wayward steersmanship.

But not just feedback, there is also feedforward to consider, a concept defined by Dudley Young whose clarity and scholarship helped me articulate what follows. If feedback is empirical and scientific, feedforward is intuitive and magical. With it we can create an environment, a ritual, a gathering at which, not for sure but maybe, Nature's spirits may appear to inform and guide and strengthen us in finding what is right to do to make Her well again. If this sounds mystical, it is, which is precisely why it's hard to talk about it in a scientific context. But just because it's hard, it seems to me all the more important. And one should not really be embarrassed. Scientists too use mythic language without any hesitation. Take the word 'pollution', for example. In ancient Greece both people and whole cities were 'polluted', not by acid rain or oil spills, but by taboos they'd broken, or desires they'd failed to curb and the only way they could redeem themselves before the gods was to make a sacrifice. Since the Greeks feared their gods, they would hasten to placate them before the retribution came - we unfortunately being more rational, decline to act until we have proof, scientific proof that is, that something bad will happen. (And even then we often wait until it does, because voluntary sacrifice is not a vaunted virtue in a culture of consumption.)

And so finally to Leonardo da Vinci, our almost mythic master of technology and art. Ironically perhaps, it was in his own time that science and religion joined in conflict, struggled fiercely and then, with the latter sulkily retreating, went each their own way. One can almost see this drama played out in Leonardo's own creative life. Consider his projectile, which he described as 'the most deadly machine that exists, for when the ball at the center bursts, it scatters the others which fire in such time as is needed to say an Ave Maria'. That this is the work of the same man who painted this same Maria as the Virgin of the Rocks, that supreme dedication to the nurturing Mother Goddess, seems to me almost inexplicable.

Did he go into the weapons business like my engineer, because there was good money for research and a steady living? So one wonders reading the resume he sent to Ludovico Sforza in which he placed painting at the very bottom of a list that included nine detailed military projects. And still it's hard to think that it was only this when so many less talented than he thrived at the courts from art. It is my belief that the more he studied and to use an appropriately phallic phrase, penetrated Nature's secrets, the more he came to mistrust the mystical and the more religion seemed to oppose research and its resulting clarities, the more he came to shun the obscurities that could not be examined directly with his senses.

And so the chasm opened between science and mysticism, intellect and intuition, mankind and Nature, a chasm which has deepened and grown wider to this day. To bridge it, which I believe essential for the survival of our planet, we have to lose our shame before the mythic and regain confidence in our intuition and if this means shedding some respect for intellect and becoming more skeptical of science, so be it. Knowledge by its nature is imperfect, whether instinctive or acquired and by giving each their due we may perhaps recover balance, both between ourselves and in our overall relationship with Nature. To quote Leonardo, "an arch is nothing other than a strength caused by two weaknesses."

It may seem at this point as though I have wandered rather far from my Garden, so let me end by turning back along the path to where I left feedforward, that place where spirits come and go, where magic strikes and contact with the mythic may be made. On the last day of the Garden's showing at the Hyde Collection, I came into the gallery and was greeted by the sound of someone improvising on harmonica. As the player moved around the room, the sweetness of the melody and serendipity of tone created a response more subtle and intense than I had ever seen. When the invisible musician finally emerged into the light, she was indeed a curious and entrancing figure. A little girl of eight or nine with dark hair reaching to her knees, whom chance had brought from far Bombay to create, or so I felt, one of those moments to which I just referred, when feedback joined feedforward and the scientific met the mythic in Leonardo's arch of unity.

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Light and Dark Visions:The Relationship of Cultural Theory to Art That Uses Emerging Technologies

Stephen Wilson, San Francisco State University, 1993*

Introduction: The Relationship of Critical Theory and Cultural Studies to Art that Focuses on Emerging Technologies

The impact of technology on contemporary life and culture is a vital issue in our age. Critical theory and cultural studies attempt to link the arts, literature, politics, sociology, anthropology, philosophy, and technology in an interdisciplinary search for relevant concepts and frameworks with which to understand the current world. Art practice and theory are being radically reshaped by this activity.

This hybrid world of culture/art criticism, which places great import on the impact of emerging technologies, has seemed unexpectedly uninterested in the work of artists who work with these very technologies. Similarly, the discourse in the art/technology world – and in the technical world in general – has not engaged deeply the concepts from cultural studies. This essay attempts to elucidate some reasons that might underlie this mutual lack of attention.

The essay has two objectives: It applies some concepts and lines of inquiry from cultural theory to inspect the practice of artists working with new technologies, and identifies ways their practice challenges these theoretical formulations. It then considers a range of theoretical stances artists can assume in relation to working with new technologies. Its goals are to help artists define for themselves a theoretical stance toward their work with technology and to advance the ability of art theory and art criticism to contend with new technologies.

I Survey of Themes from Critical Theory and Cultural Studies

This section briefly lists some interrelated concepts and themes from critical theory and culture studies that can be applied to the consideration of relationships between art and emerging technology. For a fuller elaboration of these themes, see the longer version of this paper which appeared in the Siggraph93 Visual Proceedings.

Post Industrialism: Our era is characterized by an "information economy" in which increasingly smaller proportions of the populace generate food and artifacts[1] and cultural structures and ideologies are seen as lagging behind the realities.

Electronic Media and Other Technologies: The pervasiveness and consciousness-transforming potentials of electronic media and other technologies – such as the ascention of hyperreality and the implosion of meaning – are seen as a critical feature of the post industrial landscape.

Postmodernism: . Postmodernism is a theoretical approach that defines current "decentered" cultural practice and ideology as rejecting outdated modernist notions such as the belief in historical progress, rationalization of society, and univocal truths.

Structuralism, Semiotics, Post-Structuralism, and Deconstruction: These approaches seek to understand the underlying linguistic and non-linguistic structures that explain belief and behavior in all cultures with a special focus on the ways texts and discourses shape self representation and communication. Deconstruction is an activity focused on the unravelling and unveiling of the interplay of discourses with special emphasis revealing the cultural politics of white, male, Eurocentric hegemony.

* This paper is condensed version of a paper which appeared in the Siggraph 93 Visual Proceedings © Association for Computing Machinery (ACM), 1993

The Role of the Artist and the Disappearance of the Avant-Garde: The vision of the artist as a creative genius who uses his or her special sensitivities to cultivate awareness of important cultural themes and to invent compelling expressions is seen as an outdated notion that denies the ways art world discourses are similar to other cultural forms.

II Issues in Applying Cultural Theory to High Tech Art

Although these analyses are gaining widespread attention in the world of art theory and criticism, they have not yet been widely used to understand the work of artists who work with emerging technologies, despite the fact that high tech art is situated in a junction of culture and technology potentially rich for insights. The technologies explored by artists are the very ones some analysts see as key to structuring postmodern, postindustrial society. These technologies are essential components in creating the mediated vortex of free-floating significations and the implosion of meaning. They are also crucial in the creation of new cultural niches in which issues such as control, the body, and war become prominent. Many of these artists have feet in both the art world and popular culture.

Later sections will suggest that some kinds of high tech artistic practice challenge assumptions of cultural theory and thus serve as a useful source for reconsideration of these theories. As compelling as critical theory and cultural analysis are, it is essential to stop to question and inspect the claims they make.

<u>Disjunctions Between Scientific World Views and Critical Theory</u>

Many who work in science and technology still maintain faith in progress, the universality claims of their operations, and the independent status of the phenomena they work with outside of their discourse. They can point to an impressive record of ideas tested by methods of verification that approach objectivity, and to new knowledge, understanding, investigative tools and new technologies that have transformed life in almost every corner of the earth.

The enterprise of science and technology is by no means pure. Phenomena such as uncertainty and chaos theory have shaken some of its epistemological assumptions. Lyotard in <u>The Postmodern Condition</u>[2] notes that science's fundamental narratives of legitimization are in crisis, and that many of its statements can be described as "performative" utterances -- i.e., they express commitment to action rather than description of external realities. The sociology of science has shown that research is rarely disinterested; it is influenced by ideology and political, military, commercial, and other interests. Grants are awarded and publications approved for ideas that fall within ideologically defined discourses. Seemingly benign knowledge and technologies are perverted to ends never intended by their creators. Gender, race and nationality influence who can do science and whose opinions have weight. Post structuralist analysis has shown that the conceptualization of scientific research questions and professional communication are shaped by metanarratives, just as in other fields. Thomas Kuhn in <u>The Structure of Scientific Revolutions</u>[3] has shown that scientific paradigms act as metanarratives that profoundly shape theorization and research; they change slowly through a combination of ideology and experimental results. Still, it is important to note that most practitioners believe in their enterprise and do not embrace the postmodern and deconstructive self questioning typical in the humanities and social sciences[4].

In the fields of theoretical and applied sciences, there is an optimism very different from the skepticism that marks deconstructive thought. Scientists believe they can refine theory and make universally valid discoveries, and technologists believe they can create technologies that better human life and transform culture in positive ways.

The role of computers and information technologies is one area where views of cultural critics and scientists diverge. Many critical theorists emphasize the insidious nature of pervasive, smoothly functioning information technologies that control and promote superficial thought and life. For example, Constance Penny and Andrew Ross note in Technoculture that technology is so much a part of the basic structure of society that innovations are immediately co-opted by the mainstream; thus,they dismiss the liberatory fantasies of the new technologies.[5] Jonathan Crary notes the self-delusion of those who believe in positive revolutionary effects.

> The charade of technological "revolution" is founded on the myth of the rationality and inevitability of a computer-centered world. From all sides a postindustrial society is depicted that renders invisible the very unworkability and disorder of present "industrial" systems of distribution and circulation.
>
> Most often advocacy of "alternative" uses of telecommunications and computers goes hand in hand with a naive belief in the neutrality of digital languages and a blindness to the immanence of binary notation with a specific system of technocratic domination.[6]

Negative analyses from some not usually considered critical theorists include Theodore Roszak, who in the Cult of Information[7] notes that fascination with information often works against real knowledge and deep thought, and Jerry Mander, in Absence of the Sacred[8] who describes the ways in which technology distances people from essential human experience.

Other visions see the technology not running so smoothly, but nonetheless promoting a nightmare world. For example, Crary comments that Baudrillard's analysis assumes a level of functioning that is unlikely.

> What his texts exclude is any sense of breakdown, of faulty circuits, of systemic malfunction; or of a body that cannot be fully colonized or pacified, of disease, and of the colossal dilapidation of everything that claims infallibility and sleekness .[9]

The movie Blade Runner is often cited as an example of this cyberpunk dystopia in which technology has helped to erode order and a sense of history. It is a place exemplifying Frederick Jameson's critical characteristics of postmodernism – pastiche (simultaneous juxtaposition and mutual quotation of styles from multiple eras) and schizophrenia (the breakdown of the referents of signifiers).

> the city of Blade Runner is not the ultra modern, but the post modern city. It is not an orderly layout of skyscrapers and ultra comfortable, hypermechanized interiors. Rather, it creates an aesthetic of decay, exposing the dark side of technology, the process of disintegration, postindustrialization, and quick wearing out.[10]

Others, however, see information technologies as democratizing access to information, humanizing labor, increasing productivity, deepening thought, building community, and generally empowering increasing numbers of people throughout the world.[11] Stuart Brand propounds some of these beliefs in his account of MIT's Media Lab, one of the preeminent new technology research centers.

> Is there any reason to believe that Personal Television, Personal Newspaper, Conversational Desktop, access to an infinite library of Electronic Publishing, a Vivarium of one's own and a fiberoptic connection to a Connection Machine would encourage Personal Renaissance?
>
> There is. We have already seen the arrival of personal computers make multitudes broader in their skills and interests, less passive less traditionally role-bound. That's renaissance. We've seen people use VCR's to stop being jerked around by the vagaries of network scheduling, build libraries of well-loved films, and make their own videos.

> We've seen satellite dishes by the quasi-legal million employed to break the urban monopoly on full-range entertainment...
>
> Each violated what was known about audiences. No wonder. Each made audiences into something else - less "a group of spectators, listeners, or readers" and more a society of selectors, changers, makers. [12]

John Sculley of Apple Computer describes a related vision of the technologically enabled future in the book Interactive Multimedia.

> The book you are holding is a beacon illuminating an exciting future for American education. Technologies described in this book will give us the ability to explore, convey, and create knowledge as never before. Teachers and students will command a rich learning environment that, had you described it to me when I was in school, would have seemed entirely magical.
>
> Imagine a classroom with a window on all the world's knowledge. Imagine a teacher with the capability to bring to life any image, any sound, any event. Imagine a student with the power to visit any place on earth at any time in history. Imagine a screen that can display in vivid color the inner workings of a cell, the births, and deaths of stars... And then imagine that you have access to all of this and more by exerting little more effort than simply asking that it appear ...They are the tools of a near tomorrow and, like the printing press, they will empower individuals, unlock worlds of knowledge, and forge a new community of ideas. [13]

Those who work in any number of emerging technologies –robotics, artificial intelligence, simulation, telecommunications, virtual reality, materials science,nanotechnology, and biotechnology – would describe the probable implications of their work in similar terms. Conferences, trade shows, and journals burn white hot with intellectual foment, excitement, and eagerness to invent the future.

Do these scientists and technologists live in the same world as the culture analysts? The discordance between the world views of those who work with new technologies and culture theoreticians may be an essential issue for understanding the contemporary era. One conceptualization is that one group is wrong because it lacks information. For example, a critical theorist might note that technologists delude themselves about the amount of autonomy they have in their research, the underlying metanarratives that shape their behavior, and the ultimate cultural ramifications of technology. Or perhaps the difference is more like the proverbial cup – half full to some and half empty to others based on experience and reference culture.

Artists working with emerging technologies are often caught in this discordance, which results in some of the critical confusion concerning their work. In the 1960's CP Snow identified the "two culture problem"[14]. He noted that those in the sciences and humanities were living in different worlds with different languages and norms and that the gulf was growing . It is possible that the dark interpretative tone of culture theorists stems from their experience of being acted upon by new technologies, while the optimism of scientists and technologists reflects their engagement in the processes of imagining, inventing, developing and enabling the new technologies.

Artists who work with emerging technologies face a dilemma. They stand with feet in both worlds. On one side they are invited to help create the new technologies and elaborate new cultural possibilities; on the other, they are asked to stand back and use their knowledge of the technology to critically comment on the underrepresented implications of the technology. It is no wonder that there is critical confusion in regard to the work of these artists because of the different stances they can assume. It is easy to see why the critical community might ignore or consider naive work which entertains the world views of the technologists. The section below on artist stances details different responses artists can make to this confrontation of zeitgeists.

The Status of Substantive Things and Organisms in a World Dominated by Image and Media

A basic theme explored by critical theory is the relative importance of information, codes, images and representations versus the material world. In a postindustrial, information economy most people are seen as working with mediated abstractions rather than with real things. Because of the power of computer representations, workers in many businesses don't see the real objects of their business during the work day. Telecommunication substitutions of mediated presence for physical presence highlight these trends. Baudrillard's conceptualization of a hyperreality dominated by media images and by circulating signifiers and codes increasingly disconnected from their referents speaks to the questionable status of things and organisms. Virtual reality technology, which combines visual, auditory, haptic and kinesthetic senses, promises to increase the power of representation to substitute for material experience. Some ecologists suggest that a mediated world might be good because endless production and consumption of things is suicidal. Donna Haraway's "Cyborg Manifesto"[15] points toward a future where bodies themselves might be irrelevant. The perception and meaning of even fundamental "realities" such as disease and sex are profoundly shaped by ideology and discourse.

The assessment of the decline of the importance of the material world is a critical issue for the arts and culture at large. On a basic level the diminished importance of the physical seems overstated. Birth, death, health, disease and the everyday realities of eating, moving, and sex still seem important parts of most people's experience. Many of the world's peoples still struggle to survive and spend their days struggling with the physical world Even in the developed world there is a growing uneasiness about incompleteness in even the most advanced computer simulations and representations of reality[16]. Eugene S. Ferguson comments in his article "How Engineers Lose Touch":

> Despite the enormous effort and money that have been poured into creating analytical tools to add rigor and precision to the design of complex systems, a paradox remains. There has been a harrowing succession of flawed designs with fatal results – the *Challenger*, the *Stark*, the Aegis system in the *Vincennes*, and so on. Those failures exude a strong scent of inexperience or hubris or both and reflect an apparent ignorance of... the limits of stress in materials and people under chaotic conditions. Successful design still requires expert tacit knowledge and intuitive "feel" based on experience.[17]

Historically, the arts have spanned both the material and the representational - working with image at the same time as they celebrated the substantiality and sensuality of real things as in sculpture and architecture. As Walter Benjamin noted in "Works of Art in the Age of Mechanical Representation" technologies such as photography and cinema decreased the importance of presence and "aura".

Questions of materiality are especially critical for artists working with new technologies. The imaging, communications, and information technologies they work with are key facilitators of this mediated world. The work they do helps to explore and settle new worlds of representation. Yet, it is not inevitable that new technologies only work with representation. The technologies that manipulate physical things - for example, robotics, nanotechnology, material sciences, alternative energy research and biotechnology - have been less accessible to artists and the general public. These technologies will be increasingly important, and point toward futures where technologically mediated material things have increasing importance. Artists need not accept the inevitability of a vision in which materiality becomes unimportant.

The Difficulties of Locating a Rationale for Action in a Deconstructed Milieu

Postmodernism and deconstruction can lead to a classic double bind. If all claims to truth are invalid then why should one author's vision be privileged over any others'? If every work is a recombination of texts received from elsewhere and bounded by a limited discourse community, then why should it have meaning outside that community. If originality, genius, and avant-garde status are outdated, then what is the role of the intellectual, critic, or artist? What is the origin and justification of their need to create and what is the motivation of anyone else to listen?

Norris notes in What's Wrong with Postmodernism that some post structuralists used deconstruction in a way that was much more epistemologically radical than intended.

> For Saussure, this exclusion (of referential aspects) was strictly a matter of methodological convenience, a heuristic device adopted for the purpose of describing the structural economy of language, that is, the network of relationships and differences that exist at the level of the signifier and the signified For his followers, conversely, it became a high point of principle, a belief - as derived from the writing of theorists like Althusser, Barthes, and Lacan, - that 'the real' was a construct of intralinguistic processes and structures that allowed no access to a world outside the prison-house of discourse. [18]

He further states that the validity of a writer's arguments depends on assumptions of truth and value even though their assumptions of validity would seem to contradict their theories. He quotes Derrida explaining this need:

> (writers must) invoke rules of competence, criteria of discussion and of consensus, good faith, lucidity, rigor, criticism and pedagogy ...without these strictly indispensable protocols ... deconstruction will lack all critical force. [19]

Similarly, he notes that Baudrillard's writings make no sense without some claims of truth.

> his work is of value in so far as it accepts -albeit against the grain of his express belief - that there is still a difference between truth and falsehood, ...the way things are and the way they are commonly represented....it just does not follow from the fact that we are living through an age of widespread illusion and misinformation that therefore all questions of truth drop out of the picture. [20]

All artists, critics and intellectuals who entertain these critical theories must resolve these contradictions for themselves and their audiences. On what basis can artists claim that their productions deserve an audience and that their perspectives provide a view not generally available? What does it mean in the postmodern world to say that one person has a clearer vision than another?

III High Tech Artists' Stances Toward Cultural Theory

Critical theory and cultural studies pose significant challenges to the artist. How should they conceptualize their work? What sense can they make of the art world and its relationship to the larger culture? With the growing prevalence of critical theory and postmodern analysis in art world discourse, artists can stake out their own theoretical stance; they must choose which assessments and theoretical propositions to accept or reject. Clarity is especially important for those artists who work with emerging technologies.

The sections below describe three possible stances, which emphasize different ways to respond to the critiques and to address the special challenges of new technologies:
1. Continue a modernist practice of art linked with adjustments for the contemporary era.

2. Develop a unique postmodernist art built around deconstruction at its core. 3. Develop a practice focused on elaborating the possibilities of new technology. For the sake of clarity the interrelationships are de-emphasized.

Continue Modernist Practice of Art with Modifications for the Contemporary Era

Many in the art world reject substantial portions of critical theory. They still believe in the validity and cultural usefulness of a modernist, specialized art discourse that claims universal aesthetic truth. They believe art can have an avant-garde function, that individual vision and genius are still relevant, and that artists can transcend their particular niches in cultural discourse. They hold that the art world can be reformed, without fundamental change, to assimilate previously ignored voices such as those of women, people of color, and the third world. They see the high art/low art distinction as useful. They are confident that they can appropriately negotiate the inclusion of popular culture images and media and incorporate selective insights of cultural theory without necessitating revolutionary change in the nature of art.

The work of some artists with emerging technology can be viewed as continuous with the work of artists who work with traditional media. They see themselves engaged in specialized aesthetic discourse and nurture their personal sensitivity, creativity, and vision. They aspire to be accepted by the mainstream world of museums, galleries, collectors, and critics (or for some, cinema and video). They work on concerns and in modes developed for art in the last decades such as realism, expressionism, abstraction, surrealism, conceptual work. They believe that art will continue to renew itself, find ways to appropriately connect with its host cultures and develop relevant new movements in the future. In fact they see themselves as essential to progress in art, and seek to cultivate the unique and "revolutionary" expressive capabilities of their new media and tools. They believe that the art world will ultimately incorporate even unprecedented technologies and approaches such as image processing, interactivity, algorithmic systems and virtual reality. The claim by some that these approaches so radically challenge fundamental art substructures that they cannot be assimilated will require significant critical analysis.

Deconstruction as Art Practice

Many artists who have found these theory-based analyses compelling have been attempting to develop an approach in which deconstruction itself is a main agenda. The theories provide concepts, themes, and methodologies for creating art works that examine and expose the texts, narratives, and representations that underlie contemporary life. Even more, the work can reflexively examine the processes of representation itself within art.

Technology and its associated cultural contexts are prime candidates for theory based analysis because they are critical in creating the mediated sign systems and contexts that shape the contemporary world. In this kind of practice artists learn as much as they can about working with the technologies so that they can function as knowledgeable commentators. In one typical strategy, artists become technically proficient so they can produce works that look legitimately part of the output of that technology world while introducing discordant elements that reflect upon that technology. Thomas Lawson describes this approach as it might be used in painting, but the strategy applies in all media.

> But by resorting to subterfuge, using an unsuspecting vehicle as camouflage, the radical artist can manipulate their viewer's faith to dislodge his or her certainty. The intention of that artist must therefore be to unsettle conventional thought from within, to cast doubt on the normalized perceptions of the "natural, " by destabilizing the means used to represent it.[21]

Invention and Elaboration of New Technologies and their Cultural Possibilities as Art Practice

This century is characterized by an orgy of research and invention. Knowledge is accumulating at high speed; branches of knowledge, industries, social contexts, and technologies have appeared that could not have been anticipated. These developments are affecting everything from the paraphernalia of everyday life to ontological categories. As the pace continues, predictions about future discoveries and their consequences are impossible.

Artists can establish a practice in which they participate at the core of this activity rather than as distant commentators, even while maintaining postmodern reservations about the meaning of the technological explosion. Some analysts see scientific and technological research as the central creative core of the present era. As Paul Brown suggests in his essay in the SIGGRAPH 92 Visual Proceedings, historians may ultimately see aspects of science as the main art of our era.

> I believe that the art historian of the future may look back at this period and see that the major aesthetic inputs have come from science and not from art....Maybe science is evolving into a new science called art, a polymath subject once again.[22]

As this author has described in previous articles, "Research and Development as a Source of Ideas and Inspiration for Artists"[23] and "Industrial Research Artist: a Proposal"[24] artists can participate in the cycle of research,invention, and development in many ways. They can learn enough to become researchers and inventors themselves. From the time of Leonardo until recently, the merger of scientific and artistic activity was not uncommon. The claim that this unified method of functioning is impossible now because scientific or technological research requires mastery of too much specialized knowledge and access to an elaborate research infrastructure must be critically scrutinized .

Artists can function in other ways. Free from the demands of the market and the socialization of particular disciplines, they can explore and extend the principles and technologies in unanticipated ways . They can pursue lines of inquiry abandoned because they were deemed unprofitable, outside established research priorities, or strange. They can integrate disciplines and create events that expose the cultural implications, costs and possibilities of the new knowledge and technologies.

This practice does not accept the output or the conceptual frameworks of the science and technology world as givens. Rather it seeks to update the notion of the arts as a zone of integration, questioning and rebellion to serve as an independent center of technological innovation and development. An example from just one area of technological foment will illustrate. Many electronic artists are interested in the new possibilities created by telecommunications technology and seem interested in inventing and extending the technology. Certainly, they are interested in the issues cultural theorists might raise: for example, Who controls and has access to this technology? How is it represented to consumers and to developers? What larger cultural movements is it part of? What fantasies does it tie into? Even though these topics might be substantive focuses of their work, their tone is basically optimistic about the potential meanings of these developments.

Roy Ascott, a long time pioneer in this work, illustrates this optimistic outlook in his article "Art and Education in the Telematic Culture."

> But the art of our time is one of system, process, behavior, interaction....This is precisely the potential of telematic systems. Rather than limiting the individual to a narrow parochial level of exchange, computer-mediated cable and satellite links spanning the whole planet open up a whole world community, in all its diversity, with which we can interact....With electronic media, its flow of images and texts, and the ubiquitous connectivity of telematic systems this isolation and separateness must

> eventually disappear, and new architectural structures and forms of cultural association will emerge. And in this emergence we can expect to see, as we are beginning to see, new orders of art practice, with new strategies and theories, new forms of public accessibility, new methods of presentation and display, new learning networks – in short, whole new cultural configurations.[25]

Telecommunications is just one of many fields of technoscientific research that promise culture transforming possibilities. Taking advantage of unique traditions of the arts, such as valuing iconoclasm and interdisciplinary perspectives, artists can choose to be a part of the efforts to create these new technologies and fields of knowledge. Furthermore, this artistic stance calls for artist participation in other fields beyond the digital technologies that are focused on in this essay such as new biology, materials science, and space exploration.

Crossing Boundaries

The artistic stances described above outline a range of responses artists can and have taken toward emerging technologies. Real practice, of course, is not so clearly demarcated as these categories. As they go about their work artists cross over. For example, consider how this analysis might be applied to artists' work with virtual reality (VR) technology.

Many artists seem to want to work within historically recognizable artistic traditions, with virtual reality seen primarily as a new medium. They want to create highly interactive compositions that will be judged by their thematic, dramatic, visual and sound accomplishment just as traditional media have been. New aesthetic categories focused specifically on the interactivity and kinetic engagement will no doubt be developed but the social niche of VR as entertainment or art form is not that different from what already exists. The interest expressed in this technology by the entertainment industry attest to its readiness to assimilate this technology to traditional forms. And as with traditional media, independent artists are developing works based on this technology, which elaborate poetic, expressive, craft, sensual or conceptual directions likely to be ignored by commercial interests.

One direction for artists using the VR technology in a conceptual or social commentary mode might be to use it reflexively on the technology itself. For example, they might explore the origins of the technology in military simulation, the language used to promote it, or the social niches in which it is adapted. They also might use its unique potential to offer new perspectives on body or gender (for example, allowing individuals to constitute themselves to other VR travelers in any gender desired). These explorations pass over into the deconstructive, theory based practice described above.

Other artists might be interested in pushing the functioning of the technology- for example, by extending the ways it senses body motions or the way it represents worlds. Alternatively, they might work on inventing or investigating new non-commercial applications such as ways of experiencing being in two locations at once or experiencing the life of animals or inanimate objects.. This work passes over into the technology extending practice described above.

Summary: How Can the Arts be Part of a Technological Era?

There is an acknowledged danger that technology is advancing much faster than the culture's ability to make sense of it. The arts have traditionally been a place where understanding, integration and preparation for future developments takes place. There are several competing visions of how artists can most fruitfully work with emerging technologies: treat them as new media, deconstruct their cultural implications, or participate in the processes of invention and extension.

Critical theory and cultural studies offer compelling tools for understanding some aspects of contemporary technological society. Furthermore, these theory based approaches offer powerful concepts and methodologies for practicing artists to use in responding to the realities of an electronically mediated world . However, while these approaches are useful for understanding what exists, they are problematic for envisioning what might be. Furthermore, these approaches, in their their skepticism about progress and about the possibility of innovation to transcend specific contextual discourses, are at odds with values of the researchers and inventors who believe they are working to create new cultural possibilities. Artists who work with emerging technologies are faced with the challenge of positioning themselves in these conflicting world views.

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* This paper is condensed version of a paper which appeared in the Siggraph 93 Visual Proceedings © Association for Computing Machinery (ACM)

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Art Imaging with Color Copiers
A Survey of Artworks from North America and Europe

Mary Stieglitz Witte, PhD

BACKGROUND

The history of copier technology may begin with the earliest human efforts to create mechanical records of images in their environment. Numerous devices were employed over centuries of experimentation. The camera lucida was refined by the 16th century, with photography and photomechanical printing processes introduced during the 19th century. Related tools emerged when A.B. Dick marketed Edison's mimeograph in 1887, and 3-M marketed its Thermo-Fax in 1950. Of principal note is the production of the first electrophotograph by Chester Carlson in 1938. Carlson's original patent (1939) described the 'electrophotographic copying apparatus' which would evolve into the first commercially successful photocopier. Carlson spent years trying to sell his idea to numerous companies. The Haloid Corporation accepted and developed Carlson's process. Haloid Xerox released the Xerox Model D in 1950, the famous Xerox 914 in 1959, and became the Xerox Corporation in 1961.

Artists experimented with photocopiers as soon as commercial plain paper copiers became available, and responded with increased interest when full color copiers appeared. The 3-M Color-in-Color System I was introduced in 1968. By 1970, Sonia Landy Sheridan established a program in 'Generative Systems' at the Art Institute of Chicago which incorporated this new color copier. Sheridan worked directly with an inventor of the Color-in-Color System, Douglas Dybvig. She described the program as one "which brought artists and scientists together, ... an effort at turning the artist's passive role into an active one by promoting the investigation of contemporary scientific-technological systems and their relationship to art and life."[1] Sheridan advocated concepts, dimensions, and applications beyond a limited vision of 'copy art'. As the seventies proceeded, artists were working with the 3-M Color-in-Color System I and II, and with the Color Xerox 6500. Xerox and 3-M both employed three-color systems and light-lens technology, which offered potentials as well as limits. The Xerox 6500 dominated the market during the seventies and eighties. These first color copiers offered capabilities for creative imaging, considerable manipulation of colors & images, and the transfer of images to a variety of other surfaces.

Color copiers became new tools for artists, photographers and designers. They provided opportunity for direct, spontaneous image making with potential for new transformations. The landmark exhibition 'Electroworks' was presented by the International Museum of Photography at George Eastman House, Rochester, New York, in 1979. The exhibit included a varied collection of two hundred and forty-five works ranging from experimental photomontages to limited edition books and clothing. In the catalogue, guest curator Marilyn McCray referred to copy art as having "generated activity all over the world. These highly stylized and individualized works of art are collected by major museums and sold by art dealers and galleries for prices that amaze the inventors of the processes and the pioneers of photo-copier marketing."[2] The exhibition clearly demonstrated the potential of new technologies as tools for the visual arts.

In 1982, the Centre Copie-Art was established in Montréal (Québec), Canada. The Centre has had significant impact on many levels, including international genre. Their replete blend of exhibitions, workshops, research, and catalogues, promoted the meeting of art and technology. Jacques Charbonneau, founder and managing director, described the Centre's research consequences: "Many artists arrived to a new perception of a great creative power which was unsuspected prior to the works made thanks to the Centre."[3] The Centre's main goal is to integrate copy-art into the field of visual arts.[4] The Centre Copie-Art closely cooperates with the Museum für Fotokopie in Mülheim, Germany and the Museo Internacional de Electrografia in Cuenca, Spain, as well as other copy-art centers worldwide.

Philippe Boissonnet described the Centre's ongoing 'Artist in Residence Program' as dealing with the expressive and plastic potentialities of the equipment, the unexperimented and free exploration .[5] He cites intent to "create works which would be one-of-a-kind, which would be *original* as contrasted to *a copy*. The idea: try to outspace the limits which are intrinsic to the "copigraphic tool". The idea: to feature some of the plastic characteristics inherent to the medium."[6]

Monique Brunet-Weinmann noted the stages through which copy art has progressed, and observed that it has already reached the third stage of 'institutionalization'.[7] Recognition of copy art has forged the "stage of developing a textual corpus of manifestos, vocabularies and historical summaries which are all discursive strategies to gain some leadership regarding copy art, copygraphy or electrography. This critical and theoretical production was entirely absent in the early eighties. It turns out that it is necessary to throw some light on a medium-tool that is spreading and networking at a fast pace in technological interartiality with other fields".[8]

In 1982, Louise Odes Neaderland founded the International Society of Copier Artists in New York City. Neaderland reports that the impetus for founding ISCA was the lack of opportunity to share and show copier art. The Society promotes and recognizes the use of the copier as a fine art tool. Neaderland continues to direct ISCA and publish the *ISCA Quarterly*, of which one issue a year is dedicated to bookworks. This annual 'box of books' is a favorite of both artists and collectors.

Artist members include printmakers, painters, photographers, graphic designers, book artists and computer graphists. More than twenty-five museum and institutional members worldwide subscribe to the *Quarterly*, a limited edition journal composed entirely of original art. ISCA also mounts traveling 'Iscagraphics' exhibitions, and maintains an extensive slide archive in New York.

NEW DIRECTIONS

In 1988 the Canon Corporation began marketing its Color Laser Copier, the CLC 1. This full color digital laser copier revolutionized the color copier market with digital scanning, a four color system, high resolution, and a wide range of manipulative capabilities. The Canon CLC was the first of many full color copiers to be introduced into this expanding market in the late eighties and early nineties. Sharp, Kodak, Panasonic, Richoh and Savin, among others, quickly entered the market. Canon regularly introduced additional models offering increased capabilities. In 1991 Xerox introduced its digital color copier, the Xerox 5775. The related proliferation of full color digital printers, plotters, ink jets and similar devices also increased the hard copy alternatives available to visual artists.

The current generation of digital color copiers allows increased opportunity for new directions in imaging. The switch from light-lens to digital laser scanning vastly expanded copier capabilities. Digital technology offers greater user control, versatility in creative editing, and resolution. Laser scanners 'read' the image, capture the image digit-by-digit, and process the information by computer. As input, the copiers accept color negative or positive transparencies (photographed or hand-made), prints, or actual objects on the glass. In addition, some of the new color copiers have peripheral units which allow the copier to accept input from a variety of sources, including computer files in several file formats, video signals, and CD-ROM imagery. As output, the new machines print on a variety of surfaces, and in dimensions from standard writing paper to billboard size.

The distinction between digital (discrete) and analog (continuous) representation is significant. Digitally encoded and computer processable images are clearly distinguished from that of their photographic predecessor. Critical factors are differing amounts of information and differing characteristics of replication and manipulation in each format. Digital information is easy to manipulate, recombine, and transform.

William J. Mitchell discussed the quandary of an era when artists celebrate the potential of digital image manipulation, and the press calls for a code of ethics to regulate manipulation. Mitchell noted that we may "...see the emergence of digital imaging as a welcome opportunity to expose the aporias in photography's construction of the visual world, to deconstruct the very idea of photographic objectivity and closure, and to resist what has become an increasingly sclerotic pictorial tradition."[9] He also observed that "After more than a century and a half of photographic production, we also have to contend with the powerful 'reality effect' that the photographic image has by now constructed for itself."[10] Digital imaging has jolted this reference with its new conventions, new forms, new understandings.

The fidelity of the new copiers further diminishes the traditional differentiation in the arts between original and copy. Appropriation is quick, effortless, and can be seen as a potential concern or opportunity. Margot Lovejoy says that "In a sense copier technology represents the act of appropriation itself and stands out as a site for the Postmodern because it addresses directly questions having to do with the copy and the original, authorship and originality."[11] She further notes that "The use of the copy ... is one of the new strategies of postmodern artists who are appropriating images and styles of the past to critique the conventions of art history itself -- to deconstruct or unmask the modernist notion that the "original" and "originality" rightfully dominate in assigning value to art."[12]

Questions arise concerning the legitimacy of art done by machine. Some ask if the mark of the human hand isn't necessary to art. Aren't mechanical tools the preserve of the unskilled? Can a mechanical system produce works of art that are unique, personal, of aesthetic value? Is the copying process at odds with standards of creativity? Do copiers encourage illicit appropriation? One answer is to recognize the significance of the artist's concept above the tool, material or process. The originality of the visual statement does not depend on the rarity of the image, the laboriousness or complexity of tool and process.

Repercussions to machine-aided art are certainly not new. With the proliferation of photography in the mid-nineteenth century, the painter Paul Delaroche is traditionally acknowledged as pronouncing 'From this day painting is dead'. Baudelaire is also said to have offered his observation that 'Industry, by invading the territories of art, has become art's most mortal enemy'.

Photography and industry were not fatal to painting and art, but the visual arts were immutably affected. Artists embraced the new technologies and enlarged their selection of tools and media. Just as photography proved to be a means of expression, creation, innovation, and communication; electrostatic media, computers, and electronic imaging now offer new modes of visualization. Some artists naturally turn to the new tools and media available to them. New technologies applied to art forms offer potential for new constructs, both visual and conceptual. The **slide survey** constitutes the nucleus of this FISEA presentation, and exemplifies some of these new visual paradigms. These images, with statements by the artists, speak eloquently for themselves.

THE SURVEY

The slides present a visual survey of selected contemporary artists in North America and Europe who utilize color copiers in their work. This sampling provides a rich repertory by twenty-five diverse artists exhibiting new visual paradigms. Artists approach color copiers with diversity, spontaneity, a sense of discovery, exploitation of the technology, and elements of play. The opportunity for artist/machine interaction affords the potential for new combines of art and technology, and a fresh repertory of forms, methods, communications, and interpretations. Many artists attempt to demolish the confines which are intrinsic to the photocopier. Every tool offers particular potentials as well as limits to be considered.

Artists utilize color copiers with vast divergence. Some use the machine as a large camera, bringing a variety of objects, images, and materials to the copyboard glass. One artist may use a color copier to create a visual diary or self portrait, another may use it as one would employ a small press. The artist may bring to the copier a prepared 'master' image, often a collage or synthesized work, and then utilize the copier to print the desired number in the edition. Lovejoy notes that "David Hockney calls the collection of office copiers in his studio *magic new presses*".[13] Some artists print a specific edition, signing and numbering the edition in the tradition of the printmaker. Others tap the 'press' as needed, often varying the prints and producing unique works rather than editions. A considerable number of artists use color copiers as a production tool for limited edition art books.

Other artists use color copier prints as intermediary images. One example is using the copier as a device to produce elements for the construction of a final collage or composition. The artists then fabricate one-of-a-kind works with color copy elements. An interesting paradox exists in this use of a machine engineered for duplication, employed to create unique works. Diverse manipulations during printing, or of the print afterwards, also result in unique images.

Another example of the color copier as intermediary tool are works which are transformed by heat or solvent transfers to other surfaces. This often produces a softening and/or transformation of the image which enhances the unique quality of these works.

This presenter's experience with color copiers began with the 3M Color-in-Color System I, later the Xerox 6500, and was reactivated by the Canon CLC 1. My work explores perceptual relationships, especially figure and ground interplays. With a photography background, I am challenged by both the meanings my images communicate, and the perceptual aspects of those images. Digital tools allow me to release my photoimages from their conventional frameworks and spatial cues, often challenging traditional concepts of shape and space. Multiple layers of images are combined both physically (via collage) and electronically. Figure/ground interplays allow new interconnections and relationships, creating various interpretations and readings of the imagery. They play among visual and perceptual codes, assist the perceptual plays and ploys, and attempt to expand ways of both objective and subjective knowing.

Many of the artists in the slide survey have had considerable influence in the use of color copiers as a tool/medium in the visual arts. There continues to develop a syntax of copier imaging. The images surveyed in this presentation present a look at current contexts and aesthetic organizations, and a notion of future directions.

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