# On the Future of Art

*Essays by Arnold J. Toynbee, Louis I. Kahn, Annette Michelson, B. F. Skinner, James Seawright, J. W. Burnham, and Herbert Marcuse*

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# Contents

# The Aesthetics of Intelligent Systems

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A more accurate title for this essay would be "The Aesthetics of Intelligent Systems—Them and Us," since the term "intelligent systems" refers not only to ourselves but also, or more precisely, to our computer environments. Although the art of the future could take any one of a number of directions, it seems to me that, with the steady evolution of information-processing techniques in our society, an increasing amount of thought will be given to the aesthetic relationship between ourselves and our computer environments—whether or not this relationship will eventually fall into the scope of the fine arts.

Art continues to intrigue us because it deals with ambiguous and often obscure levels of information. Up to now, the fine-art object has been a self-contained and finite source of information: once the art object has been created, it can only impart its own presence. Its messages are received gradually, only after personal revelation, and they are the delights of connoisseurship. Yet art can also impart another kind of information, if viewed in other contexts. More comprehensive studies and a new historical vantage point will allow us to see art objects as they have never previously been seen.

The continued evolution of both communications and control technology bodes a new type of aesthetic relationship, very different from the one-way communication of traditional art appreciation as we know it. If, as the scientist Colin Cherry has written, "all communication proceeds by means of *signs*, with which one organism affects the behavior (or state) of another," then I suspect that the "aesthetics of intelligent systems" could be considered a dialogue where two systems gather and exchange information so as *to change constantly the states of each other.*

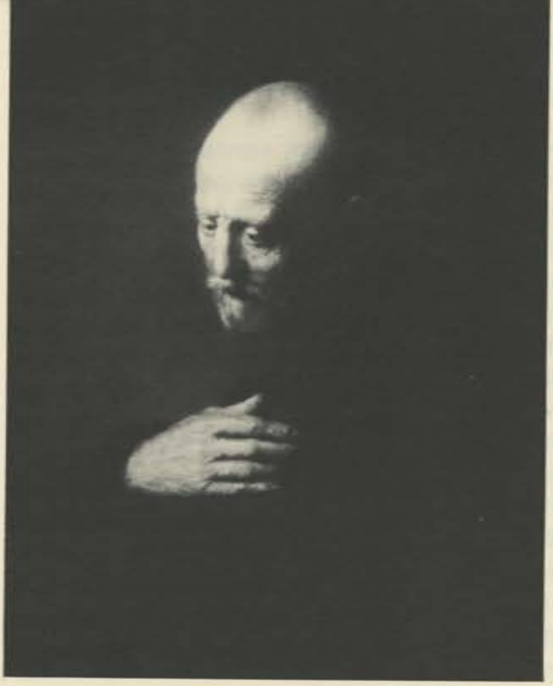
Pride, or the refusal to acknowledge continuity with machines, is at the bottom of man's continuing distrust of the original Industrial Revolution. This distrust is more diffuse than it was two hundred years ago, but it is still as strong. For most of the twentieth century machines have been used to make avant-garde art, but, with a few exceptions, artists have been careful to preserve the illusion of hand-made art. The decade of the nineteen-sixties dispelled that illusion. The art establishment no longer denies that machines may make art, but there is still considerable resistance to the notion that machines can be art or a direct part of the art experience. Thus, motorized art has so far been considered an aesthetic failure and has not yet secured for itself a favored niche in art history. This conclusion, however, may be premature.

Until a few years ago machines were used primarily for production and transportation. We are now entering a second age of machines, although few of its values are as yet clear either to the public or to the scientists bringing it into existence. The new machines are information-processing systems. These not only regulate production but also communicate with other machines and with human beings. The function of this technology is not the production of materials but the analysis and generation of information. It has been suggested that the field of object-production is already too well analyzed and too technically structured to provide further incentive for the artist. I tend to agree, for it now seems almost inevitable that artists will turn toward information technology as a more direct means of aesthetic activity.

To those familiar with the problems of modern art, the emphasis on the use of machines to produce a "human" form of communication will seem either reactionary or misplaced. Historically, abstract artists have rejected the work of their predecessors on the grounds of anthropomorphism, or, to put it another way, they have rejected the idealism traditionally attached to anthropomorphic imagery. Consequently, their art has reflected the contemporary tendency to maintain an "objective" or "scientific" view of reality and has managed to communicate aesthetic values only in an esoteric form.

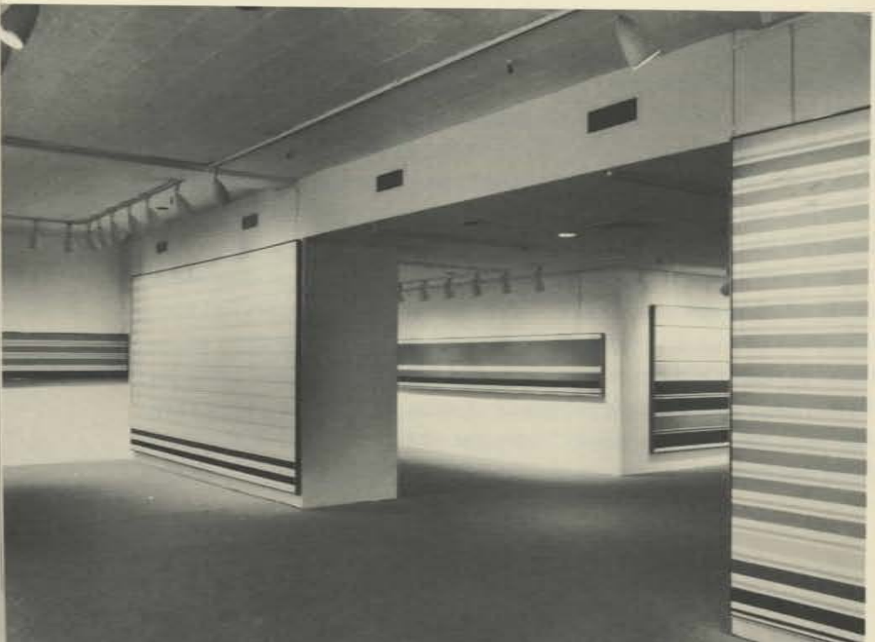
But we must look beyond replication or illusionism to discover the basis of anthropomorphism. All art, whether abstract or representational, is in fact anthropomorphic if one considers art not in terms of appearances but in terms of its function and relation to human activity. Tools, from the simplest hand implements to the most sophisticated computers, are extensions of man's attempt to shape his environment. And in the same sense, symbols too are human extensions. According to the biologist P. D. Medawar, there are two types of evolution: endosomatic, or genetic, evolution, the slow process of hereditary change; and exosomatic, or cultural, evolution, which takes place outside the human body and applies to our tools, symbols, and other invented extensions. (The development of the space capsule is an excellent example of exosomatic evolution.) An awareness of cultural change therefore is accompanied by an understanding of anthropomorphic values rather than a rejection of them.

A cornerstone of the *l'art pour l'art* sentiment is expressed in E. M. Forster's remark: "History evolves; art stands still." For a century which has seen the resurrection of so many earlier artistic conventions, these words contain a double truth. But, in less epigrammatic terms, what Forster meant was that we cannot validly compare periods in art history as more or less advanced in development—that great art defies



Rembrandt: *Portrait of the Artist's Father,* c. 1630. *Collection Museum of Fine Arts, Boston*

Kenneth Noland exhibition at André Emmerich Gallery, New York, 1967



qualitative measure in degrees of sophistication or psychological effectiveness. I suspect, however, that this attitude reflects the view of Forster's generation toward art history and its particular concept of image-making and iconology, rather than revealing any innate truth about art.

For instance, let us look at two apparently disparate examples of painting: Rembrandt's portrait of his father and Kenneth Noland's work on exhibition at a gallery. The essential difference between the two is not in the paintings themselves, since both are pictorial abstractions made by covering canvas with liquid paint (it is only within the past two decades, incidentally, that we have gained enough scientific objectivity to regard Rembrandt's baroque realism as a kind of abstraction). The real difference here is in the way we are forced to look at the works of art. The Noland paintings, installed in the gallery, challenge the conventions of classical pictorial space by extending beyond the range of normal vision, beyond the limits of a frame, beyond the single viewpoint imposed on the observer of the Rembrandt portrait. We have been conditioned by art-history texts to look at art in the classical manner, as Rembrandt did, where the work is removed from its environmental context either by the frame of the painting or by the arbitrary decision of a photographer. Noland has, in this instance, restored the kind of visual communication that existed when the cave-dweller observed the red bison on the walls of the Cave of Lascaux; the distortion involved here is the result of environmental awareness rather than of the illusions of optical-iconic space. My point is McLuhanite: it is the mode of communication (the printing of the photograph of a work of art) rather than the message itself (the work of art) that has defined and leveled our response to art.

If we look at all earlier art as a form of communication—ignoring style, content, and quality—we find that the communication is a contemplative, one-way process. We have already seen in happenings, kinetic art, and luminous art some premature attempts to expand the art experience into a two-way communication loop. These art forms utilize rather crude technical means, sustaining both a real and a conceptual distance between the spectator and the work of art. As our involvement with electronic technology increases, however, the art experience may undergo a process of internalization where the constant two-way exchange of information becomes a normative goal. We should rightfully consider such a communication shift as an evolutionary step in aesthetic response.

This shift represents what could be called a figure-ground reversal in human perception of the environment. Until now, Western thought has relied upon a fixed viewer-object (or subject-stimulus) relationship, where concentration is merely a matter of shifting objectives. A great deal of technological rationalization has derived from this attitude, which has led us to think in terms of human domination and environmental passivity. The change that I perceive, however, encourages the recognition of man as an integral of his environment. The biological sciences are already beginning to realize the mistake of separating organisms from their habitat or subjects from their settings. If the computer has any experimental meaning, it will be to extend our nervous systems farther than the communications media have done so far.

We tend to think of the computer at its present stage of development as a super-fast calculator or data file; few of us conceive of it as a system which can reorganize many remote environments and channel them into a sustained and coherent experience. One of the truisms of innovation is that all inventions begin by taking the shape of the device which they have superseded. For instance, one computer scientist told me that many present computer applications are analogous to trying to fit a steam engine to the body of an iron horse. Like many of us, most artists still envision the computer as an iron horse. Their approaches usually stem from a desire to see the computer as an elegant tool for making traditional art. Since the early and middle nineteen-sixties, scientists such as Michael Noll and Kenneth Knowlton of Bell Laboratories in New Jersey have pioneered in the development of computer graphics. As a rule, their attempts to use printout devices have produced art which is very similar to examples of modern painting. I must point out, however, that the original purpose of most of this work has been scientific rather than artistic experimentation.

Taking a different approach, the sculptor Johan Severtson uses the computer to program parameters for his sculptures. The resulting data give him literally hundreds of possible compositional variations from which to choose. Utilizing the best patterns, he fabricates large plate-aluminum sculptures. At one point I suggested to Severtson that his pages of computer data, which can be seen as drawings of exquisite variation, were more intriguing than the resulting sculpture. Interestingly, for the past two years Severtson has concentrated upon filming the computer in the process of designing, and he has shown the films as integral parts of the works of art.

One of the most obvious uses of the computer is to create anthropomorphized sculptures. With a Dada sense of humor, Ed Kienholz created *The Friendly Gray Computer—Star Gauge Model 54*. Essentially, it is a chassis set on rockers, with a few active lights and motors forming the semblance of a face. Kienholz seems to be saying that after all computers feel too, but he also makes it clear that we are confronted with an unknown and potentially dangerous species.

Another pioneer in the use of cybernetic principles and, recently, of computers is the French-Hungarian artist Nicolas Schöffer. In 1956 the artist previewed his first responsive sculpture, *CYSP 1*, at the Sarah Bernhardt Theater in Paris. This early venture, a tall skeletal structure with spinning disks and beacons which responds to light and sound, let to Schöffer's *Cybernetic Light Tower*, a structure over a thousand feet high which monitors and reports on various conditions in the Paris environment. His efforts do not reflect the values of a cybernated city however, but the values of an artist trying to automate a monumental sculpture. Schöffer's work has a kind of nineteen-twenties and -thirties futurism about it—strikingly like the stills from Alexander Korda's motion picture *Worlds to Come*.

These examples of computer-oriented art are mentioned because they represent some of the better-known attempts to date. By formalist art standards, or in terms of everyday interest, they are not terribly exciting, but as experiments they force us to think about the implications of a very important new tool. During the summer of 1968 the Institute of Contemporary Art in London presented "Cybernetic Serendipity," an exhibition of cybernetic and computer-oriented art from all over the world. The show contained a few of the works I have mentioned, as well as exhibits illustrating the history of cybernetics; some results of various attempts to use the computer in the creation of poetry, music, dance, films, and architecture; and a number of cybernetic artifacts designed by scientists and engineers.

During a conversation I had with Miss Jasia Reichardt, the curator of "Cybernetic Serendipity," she lamented the fact that so few artists are concerned with the use of computers. She felt that the ideas of scientists dealing with the creative implications of computers were considerably more interesting than what artists had to say about the uses of information-processing technology. Miss Reichardt deplored above all the dearth of computer-supported exhibits which could be shown in museums; time, money, and technical complications have put the majority of them out of reach. "Where *is* all the computer art?" summed up her feelings.

Significantly, Europe has been the breeding ground for a school of scientists, artists, and philosophers involved with the aesthetic implications of computer theory. *Kunst und Kybernetik*, a book published in 1968 in West Germany, contained a number of papers on the subject, and in the summer of 1968 several contributors to the book gathered for an international symposium on "Computers and Visual Research" during the exhibition "New Tendencies No. 4" in Zagreb. Much of the discussion centered on the information-theory analysis of traditional and computer graphic art. Yet the amount of art or art study done with the aid of a computer in Europe is small, except possibly in West Germany, where a relatively large number of computers is in operation. More important than the number of computers, however, is the availability of free computer time. Countries without computer time for nonessential tasks can devote nothing to art, although the desire to do such research may be there. It is ironic that in the United States, where there is a surplus of computer time, no concerted attempt has been made to use the computer as an art tool. Perhaps this is no more than an indication of our priorities.

Although "Cybernetic Serendipity" had significance as a historical event—the first comprehensive exhibition of computer-derived art—its real meaning lay in those doubts and disappointments expressed by Jasia Reichardt. We are dealing with an art mode whose aesthetic dimensions have not yet been fully comprehended by the artist. McLuhan reflected that IBM did not skyrocket in growth until it decided that its task was information-processing rather than the business of selling office machines. Indeed, a computer-systems specialist once told me that his hardest job was to convince corporations that it was dangerously shortsighted to follow five-year plans. These observations tell us something about the essential nature of the computer. Used to its fullest, the computer is a part of a continual system and, as such, it processes information metabolically. In other words, the computer is not a problem-solver in the classic sense, but a means by which information is directed incrementally toward the maintenance of a constant level of stability, a function similar to that of the human nervous system.

The computer's most profound aesthetic implication is that we are being forced to dismiss the classical view of art and reality which insists that man stand outside of reality in order to observe it, and, in art, requires the presence of the picture frame and the sculpture pedestal. The notion that art can be separated from its everyday environment is a cultural fixation, as is the ideal of objectivity in science. It may be that the computer will negate the need for such an illusion by fusing both observer and observed, "inside" and "outside." It has already been observed that the everyday world is rapidly assuming identity with the condition of art.

Exhibition of works by Niki de St. Phalle and Jean Tinguely in Central Park, summer 1968 *(Photo courtesy New York City Parks Department)*

Dennis Oppenheim: *Pennsylvania Wheat Piece*, 1968

My last point can be illustrated by viewing the contrast in the two environments pictured. The first is an outdoor exhibition held in Central Park in 1967 of machine sculptures and *Nanas* by Jean Tinguely and Niki de St. Phalle. As you can see, a hedge-covered fence and various signs clearly indicate to every pedestrian that the art is not to be touched. In a sense, the hedge and padlocked gate surrounding the garden serve the same purpose as the frame around an oil painting: they tell the onlooker that the sculptured animals are to be experienced but that they do not exist in the "real" environment where casual involvement is possible. On the other hand, Dennis Oppenheim's *200' × 900' Wheat Field,* which was executed on a farm in Pennsylvania during the same summer, is an example of art without boundaries. Here the artist directed the mowing, baling, gathering, and unloading of a portion of the crop, considering each activity as a part of his art. Only the fact that the artist himself has selected the site and the direction of the work separates his activity from that of the farmer's. Such an endeavor is very close to what is called conceptual art.

In *Duration Piece* #9 Douglas Huebler conceived of a series of space-time transactions as a "site sculpture." The mailing of a box to six locations across the country and the return of registered-mail receipts defined a straightline trajectory of the art work across the United States. What intrigues me is not the resulting documents but the fact that a work of art using a public communication channel was conceived and executed. Artistic volition is the only factor which separates it from millions of similar acts. This ordinariness implies no lack of artistry, but rather the realization that art does not have to be physically isolated or tangible to be effective.

The word "environment" has recently been used to define a popular alternative to painting and sculpture, the traditional modes of art-making. Many environments are paintings or sculptures, or a combination, structured to fill a room-sized space. If we consider this accepted form of art environment in terms of our previous discussion of a computer environment, we come to some interesting conclusions. First, most art en-


Douglas Huebler: Documentation for *Duration Piece #9,* January–February 1969. 10,045 miles. Time: 64 days. Berkeley, Calif.; Riverton, Ut.; Ellsworth, Neb.; Alpha, Ia.; Tuscola, Mich.; Hull, Mass.

vironments are pre-eminently contrived. Second, if computer environments are just now becoming the means by which we extend our senses in order to increase our knowledge of an environment and, perhaps, to establish a dialogue with elements within that environment, then we should not expect too much as yet from artists.

Nevertheless, various artists have tried to produce situations where the spectator's presence has triggered bits of information. For example, Anthony Martin recently produced a *Game Room* (1968), a series of floor spaces which, if stood upon, would bombard one with "mixed media." At the same time, Jean Dupuy and Ralph Martel constructed *Heart Beats Dust,* which consists of a palpitating pile of lithol rubine, a very fine, brilliant red pigment. A 15-inch speaker mounted under a rubber membrane vibrates the lithol rubine, which produces wave

Pulsa: *Light-and-Sound Installation,* January–March 1969.
*Yale Golf Course, New Haven, Conn.*

patterns. In a version shown at the Brooklyn Museum's "Some More Beginnings" exhibition, spectators could vibrate the speaker by holding a microphone next to their hearts. I should also mention James Seawright's *Electronic Peristyle* (1968), a circular array of twelve black formica columns containing lights, blowers, and sound-generating equipment.[1] Here the interruption of photoelectric circuits by the spectator produces a series of sounds, light patterns, and breezes. While some margin of ambiguity as to the meaning of the stimuli and their relation to the spectator is permissible and even desirable in such a work, Seawright's *Electronic Peristyle* fails to build into a coherent or aesthetically meaningful experience, and this remains a central deficiency of most art predicated upon the feedback principle.

Other problems arise in the Pulsa Group's computer-driven, strobe-light outdoor installations. Centered around the New Haven and Boston areas, these are the most ambitious programed art environments to date. Pulsa has used components of analogue and digital computers to produce high-speed con-

[1] See illustration earlier in this book, in James Seawright's "Phenomenal Art: Form, Idea, and Technique."—Ed.

figurations in sound and light. These patterns are permutational, hence almost infinite in variety. Spread out over several acres of rolling lawns, the Pulsa environments physically transcend the quasi-painting results of other programed-light art forms produced to date. The experience of walking through a Pulsa installation is essentially that of encountering random strobe-light bursts. Patterns appear only when one is to some degree removed from the field of lights. As a group, Pulsa is not insensitive to the need for using a computer more elegantly. Its members talk of the computer as an environmental sensing device for structuring human participation in the environment. The lack of adequate financial backing is a major obstacle to their plans.

It would seem that all responsive environments, whether computerized or natural, have the same prerequisite—that is, some semblance of intelligence. We speak of intelligent organisms, but we must acknowledge that environments possess a level of intelligence too, depending upon the richness of ecological channels of communication. Some ecologists feel that we can rightly speak only of a symbiotic intelligence, that of the organism-environment. In a similar way, many humanists and naturalists lament the loss of man's prescientific sensitivity to changes and conditions in the natural environment. They regard technology as an instrument for dulling receptiveness, and consider that technology, at best, has given us a false sense of security. Obviously there is substantial truth to these assertions. A technological environment monitors only the things that seem most essential to it. This fact may account in part for the tragic decay of our natural surroundings. But I suspect that this decay is primarily due to behavioral patterns of the mechanical age, and I believe that the computer can help to transcend this condition. Used with more wisdom than we appear to have now, computer systems can sensitize us to information in the environment that would otherwise be ignored.

Another simple responsive environment is Hans Haacke's *Photo-Electric Viewer-Programed Coordinate System*. Haacke's room contains a grid of infrared light beams and photo-

Hans Haacke: *Photo-Electric Viewer-Programed Coordinate System,* 1966–1968

resistor switches which are nearly invisible to the spectator. The switches control the lights just above them, so that the spectator defines his own presence by reading the light grid. Haacke would like to eliminate specific light sources like the row of light bulbs used and to utilize only the pale and diffused illumination from the wall itself. The spectator's relationship with the room and his ensuing aesthetic experience are precipitated by his own bodily activities; no contemplation of or empathizing with an object is necessary.

Les Levine considers television to be an environmental tool because it is integrated into our lives to the point where it is invisible. Levine's first major television piece was *Iris,* a battery of television monitors and cameras that scanned their immediate vicinity. Although *Iris* appears as an iconic presence, the artist has rejected the painter's use of television as an abstract pattern-generator, considering it a trivial function. Levine demonstrated the kind of responsive environment that television can be in his use of three monitors and cameras during a panel discussion at New York University's Loeb Center. The artist was asked to appear with several other speakers,

Les Levine: *Television Piece,* 1968. *Loeb Student Center, New York University*

but chose instead to show himself as a group of television images. Like the computer, television becomes an environment embedded within the more pervasive physical environment which we associate with day-to-day reality.

At this point I want to shift my discussion from the efforts of artists who deal with electronic information-processing to those of scientists. If "intelligent systems" can refer to computer environments, then we are dealing with a dichotomy of human and nonbiological intelligence. Let me briefly compare the brain and the computer as information-processing systems. The human brain has an excellent capacity for retrieving and juxtaposing stored information. Its number of interconnections is very high, running into the billions. As a general-purpose problem-solver, it far transcends any machine made to date. Computers, on the other hand, can handle tremendous amounts of information for extended periods of time, but operate in much more routine ways than the brain does. Unlike the brain, most computers are incapable either of organizing themselves or of comparing disparate types of information. As one scientist put it, computers are like very quick but stupid children who must be told everything in explicit detail. Intelligence can be generally defined as the ability to solve a wide variety of problems in many environments. If that is accurate and not merely anthropomorphic, then it is clear why human beings still outthink computers in most circumstances.

The possibilities of nonbiological intelligence were first explored in the writings of Allen Turing, John von Neumann, and Ross Ashby, three pioneers of cybernetics and computer theory. During the early days of computer development (1950–1959) there were extravagant hopes and speculations for solving the riddle of human intelligence by duplicating it. Repeated failures have elicited extreme caution and, in some cases, downright pessimism in the scientific world.

Let us examine briefly some of the most important approaches so far to the problem of producing nonbiological intelligence, an area where the concepts of intelligent environment and computer environment begin to merge. Although the computer environment is still severely limited by the computer's inflexibility and by its extremely narrow range of contact with the outside world, and although the problem of simulating human intelligence is far from solved, enormous advances have been made in computer technology over the past fifteen years to the point where the computer[2] has become a prime factor in the analysis of any social philosophy of the future. Although there are basic differences between an art environment, where all information is given in the form of applied physical-visual effects, and a computer environment, which is concerned with the amplification and exchange of information, I believe it is not unreasonable to envision a future of art in terms of these significant developments.

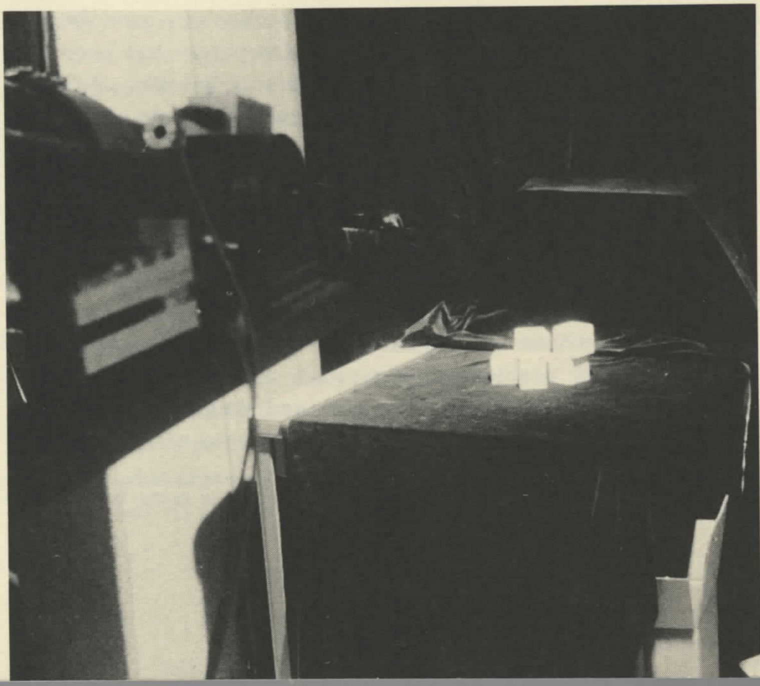
"Artificial intelligence" is a term frequently used to denote the use of heuristic and algorithmic computer programs in various areas of problem-solving, such as pattern-recognition, search methods, learning processes, and language-translation. Some critics have insisted that such programs can never equal

[2] Note that I have used the word "computer" in a general sense, since computers today are actually computer systems comprising many types of machines.

human intelligence, since they are based on a partial understanding of only some of the techniques employed by the brain. And the fact remains that computer systems lack the sensory equipment necessary to deal adequately with the outside world. As Seymour Papert, one expert in the field, has pointed out, we deprive the machine of the means of experiencing reality as we do and "then complain that machines cannot be intelligent. We're like people who put pigs in filthy sties and call them dirty animals."

The Architecture Machine was developed at Massachusetts Institute of Technology by the architect Nicolas Negroponte and Marvin Minsky, one of the pioneers of artificial-intelligence research. This is a computer system in which a problem-solving capacity has been linked with sensing devices in order to discover and reorganize an environment. A computer-linked camera monitors a pile of white blocks on a flat black background, and the resulting monocular picture of the pile describes measurements, perspective, sides, joints, and texture, in that order

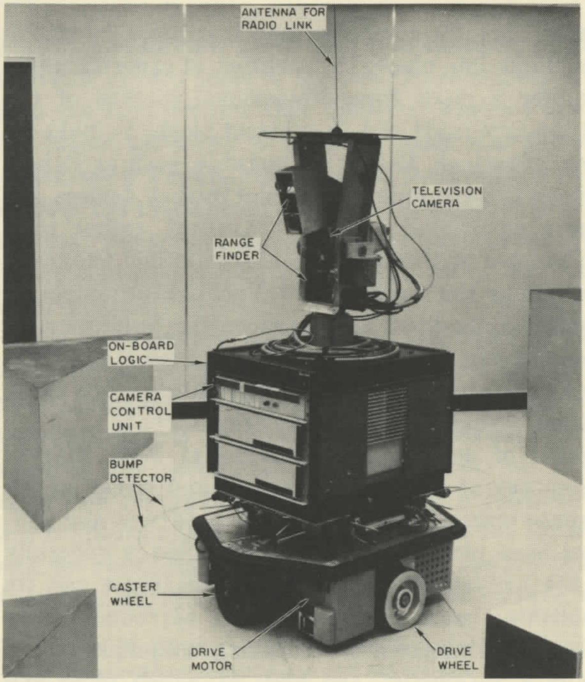
Nicolas Negroponte and Marvin Minsky: The Architecture Machine, 1968. *Massachusetts Institute of Technology*



of importance, so that the computer may instruct a hydraulic arm to fit new blocks into place. The addition of cameras would give the computer a clear three-dimensional picture of the blocks so that the arm could add or subtract blocks to make up new spatial configurations. This is an instance, such as Papert mentioned, where the computer input and output devices are "trained," like a small child, to see the world, rather than being given a picture of the world as a predigested program. Negroponte envisions the Architecture Machine ultimately as a centrally located data bank connected to the building patterns, utilities, and demographic problems of a city. In effect, it could become a metabolic planner, dealing with a city's problems in "real time"—that is, as problems arise.

As a professor of electrical engineering at MIT, Marvin Minsky has been one of the chief defenders and critics of artificial-intelligence research. While his chess programs and ball-catching robots have received much publicity, less is generally known about his brilliant analysis of finite machines and its effect in demolishing many of the illusions surrounding experiments in artificial intelligence. In talking with Minsky one finds that he is a rationalist, the likes of which make the French Encyclopedists appear church faithful. He is convinced that free will and intelligence are culturally sustained myths—like the traditional concept of art. Minsky does concede that art is stimulating because it brings out some of the more noble and sensitive characteristics of man, but he insists that art remains intellectually underdeveloped precisely because the fundamental questions of art, of its existence and purpose, remain undefined. (I was tempted to add that the same is true of mathematics.)

As a scientist with some ability for composing and performing music, Minsky maintains that the intellectual competence of a great artist such as Beethoven is considerably below the reasoning powers of any major scientist, a view that most cultural anthropologists and clinical psychologists would have trouble supporting. Out of this conflict arises one of the dangers cited by moral critics of machine thinking: if such activity




Automaton Vehicle, 1963-1968. Stanford
Research Institute

becomes a reality, the scientist is liable to bias it by his own specialized view of intelligent behavior.

At Stanford Research Institute in Menlo Park, California, scientist Charles Rosen and his staff have developed an Automaton Vehicle. This device is connected by radio to a time-sharing computer. Its camera and logic-control unit work with four sensory systems: tactile sensors, an optical range finder, a shape-describing television camera, and a navigation system. The Automaton Vehicle moves about the room, touching the geometric objects shown in the photograph. From these experiences it builds an internal map—rather like a person becoming accustomed to a room in the dark. Although the robot's sensing devices are varied and highly sophisticated, the process of interpreting and using sensory data remains comparatively primitive. Yet many different excursions around the room can succeed in giving the vehicle a usable "past."

Bionics and research in self-organizing systems are two closely related alternatives to developing artificial intelligence. Both attempt to simulate or reproduce aspects of living organisms, such as self-organization, which seems to be a property unique in intelligent life, involving perception, growth, learning, development of neural structure, and the effects of environmental feedback. Practical goals of this research include supplementing human sensory capacities and improving human intelligence through genetic engineering.

The implications of bionic research were brought out by an editorial in the *IEEE Spectrum* magazine (August 1967) entitled "Man, a Subsystem?" It emphasized that nothing more than anthropomorphic vanity accounted for sending men into space on jobs that machines could be made to accomplish more efficiently, pointing out: "As a subsystem, man leaves much to be desired. What other system has no significant prospect of miniaturization or ruggedization, can work at full capacity only one quarter of the time, must be treated as non-expendable, requires a critical psychological and physical environment, cannot be decontaminated, and is so unpredictable?"

All efforts to produce nonbiological intelligence depend upon an organism-environment relationship. As previously mentioned, this may be humanly interpreted as a "program" or, as in the case of the MIT and Stanford robots, the environment may be a limited portion of the real world. Another approach is described as "evolutionary programing," in which the "organism" and "environment" are numerically simulated through two linked computer systems. The "environment" is a generated number series. Survival depends upon the organism's logically predicting the number series. The organism, or the computer's problem-solving strategy, is randomly altered and the new organism must predict the environment or it is discarded for the original strategy. In this way the next generation is always heir to a successful strategy, and thus organism and environment evolve together. "Quick-time" computer operations allow many mutations and generations of problem-solving to evolve in a matter of minutes. Such an approach has significance for the other areas of study in nonbiological intelligence, for, as Marvin Minsky has said, "Once we have developed a firm evolutionary technique, the development of artifical intelligence will come quickly."

For art, possibly the most significant form of nonbiological intelligence, or hyperbiological intelligence, is that of "human enhancement through man-machine relationships." Briefly, this includes all efforts to learn and solve problems through interactive, time-sharing computer programs, where a person communicates directly with the program through one or more terminal devices. The objective is to think creatively with the computer in "real time," or in the time it takes to carry on a normal conversation. Joseph Licklider, director of Project MAC at MIT (Machine-Assisted Cognition is one of several names for this project), believes that such time-sharing systems will have immense impact upon our culture—in all phases of life, including art—during the nineteen-seventies. When I pressed him to verify this statement, he responded with two other statistics.

Licklider believes in the dynamics of exponential growth. The population, he states, doubles every thirty years; the amount of information doubles every fifteen years; and the number of computers and other types of information-processing equipment doubles every two years. He also asserts that within ten to twenty years computers will engage in activities and show a high intelligence that no one can dispute. In 1967 at the Metropolitan Museum of Art in a seminar on the use of computers in museums, Licklider suggested that some of the restraints have to be removed from computers as communication devices before they become acceptable tools to the artist. He sees the need for larger, brighter, and more interactive display tubes, and also for terminal equipment sensitive to light patterns, vibrations, pressure, textures, and sounds—in other words, the full array of sensory input-output devices available in human communication.

While these are ideal goals, Licklider also touched upon more practical considerations for the aesthetic use of interactive systems, such as the technological lag, where cost, general usability, and proliferation of means will determine when and how the artist can use computers for direct creativity. He believes that there will be an evolution in the artist's use of applied technology. Up to now the artist has been involved in building relatively simple machines that turn lights on and off or move components. Because of advances in computer technology, however, artists will probably be forced to concentrate on programing existing equipment rather than building more hardware. Licklider points out that we are gradually "turning up the gain" (amplifying the message) in all areas of communication, education, entertainment, and art. The computer is potentially the best available means for reinforcing these communication loops with the human brain, because if something is not interactive, it is nonmotivating. However, he insists, one should expect considerable resistance to any shift of art in this direction. For one thing, intellectuals need less interaction than most people; this fact accounts for their strength and weakness. Consequently, intellectuals have a large capacity for sustained involvement with one-way symbolic systems, and painting and sculpture are among the more treasured of these symbologies.

During the past year I was invited, as an artist, to learn to use the time-sharing computer system at MIT's Lincoln Laboratories. I was fortunate to have for teachers two men deeply interested in making the computer a creative tool and in allowing artists access to a computer: Oliver Selfridge, a mathematician by training and one of the pioneers in artificial-intelligence research; and Jack Nolan, currently president of the Massachusetts College of Art and formerly Group Systems Leader at Lincoln Laboratories. They are both dedicated to the goal of enabling the untrained layman to use a computer almost immediately and they believe that the entire field of artificial-intelligence research is highly overrated and misguided. Selfridge feels that the future lies with a man-computer symbiosis, and that "so far the creative person in the computer environment is highly frustrated. Computers are not yet flexible enough. The answer is to reward lazy people who demand easier and more understandable computer languages by giving them these languages."

I studied the rudiments of one language, FORTRAN, using a primer written by Oliver Selfridge. Its goal is to teach conversation with a time-sharing computer in very much the same way a child learns to speak: by trying different word combinations and waiting for a desired response. Using this, I never studied the structure of the computer's system, or the grammar of FORTRAN, but only attempted to communicate with the computer and to become familiar with the "computer environment" as if I were adjusting my thinking to the intellectual capabilities of a new acquaintance in conversation.

I then began to learn a computer display language, CAFE, which was developed by Jack Nolan for making constructions

Jack Burnham at console, Computer Room, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass., 1968

using only straight-line segments. This is a simplified language which develops some types of figures rather slowly, but which is still considerably faster than feeding the computer punch-card instructions. Using a special camera attached to a CRT screen, I found this is an excellent and relatively inexpensive way to create animated movies in a few hours or a few days. Eventually, however, the lack of content and dynamic variety in the program may prove to be a drawback for the artist. The illustration shows two computer specialists and myself seated in front of an IBM 2250 display unit. This is attached to an IBM 360, Model 67, time-sharing computer.

Selfridge and Nolan took for granted that, once mastered, the computer would be a superb artistic tool for generating graphic designs. Perhaps it is, but as an artist I found the real challenge of a computer to be in discovering a program's memory, interactive ability, and logic functions. One gradually learns to conceptualize an entirely abstract model of the program. As with one's own mind, parts are brought out for inspection as needed. Moreover, a dialogue *evolves* between the participants—the computer program and the human subject—so that both move beyond their original state. Of course it is unrealistic to expect artists to begin to use computers the way they use paints, canvas, and welded steel. As a rule, new and exotic technology has not led to the production of great or even good art. Somehow the aesthetic implications of a technology become manifest only when it becomes pervasively, if not subconsciously, present in the life-style of a culture. In terms of a public utility, we are at least ten to fifteen years away from the kinds of machine creativity that I have discussed. But if I have tried to make an argument for an eventual evolution toward two-way communication in art, it is because present social circumstances point in that direction.

In spite of much dissatisfaction with the results of technology in this century, I cannot believe that the world would willingly revert to a less sophisticated technological level; that could happen only by accident. We now witness all the signs of environmental decay: urban systems breakdown, greater crime, pollution, resource depletion, and political rebellion. Because socially structured self-interest has effectively prevented us from dealing with these interconnected problems, some social scientists feel that the process of group decision-making is on the verge of collapse in many of the large industrialized countries. The current dissension may be the result of a basic fault in communication—if we assume that it is education that encourages enlightened self-interest. In the next decade two-way public television, household computer systems linked to data banks, and voting by telephone will become technically feasible. Is there any reason, however, to believe that these systems will be used with any more wisdom than public television is now?

My conjecture is that computers will radically reorganize social values, although in the first stages they may do it badly. I believe that they will be seen as one of the few reasonable alternatives to continued social, technical, and ecological chaos. My hope is that the initial complexity of these information systems will not prevent substantial numbers of artists from using and thinking about them. Insensitive and indiscriminate handling of information in central data banks will become a major and political. issue, as will the progressive withdrawal of human creativity from semiautomated industries. One begins to hear about a "sanitized elite," answerable to nobody, who will control all information going into their own data files. Wealth and ownership might cease to be the prerequisites of power as access to and control of information take their place. My conversations with computer scientists impel me to believe that these are not idle fears. Practiced in a free environment, art is political in that it reveals cultural inhibitions and symptoms of repression. Even if art is a form of metacommunication and only indirectly political, it has much to lose by not involving itself with these extremely subtle and potent media.

Involvements with such information-processing techniques as I have described are bound to provoke structural shifts in the art world. Here are a few as I see them. The traditional notion of consecrated art objects and settings will gradually give way to the conclusion that art is *conceptual focus*, and that the boundary conditions of form as process and system transcend the more literal notions of geometrically defined form. Thus any space-time fragment of reality may serve as subject matter. The breakdown and confusion between canonical art forms will continue until it is agreed that they place a false emphasis on physical and sensual isolation as prerequisites for aesthetic valuation.

As the computer environment further condenses the known world and as it increasingly becomes an elegant surrogate for global experience, a profound change will take place in the acquisition of knowledge and sensitivity. Until very recently the machine-age Protestant ethic placed a high value on learned knowledge, since one-way learning through print demands great patience and repetitious labor. And as John McHale has pointed out, our "cultivated aesthetic taste is also associated with the acquisition of hard-won understanding." As we begin to treat art environments as pure "lived experience," we realize the strong parallel between the symbology of the printed page and the structural and iconographic complexities of "appreciating" a painting or sculpture. The processing of electronic information between two systems is pre-eminently lived experience, and thus learning-feeling-sensing appear to be effortless. Already critics oriented to the literate-optical tradition have expressed profound distrust of art environments "where there is nothing to be seen or interpreted."

The secularization of art will continue. I suspect that there will be a gradual phasing out of artists and art training in the conventional sense. One computer specialist said to me, "You think machines are only capable of sterile, mechanically perfect products? Give us the time and demand and we will show you better 'handcrafted' goods than any person can make." It will be interesting to see if we phase out all handcrafts as economic liabilities or maintain them under some ideological pretext of their importance to human existence. It seems reasonable to predict that artists may function in a wide range of occupations, no longer identified with a few medieval crafts, and will be recognized as people who, within the limits of their fields, solve problems in unique and particularly elegant ways.

Gradually we may realize that the conditions of art are contingent upon our understanding of human communication. From what I have suggested here, it may seem that the electronic technologies are making deep inroads into this most private of all mysteries. But if we are to believe the great linguist Noam Chomsky, we know next to nothing about language and and intercommunication. As long as this holds true, the survival of art is assured.