SIGGRAPH '82 ART SHOW

Boston Massachusetts July 26-30, 1982

ART SHOW COMMITTEE:

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INTRODUCTORY ESSAYS:

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A. Michael Noll
Cynthia Goodman

front cover:
Mike Marshall
"Beam and Bubbles" 1982

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"Santy Fold" 1982

The Siggraph '82 Art Show celebrates the increasing access to electronic technology available to artists today and the growing aesthetic awareness in computer graphics.

Over one thousand entries for this juried exhibition arrived from all over the world. All the work was produced after January 1, 1980. The eighty-eight pieces in this show are diverse in style, medium and technique, holding as a common thread the pursuit of artistic excellence. The use of computers in these works shows that style is established by the artist and not identifiably derivative of the hardware, as was the case five years ago.

We invite artists to participate in Siggraph and encourage them to use it as a teaching and learning forum. Technological art is the future of communications and the source of new and powerful imagery.

An exhibition highlighting the recent achievements of artists working with computers

Elaine L. Sonderegger
General Conference Chairman

TOWARD AUTONOMOUS REALITY COMMUNITIES

A Future For Computer Graphics

Gene Youngblood

Gene Youngblood is an internationally known author and lecturer in electronic art and technology who currently teaches at both the California Institute of the Arts and the California Institute of Technology. Mr. Youngblood has organized international conferences on The Future of Television for The Annenberg School of Communications at U.S.C. and for The Directors Guild of America. He is author of EXPANDED CINEMA (1970), the classic work of media theory and criticism, and is completing a new book, THE FUTURE OF DESIRE, a political and philosophical analysis on the revolutions in biology and electronic technology.

It may live in a vacuum tube (for a few more years at least), but to hear the Mercantile Masters talk you'd think computer graphics lives in a political vacuum as well. For electronics, however, the last quarter-century has been equivalent to pulling back the string on a bow — the storing of enormous technological potential. Now the string is about to be released in the universal application of that technology: the next 25 years will be the flight of the arrow, propelling us into the Electronic Age and precipitating an historically unprecedented revolution in communications. And in the shadow of the Communications Revolution we begin to understand the awesome cultural and political implications of that protean force we refer to so feebly today as computer graphics.

Autonomy and Heteronomy

The practice of the moving-image arts can be divided into five technical categories: (1) *production* or acquisition of image and sound; (2) recording this information in some *storage* medium, (3) *processing* or post-production, (4) *distribution* of the material to its target address or marketplace, and (5) the *display* or presentation of it in one or more formats. Today autonomous individuals have access to tools for the recording, storage and display of audiovisual information but very few of us have processing technology and only the Mercantile Masters control national distribution. The result is cultural heteronomy ("other-law"), a hierarchical structure of authority and reality.

However, I suggest that within ten years the Communications Revolution will give every household the technical capability to engage in all five fields of moving-image practice. That's because the computer is a universal machine that can contain and become all media, and because VLSI technology will increase computing power by a factor of a thousand in a decade. Thus the computer, on line to user-controlled networks, will *become* the tools we need to practice the construction of social reality. The result will be cultural autonomy ("self-law"), a nonhierarchical structure of authority and reality, characterized by the proliferation of "autonomous reality-communities." I shall speak more of this momentarily; meanwhile, consider the following:

The Moving-Image Arts

In ten years the video camera will be a tubeless 100-percent solid-state handheld computer with image resolution greater than 35mm film. It will contain no internal optics, will focus automatically by sonar or Fourier analysis, and microprocessors for image deconvolution or image enhancement will obviate the need for expensive lenses. Lensless zooming will be accomplished by computer operations on the signal rather than mechanical manipulation of the lens. Recording will be digital, on metal tape (later in semiconductor or bubble memory), and the entire camera/recorder unit, resembling a super-8 system, will sell for less than $1000.

That's the computer as camera; what about the computer as *source* of the image? We know all about that, don't we? Taking seriously the predictions about VLSI, and remembering that software trails hardware by about five years, we can safely assume that the personal computer of a decade hence will be a 32-bit "geometry engine" pipeline processor capable of addressing at least a gigabyte of virtual memory, with throughput rates adequate for real time shaded 3-D graphics with a resolution of at least 1000 x 1000 pixels. It will also function as an image processor which, with add-on cards, will perform all the post-production "effects" today requiring $200,000 industrial tools or custom user-built devices like Dan Sandin's Digital Image Processor or Woody Vasulka's Digital Image Articulator. And it'll control a read-write optical disc for video editing.

Of course the personal geometry engine with its flight-simulator capability will be on line to broadband cable and switched optical fibre networks providing custom distribution and access to "telegraphics" and "network reality synthesis." At the amateur level thousands of young warriors will live in labyrinthine networked adventure games and computer clubs will operate dedicated cable-TV channels, showing their simulations and sharing their programs in video as the non-member cable audience looks on and learns. At the venture-capital level, commercial Image Utilities with pictorial data bases will offer real-time interactive simulation: just punch up the right cable channel, turn on your Apple IX and shake hands with the animated ouput of Cray-5 or the latest Josephson-junction superbrain. The data bases, like visual hypertexts, will consist of morphological, anatomical and physiological algorithms for the synthesis of environments, figures and behaviors specified and controlled by the subscribers who could, of course, download the results in their own local memory for future metaconstructions.

Amateurs and Professionals

One consequence of all this will be a loss of distinction between who's a professional and who's an amateur insofar as that's determined by the tools to which we have access. No motivation is as pure, no achievement more dignified than that of the amateur who does it for love. Yet in our professionalized society this most noble aspiration has been reduced to a sneering joke — the amateur as some kind of bozo — as though doing it for love were synonymous with ineptitude, an absence of quality and value. As a matter of fact, by far the most interesting computer graphics I've seen have been produced by skilled amateurs in their living rooms using tools they designed and built. They aren't "hobbyists," they are artists; but please excuse them, they can't afford a Cray-1 — yet. But just give us quality tools and see what happens.

By the end of this decade millions of amateurs will be evolving new computer graphics routines, constructing private visual languages over conversational networks like some thousand-headed Hydra, dwarfing the "contribution" of military-industrial professionals and reducing them to a rather embarrassing historical footnote. As a matter of fact, military-industrial domination of computer graphics signifies its immaturity as a medium. A tool is "mature" insofar as it's easy to use, accessible to everyone, offering high quality at low cost, and characterized by a pluralistic rather than singular practice, serving a multitude of values. Professionalism is an archaic model that's fading in the twilight of the Industrial Age; the Simulators of the Apocalypse should be honored to share the SIGGRAPH spotlight with noble amateurs — heroic warriors of the Electronic Age — who shall inherit the world of simulation by living in the worlds they simulate.

Communication and Conversation

The migration to alternative reality communities will not be achieved through communication. Communication (from the Latin "a shared space") is interaction in a common context ("to weave together") which makes communication possible and determines the meaning of all that's said: the control of context is the control of language is the control of reality. To create new realities, therefore, we must create new contexts, new domains of consensus. That can't be done through communication. You can't step out of the context that defines communication by communicating: it will lead only to trivial permutations within the same consensus, repeatedly validating the same reality. Rather, we need a *creative conversation* (from the Latin, "to turn around together") that might lead to new consensus and hence new realities, but which is not itself a process of communication. "Do you mean this or this?" "No, I mean thus and such . . ." During this non-trivial process we gradually approximate the possibility of communication, which will follow as a trivial necessary consequence once we've constructed a new consensus and woven together in a new context. Communication, as a domain of stabilized non-creative relations, can occur only after the creative (but non-communicative) conversation that makes it possible: communication is always non-creative and creativity is always non-communicative. Conversation, the prerequisite for all creativity, requires a two-way channel of interaction. That doesn't *guarantee* creativity, but without it there'll be no conversation and no creativity at all. That's why the worst thing we can say about the mass media is that they can only communicate — at a time when creative conversations on a massive scale are essential for human dignity and perhaps even our very survival.

Simulation and Desire

What's important to realize is that in our conversations we create the realities we will talk about by talking about them: we become an autonomous reality-community. To be conscious observers we need language (verbal or visual), and to have language we need each other: the individual observer, standing alone, is an impossibility; there is only the observer-community or reality-community that can talk about things (like religion, art, science) because it creates the things it talks about by talking about them.

The Electronics Revolution, bringing conversational machines and networks, will give rise to autonomous reality-communities of politically significant magnitude, defined not by geography but by consciousness, ideology and desire. As constituents of these communities we shall hold continuously before ourselves alternative models of possible realities. We shall learn to desire the realities we simulate by simulating the realities we desire, specifying, through our control of context, what's real and what's not, what's right and wrong, good and bad, what's related to what, and how. This is the profound significance of simulation: it is not fiction, it is the future of politics, reality and desire. The purpose of fiction is to mirror the world and amuse the observer; the purpose of simulation is to create a world and transform the observer. Behold: armies of amateurs gather even now, preparing for the Image Wars, conspiring to abolish once and for all the ancient dichotomies between art and life, destiny and desire.

COMPUTERS AND THE VISUAL ARTS: A RETROSPECTIVE VIEW

A. Michael Noll

While working as a research scientist at Bell Telephone Laboratories, Murray Hill, NJ, A. Michael Noll helped to pioneer the creation of computer-assisted art work during the 1960s. He exhibited his work in the first American and international expositions of computer graphics. He has published proposals for and critiques of the new aesthetic dimensions offered by computer graphics in many visual, art, dance, aesthetics, and technical journals. He is currently planning the development of videotex and other telecommunications services for AT&T.

"In the computer, man has created not just an inanimate tool but an intellectual and active creative partner that, when fully exploited, could be used to produce wholly new art forms and possibly new aesthetic experiences."

Fifteen years ago I wrote these words; they represented my view then of the potential for the use of the digital computer in the visual arts.[1] However, these "new art forms" and "aesthetic experiences" have yet to evolve, thereby possibly supporting the conclusion that the use of the new technologies in the arts has been a "panacea that failed."[2] This estrangement between promise and reality could lead to a disillusionment with the use of computers in the visual arts, but in my judgment this would be a premature conclusion given the relative infancy of this application of computer technology.

In the early 1960's, a number of computer researchers began investigations of the use of computers in the visual arts. My own work in this area at Bell Labs touched upon computer choreography, computer-generated stereoscopic movies (a form of kinetic sculpture), and "random" patterns, all produced by a computer-controlled microfilm plotter.[3] Others in the same time frame, like Ken Knowlton and Ed Zajac at Bell Labs, were also investigating the use of digital computers in animation for artistic and educational purposes.[4,5]

Computer art grew slowly but steadily during the 1960's, and a number of international exhibitions were held, most notably *Cybernetic Serendipity* in London in 1968.[6] More and more computer specialists joined the ranks of the "computer artist."

After utilizing a four-dimensional perspective-projection technique to create the computer-animated main title sequence for a network television special,[7] I became somewhat disillusioned with computer art and "retired" from the field. My last written thoughts on the subject were that "... the use of computers in the arts has yet to produce anything approaching entirely new aesthetic experiences."[8] I also wrote that "... little has actually been accomplished in computer art..." in its first decade.

This disillusionment is not surprising. A similar thing happened in computer music. I remember about fifteen years ago when the accomplished conductor Maestro Hermann Scherchen remarked to me that the effects produced then by computers in music could be as easily duplicated with a few audio oscillators in his studio in Gravesano. However, the technology of electronic and computer music has progressed greatly over the last decade.

The early pioneers in computer and electronic music where technologists whose major contributions were in the development and fostering of the technology. One particularly laudible pioneer was Max Mathews at Bell Labs who also created an environment in which musicians had access to the computer music technology.[9] These pioneers and musicians were personally interested in classical music and hence naturally applied their investigations to that area. However, it was not the serious classical music field that ultimately exploited the new electronic technology but rather the mass-market pop and rock fields. Musicians appeared who were thoroughly familiar with using the new technology as musical instruments. The artistic emphasis was on the effects and the quality of the sounds produced and not on the technology itself.

This view of the development of computer music supports the conclusion that the pioneers of technology are often not the ultimate exploiters of their technological inventions. Furthermore, the utilization of the technology is frequently in areas not envisioned by the pioneers. And lastly, the ultimate exploitation usually takes much longer than envisioned at the invention of the technology.

Something similar has occurred concerning the use of computers in the visual arts. It is in the field of graphics and graphic design — and not the more-classical visual arts — where the use of digital computers has achieved success. Computer graphics systems are widely and routinely used to produce slides for graphic presentations in the corporate world. The production of masks and designs for integrated circuits has been greatly facilitated by the use of computer-graphic systems. The world of commercial television and advertising has increasingly turned to computer graphics, and the design of textiles and wallpaper are already being facilitated by computer graphics.

The technology for using digital computers to create visual images has advanced steadily over the years. I can remember a time when the use of color was quite novel requiring complex color separations produced from black-and-white display tubes. Now, color display and high resolution are the rule, and costs continue to decline. Developments in software have solved the hidden-line problem and facilitated the use of shading for depicting surfaces.

It is in its use as a serious artistic medium in the visual arts where the digital computer has not yet achieved its anticipated potential. Digital computers are being used to create visual imagery, but many people feel that something is missing.

The images sometimes appear to be attempts to mimic other media. Many are cold and sterile and are somewhat devoid of human expression. Randomness combines with geometric structure to create designs that are frequently interesting but that are little more. One is frequently left with the impression that many patterns are simply experiments in learning the new medium.

Can it be that, as Jack Burnham believes, there is some fundamental dissimilarity between art and technology as systems of "human semiosis."[2]

Or is there something inherent in the computer that makes it particularly well suited to producing geometric designs but poorly suited to expressing stimuli from reality and nature.

Or is it, as I believe, far too soon to judge the true impact of the digital computer in the visual arts. After all, many decades had to pass before photography moved beyond being only a technology and became recognized as an artistic medium, and video is only now beginning to achieve that status.

I am optimistic and hopeful for the future of computers in the visual arts. I do not believe the future lies in using the computer to mimic what can be done better with other, conventional media, even though the computer can eliminate drudgery and perform with lightening speed. Perhaps the future will evolve in ways that are difficult now to envision as potentially totally new art forms evolve from the computer technology.

One thing that is clear though is that the future will have truly arrived when the emphasis is on *what* has been produced as opposed to *how* it was produced. Far too much of the computer art produced thus far places too great an emphasis on the *computer* and far too little on the *art*. It is as if the medium has become the art!

Also much computer art does not utilize the interactive and dynamic potential of the computer. Static images are programmed that do not relate to the individual viewer. The potential for the computer to sense the viewer's state of being and change the imagery accordingly has not been thoroughly explored. The man-machine communication problem is still challenging; the computer is a difficult medium for artists to control; and the technology remains mostly inaccessible.

At one time, I parroted Allon Schoener's belief that a form of "citizen-artist" could emerge from the use of the new technologies.[10]

The increasing growth in home computers with color graphics capabilities would seem to be bringing us closer to that day. However, I believe that the aesthetic sensitivities and training of the artist are and will continue to be unique in the use of the computer, or any artistic medium for that matter. What might happen from the growing popularity of home computers is the gradual growth of a body of people who are keenly literate in computer graphics and who later become artists bringing the computer medium along with them and contributing to its development.

Creative persons from the artistic community — not technologists — must continue to appear who are expert in the use of the computer medium. The computer as the medium must surrender to the artistic effects produced. Presently, the two continue to be too intertwined. In conventional art it is rare that one would criticize the medium in general, for example water colors, if one did not like a particular work utilizing that medium. Unfortunately this is not the case in computer art which remains tied to the computer community and has yet to find its home in the artistic world.

In final conclusion, I am indeed optimistic about the future of computer art and have come full circle to again believe in the great promises of the paragraph quoted at the beginning of this essay. I have no doubt that it will occur — the key question is when.

Footnotes

1. "The Digital Computer As A Creative Medium," A. Michael Noll, *IEEE Spectrum,* October 1967, pp. 89-95.
2. "Art and Technology: The Panacea That Failed," Jack Burnham, *The Myths of Information,* Edited by Kathleen Woodward, Coda Press, Inc. (Madison, Wisconsin), 1980, pp. 200-215.
3. "Computers And The Visual Arts," A. Michael Noll, *Design and Planning Number 2,* Edited by Martin Krampen and Peter Seitz, Hastings House, Publishers, Inc. (New York), 1967, pp. 65-79.
4. "A Computer Technique For Producing Animated Movies," Kenneth C. Knowlton, *AFIPS Conference Proceedings,* Vol. 25, 1964, pp. 67-87.
5. "Computer Animation: A New Scientific And Educational Tool," Edward E. Zajac, *Journal Society Motion Picture and Television Engineers,* Vol. 74, November 1965, pp. 1006-1008.
6. *Cybernetic Serendipity,* Edited by Jasia-Reichardt, Studio International (London), 1968.
7. "Computer Animation And The Fourth Dimension," A. Michael Noll, *AFIPS Conference Proceedings,* Vol. 33, 1968, pp. 1279-1283.
8. "Art Ex Machina," A. Michael Noll, *IEEE Student Journal,* September 1970, pp.10-14.
9. "Inteview With Max Mathews," C. Roads, *Computer Music Journal,* Vol. 4, No. 4, 1980, pp. 15-22.
10. "2066 And All That," Allon Schoener, *Art in America,* Vol. 54, March-April 1966, pp. 40-43.

ART AND TECHNOLOGY: BRIDGING THE GAP IN THE COMPUTER AGE

Cynthia Goodman

Cynthia Goodman, art critic, historian, and curator, has published widely in various publications including Arts Magazine, Portfolio, *and* Harper's Bazaar. *Her numerous exhibitions and catalogue essays include* "Hans Hofmann as Teacher: Drawings by His Students" *(Metropolitan Museum of Art),* From the Collection of Governor Nelson A. Rockefeller *(State Legislature Building, Albany),* Frederick Kiesler's Endless Search *(Andre Emmerich Gallery, N.Y.),* Helen Frankenthaler in the 1970's *(Saginaw Art Museum),* Judith Godwin *(Ingber Gallery, N.Y.), and* Hans Hofmann: A Centennial Appreciation *(Andre Emmerich Gallery, N.Y.). She is currently writing an article on computer art for* Portfolio Magazine *as well as compiling a catalogue raisonné of the paintings of Hans Hofmann, and a catalogue of the Hofmann collection at the University Art Museum, Berkeley, for publication by Cornell University Press.*

Much as the majority of the art public has tried to ignore the art and technology phenomenon, it is no longer either possible or fashionable to do so. The large retrospective of video artist Nam June Paik at the Whitney Museum in New York in the Spring of 1982 was just one of numerous recent examples of the acceptance of the new technology in a traditional art environment. A lack of familiarity with the actual process by which the works are made, has caused the word "computer" in connection with art to be met with particular distrust out of the ill-founded fear that this mystifyingly complex machine might soon replace the artist in the creation of art. Yet in spite of the electronic implementation, computer-aided art is still in many ways as much a handcrafted product as conventional art forms but simply processed in a different manner. Furthermore, because most artists are as of yet unacquainted with the mechanics and potential of computers, their accomplishments on computer systems, which may assume various forms including color xerography, photo enlargements, plotter drawings or video, to name only a few, are often the product of intense collaboration in a laboratory-like environment between the artist and someone technically proficient in the computer field. This practice is in antithesis to the myth of the sculptor or painter struggling preferably in solitude in a studio to realize his artistic concepts in pencil, paint, metal, stone, or other common materials.

The products of art and technology have often been rejected outright. Lillian Schwartz's frustrating, yet enlightening encounter probably typifies countless others experienced by her colleagues. In 1969 a computer generated print which Schwartz submitted to a competition in New Jersey was rejected. The following year, she entered the same print, listing the medium as silkscreen. This time, not only was the print accepted but also bought by the Trenton Museum for its permanent collection.

In spite of popular misconceptions, developments in technology have gone hand in hand with evolution in the field of the arts throughout much of history, and the accomplishments of numerous outstanding artists have been intertwined with and enhanced by their knowledge of science. Leonardo da Vinci most frequently comes to mind as the artist whose profound curiosity about the mechanical sciences coupled with his fertile imagination and ingenuity as an inventor, produced a great number of drawings of interest for the scientist as well as for the lover of art. Representing only one of his many engineering concerns, among his sketches are over five hundred dealing with the phenomenon of flight including drawings of helicopters, parachutes, gliders, and flying machines propelled by man.

Nevertheless, Leonardo's aeronautic studies had no direct application on aviation. However, according to Dr. Jon B. Eklund of the National Museum of History and Technology in Washington D.C., who organized with Dr. Cyril Stanley Smith of the Massachusetts Institute of Technology the exhibition "Aspects of Art and Science" for the Smithsonian in 1978, their researches have led them to conclude that in numerous situations the technology developed by artists has had a direct application to science as well as science contributing to the arts. The use of acids and other corrosive materials in the etching process is a prime example of his theme and one which he illustrated with a group of carnelian beads from Chanhadaro, India, that show how as early as 3000 B.C. craftsmen were using an alkali substance to etch decorative patterns into such ornaments. Acids were also used by the Pre-Columbian cultures of Central and South America in order to create a gold surface in a process that has become known as "depletion gilding." In Europe the potential of the etching medium was later developed as a means of decorating armor. Finally, this technique culminated artistically in the production of works of the high calibre of Rembrandt's prints. As Eklund has noted, some of the first mentions of the use of acids appeared in conjunction with etching, and in spite of the eventual improvements upon the artisans' knowledge of acids based on an intimate familiarity with their medium, their preparations remained in the literature on this subject well into the eighteenth century.[1]

A link between the worlds of art and science has intrigued and challenged many artists of the twentieth century. In this respect, the Futurists were particularly explicit about their goals, proclaiming in their "Technical Manifesto" of April 11, 1910, that art should portray the world as created by "victorious science." Although not as consistent as the Futurists in their allegiance to modern technology, recent discoveries also exerted a force upon the art of the Russian Suprematists. In an early manifesto, Kasimir Malevich, one of the leaders of this group, extolled an art based on "weight, speed, and the direction of movement." The references to non-Euclidean geometry in the Cubist writings of Guillaume Apollinaire, Albert Gleizes, and Jean Metzinger are most likely based on a contemporary interest in geometry rather than a knowledge of Einstein's Theory of Relativity as has been postulated.[2] However, Einstein's affect on scientific and artistic communities alike after 1919 when his theories on space came to public notice was enormous. Hans Hofmann, for instance, one of the major figures in the group of American artists known as the New York School, who rose to international prominence after World War II, called his last series his "Quantum" paintings, undoubtedly a reference to Einstein's theory.

Hofmann also noted on a number of occasions how integral he felt art and science were. The "Preface" to the 1931 edition of his unpublished manuscript *Creation in Form and Color* opened with the observation that: "All productivity finds realization simultaneously in an artistic and scientific basis. For that reason in the end, creative science is art and creative art is science."[3] Perhaps his youthful achievements as an inventor led him to choose to stress the creative aspects of the scientific process rather than its rigid formulas. Assuming an attitude that was to contribute greatly to the acceptance of the scientist in the realm of art, Hofmann announced that "the scientist is also a creator when his search leads him to new dimensions."[4]

A fascination with machinery has played an increasingly larger role in the world of art since 1900. The form of the machine has appeared in the work of many painters and sculptors including Fernand Léger, Max Ernst, Robert Delaunay, and Paul Klee, who in such paintings as his famous *Twittering Machine* was able to combine his attraction to mechanical devices with his sense of humor and exquisite draughtsmanship. Many other artists incorporated modern technology in their artistic concepts. In 1920 Marcel Duchamp in collaboration with Man Ray constructed a *Rotary Glass Plate (Precision Optics)* as a motorized construction of painted plexiglass and metal in which the five panels rotated to create the illusion of existing as one spiral when seen frontally. Russian Constructivist Vladimir Tatlin's fifteen foot high model for his *Monument for the Third International* to honor the Bolshevik Revolution also designed in 1920, was constructed of wood and metal with a motor to move it as he hoped the full scale structure of iron and glass would when built. Frederick Kiesler - always abreast of the latest technological advances - incorporated film instead of a backdrop for the first time in live theater in 1922 in a Berlin production of Karl Capek's play *R.U.R.* In 1932 Alexander Calder created a sensation in two exhibitions, one in Paris and one in New York, by exhibiting the motorized sculptures which have become known as his mobiles.

Modern technology entered the composition as a functioning formal element in the "combine paintings" of Robert Rauschenberg. In his 1959 picture *Broadcast*, for example, he incorporated three radios, the dials of which could be operated by the viewer to change the stations. Continuing this tradition, Tom Wesselman playfully positioned an unclad female lounging in front of an operable miniature television set in his assemblage *Great American Nude #39* of 1969. Other artists employed the advances of modern technology as a means of expanding their traditional vocabulary. The innovations in the stain paintings of Helen Frankenthaler and Morris Louis, created by soaking paint into unprimed canvas beginning in the fifties, may be attributed to a great extent to the properties of the newly invented water-based acrylic paints. In the sixties, Dan Flavin first executed pieces of sculpture from fluorescent light bulbs, and sculptor Larry Bell sensitively colored glass boxes, using a technique initiated by the U.S. Air Force to cover the glass surfaces in the pits of their fighting planes.[5]

In the late 1960's art world attention began to be notably focused on the liason between art and technology. Engineer Billy Klüver and artist Robert Rauschenberg founded E.A.T. (Experiments in Art and Technology) in 1967 based on a goal they expressed jointly in one of the first publications of *E.A.T. News*, that is, "to catalyze the inevitable active involvement of industry, technology, and the arts." In order to do so, "E.A.T. has assumed the responsibility of developing an effective collaborative relationship between artists and engineers."[6] This organization was stimulated by their conviction that such an interdisciplinary interaction would prove beneficial not only to the participants but also to society as a whole.

The major accomplishment of E.A.T.'s joint efforts was the Pepsi Cola Pavillion designed for the World's Fair in Osaka, Japan in 1970. This pavillion contained the first light-sound system built for a spherical structure, the largest spherical mirror ever constructed - a mirror which reflected the viewers on the 90-foot high ceiling, and a man-made cloud containing water which floated above the dome.

The first opportunity to explore the art and technology phenomenon in an art museum context began in 1966 when Maurice Tuchman, Curator of Modern Art at the Los Angeles County Museum of Art, conceived what came to be known as the "Art and Technology" program. Tuchman's plan was to place approximately twenty major artists in residence for as long as a twelve week period within major technological and industrial corporations based in California.

Tuchman's proposal was motivated by a belief similar to Klüver's and Rauschenberg's, that giving the selected artists access to modern technology would greatly increase their artistic capabilities and be advantageous to industry as well. Among the 76 artists and their corporate sponsors who eventually participated in this large scale project were Andy Warhol (artist in residence: Cowles Communications, Inc.); Jean Dupuy (artist in residence: Cummins Engine Company, Inc.); Tony Smith (artist in residence: Container Corporation of America); Claes Oldenburg (artist in residence: Gemini G.E.L.); and Robert Rauschenberg (artist in residence: Teledyne). The objects created by the artists in this program were exhibited at the Los Angeles County Museum in 1970.

"The Machine as Seen at the End of the Machine Age," an exhibition curated by Pontus Hulten at the Museum of Modern Art in New York in 1968, documented artists' attitudes toward technology beginning with Leonardo and continuing through the machinist paintings of Francis Picabia to the "meta-matic" machines of Swiss-born artist Jean Tinguely. Pointing toward the direction of future collaborations, included in this exhibition was Edward Kienholz's *Friendly Grey Computer.* This construction was seated comfortably in a rocking chair, because as the artist compassionately explained in his operating instructions, "computers sometimes get fatigued and have nervous breakdowns . . . hence the chair for it to rest in . . . remember if you treat your computer well, it will treat you well."

Also in 1968, Jasia Reichart curated the exhibition "Cybernetic Serendipity: the Computer and the Arts" at the London Institute of Contemporary Art. Her exhibition, the first international survey of computer inspired art, included poetry, painting, sculpture, choreography, music, drawings, films, and architecture, demonstrating how pervasive the use of advanced technology in the creation of art had already become.

It was from within the field of computers that developments with the most radical implications for the art field were to evolve. The exhibition "Software, Information Technology: its new meaning for art," curated by Jack Burnham and sponsored by the American Motors Corporation at the Jewish Museum in New York in 1970, had as its goal to use computers in a museum environment. Planned as a sequel to Pontus Hulten's exhibition "The Machine," Burnham hoped that "Software" would demonstrate "the effects of contemporary control and communication techniques in the hands of artists," encouraging them "to use the medium of electronic technology in challenging and unconventional ways."[7] Of prime importance, this show was to enable the public to interact with the artists' programs. In the group of artists who took part in "Software" were Les Levine, Doug Huebler, Robert Barry, John Baldessari, Agnes Denes, Lawrence Weiner, and Hans Haacke. The most astonishing aspect of this exhibition in consideration of the art museum surroundings in which it was shown, was that it contained machines but no traditional works of art.

As much as the previously discussed exhibitions and projects represented major attempts to bridge the art and technology gap, their widely publicized failures and problems contributed significantly to the fact that proponents of the use of technology in the service of art have faced much resistance in their struggle to win acceptance from a majority of the art community. Because of their disagreements, E.A.T. was eventually dismissed by Pepsi as administrator of their pavillion at the 1970 World's Fair. In the Art and Technology program there were also a number of misunderstandings and disappointments arising both from personality conflicts and unrealized expectations on the part of the artists as well as the companies involved. The "Software" exhibition was plagued by malfunctioning machinery which further alienated skeptical members of the art world. Critic Thomas B. Hess, described as looking like "shipwrecked victims after thirty days in an open boat" the four, poor, terrified gerbils in *Seek,* the collaborative installation of Nicholas Negroponte and the Architecture Machine Group from M.I.T., the malfunctioning arm of which was covered by the animals' excrement. He continued with a warning typical of the antagonism provoked by this exhibition, that "artists who become seriously engaged in technological processes might remember . . . what happened to four charming gerbils." With a lack of sympathy also characteristic of the movement's adversaries, Hess concluded by advising those who were disconcerted by the poor performances of the equipment in the show to simply accept that, "the big point in Art and Technology manifestations over the past ten years has been that none of the technology works."[7]

In spite of such negative criticism, the promise of rich interchanges between art and science that aroused international notice at the World's Fair in 1970, has since evolved into an increasingly symbiotic relationship between artists and computers. Whereas some artists, especially those involved in the field of 2-D animation, have turned to the use of computers to facilitate or expedite an existing means of expression, others including David Em, Darcy Gerbarg, and Lillian Schwartz, are increasingly involved in exploring the potential of computer systems to extend their imagery and painting capabilities. Recent computer innovations have allowed others in the field including Jim Blinn, Turner Whitted, Loren Carpenter, Nelson Max, Lance Williams, Ephraim Cohen, and John Whitney, Jr., to name only a few, to explore the challenging new domain of 3-D animation.

Not only is the potential of the computer vast for creating two-dimensional works of art but also for the truly three-dimensional . The computer can assist in the actual fabrication of a sculpture through its participation in the milling process as well as in the conception and design. Ron Resch and Robert McDermott's approximately 40 foot high *Hungarian Easter Egg,* now installed in Edmonton, Canada, was both fabricated and designed using a computer.

The scale-translation difficulties encountered when rendering a piece of sculpture from a line drawing into a three-dimensional solid have always plagued the sculptor. As sculpture has grown to monumental proportions, this problem has become even more acute and the issue of siting more crucial and frequently troublesome. Whereas it is extremely arduous to move tons of steel on location, it is relatively simple to move a model of even the largest sculpture on the computer screen. Furthermore, not only can the computer aid the sculptor in translating his designs from two dimensions into three, but once a model is constructed, it also allows him to rotate the piece 360 degrees to view it from any side or from ten stories above. This ability is particularly helpful for the growing number of large sculptures commissioned for public spaces. The importance of the opportunity to preview a sculpture on site also increases as the fabrication of pieces without the sculptor present but merely from his designs becomes commonplace.

In much the same way that the computer has proved to be a great aid in solving engineering problems for architecture, computer capabilities have similarly been applied to determine the stresses in large scale pieces of sculpture. The 36 foot high bronze, concrete, and ceramic sculpture *Serendipity* by Joan Miró, for example, now situated on the plaza west of the Brunswick building in Chicago, Illinois, designed by Skidmore, Owings, and Merrill, was first analyzed in this architecture firm's computer center to determine its structural design before being assembled. Although in this instance the artist was not involved at all in the computations of his sculpture, one cannot dismiss the possibility that in the future the computer might become as commonplace in the sculptor's studio as plaster and welding tools are today.

Jaacov Agam was one of the first internationally recognized artists to take advantage of computers to achieve his desired effects. While Visiting Lecturer at the Carpenter Center for the Visual Arts at Harvard University in 1968, one of Agam's initial computer projects in collaboration with David Cohen was the execution of studies for his sculpture *Star of Life,* based on the form of the Star of David. By his appreciation of how using computer technology has enabled him to expand his artistic possibilities, Agam is representative of the rising generation of computer artists who are incorporating this tool into their aesthetic vocabulary.

The revolution created by the advent of the computer in the fine arts field is manifest not only in the objects themselves but also in the manner of their presentation to the public. Submitting slides of existing works of art to a jury for possible inclusion in an art show is an accepted procedure. The slides submitted for consideration by the jury of the SIGGRAPH '82 exhibition, however, marked a departure from this practice in that they served as records of works of art which for the most part at the time of entry still existed only in the memories of computer systems around the world. In many cases, both the scale and the method of printing the finished pieces were not yet determined when the slides were submitted. Also because of the dependence upon technical assistance required by many artists in order to execute their plans, there are numerous products of collaborative efforts in the SIGGRAPH '82 Art Show. In addition, the exhibitors - including computer scientists and mathematicians as well as painters, sculptors, video and filmmakers - represent a much broader based group of artists than in a traditional exhibition situation.

The nature of the various works on display depended to a great extent on the capabilities of the systems available to the artists. These systems may vary from high resolution (where the tendency is for the works to be more collaborative efforts) to low resolution (where the artists are more likely to develop their own software). As so far, relatively few painters and sculptors are familiar with computer programs and technology, the direction for the future seems to be one of closing the distance between artists and programmers. It is anticipated that not only will a greater variety of programs and systems soon be available to artists but also that more artists will learn how to do their own programming.

The enormous range of the potential means of expression offered to the artist by the computer is evident in the diversity of the works in the SIGGRAPH '82 Art Show. Some of the captivating new alternatives are represented by Rob Faught's computer-milled bas relief, the plotter drawings of Colette and Charles Bangert, the picture processing in Francis Olschafskie's young ballerina for which the photograph was first scanned into a computer and then the colors were manipulated, and Margot Lovejoy's multiple image etchings based on geodetic data which in their format recall Andy Warhol's use of repetitive imagery (in spite of the discrepancy in the scale of their work). Also of interest are the text manipulation both in Ed Post's frustratingly undecipherable multi-colored message composed of different kinds of letters and numbers some upside down and others in reverse and that in the composition of Joel Slayton, reminiscent of some early twentieth century attempts by the Cubists and the Russian Constructivists to incorporate typography into their pictorial compositions, the colorful, abstract 3-M Scanamural of Joan Truckenbrod, and the font design for the letter "o" of Kris Holmes and Charles Bigelow. Noteworthy as "state of the art" technology are the photographs of digitally synthesized 3-D images by Dick Lundin whose fictitious instrument lies in its case on a wood-grained stage achieved by exploiting the computer's ability to create texture, Robert Conley's study of reflections and refractions, Richard Balabuck's fantasy of glistening architectural columns both stationed upright and fallen on a brightly patterned tile floor, and Benoit Mandelbrot and Richard Voss's imaginary landscape synthesized using fractals. Nelson Max's enchanting moonlit seascape is an example of a still from computer animation. The illusory vision of a planet by Tom Dewitt, Vibeke Sorensen, and Dean Winkler, is a still frame from digitally processed video. For his portraits of famous people, Ken Knowlton programs the computer to arrange dominoes according to a specific set of constraints resulting in half-tone likenesses. The sculptures of Ron Resch, Rob Fisher, Frank Smullin (represented by a series of preliminary drawings for it), and David Morris, were designed with the assistance of computer technology.

Hopefully, computer-aided art such as that on exhibition at the SIGGRAPH '82 Art Show will soon be commonly accepted in art museum settings making it available to a wider audience, and increasing numbers of artists will be attracted to the field. Some of the intriguing recent options which may lure an artist to the computer are 3-D modeling, palettes of up to 16 million colors, innumerable brushes, animation inbetweening, and software programs which allow the scale, color, and format manipulation of visual images in ways for the most part impossible in physical mediums. The extraordinary new methods for aesthetic exploration now available to the artist "with the aid of the computer" have made it possible as Ruth Leavitt has expressed with a widely shared awe, to "explore areas which artists in the past only thought possible to dream about."[9]

Footnotes

1. Jon B. Eklund, "Art Opens Way for Science," *C and EN* (June 5, 1978), pp. 25-32.
2. Linda Henderson, "A New Facet of Cubism: 'The Fourth Dimension' and 'Non-Euclidean Geometry' Reinterpreted," *The Art Quarterly,* vol. XXXIV (Winter, 1971).
3. Hans Hofmann, *Creation in Form and Color* (1931), unpublished manuscript, p. 1.
4. Hans Hofmann, talk, Dartmouth College (November 17, 1962).
5. For an excellent discussion of the new materials and technology used by artists in the sixties, see Douglas Davis, *Art and the Future* (New York: Praeger Publishers, 1973).
6. Billy Klüver and Robert Rauschenberg, in *E.A.T. News,* vol. 1, no. 2 (June 1, 1967).
7. Jack Burnham, *Software, Information, Technology: its new meaning for art,"* exhibition catalogue (New York: Jewish Museum, 1970), p. 10.
8. Thomas B. Hess, "Gerbil ex Machina," *Art News* (December, 1970), p. 23.
9. Ruth Leavitt, ed., *Artist and Computer* (Morristown, N.J.: Creative Computing Press, 1976), p. 101.