# A Selected Chronology of Computer Art: Exhibitions, Publications, and Technology

*By Copper Giloth and Lynn Pocock-Williams*

The following time line presents a historical review of computer art from 1960 to 1990 with an encapsulated summary of technological developments from the preceding fifteen years. To provide a context in which to see computer art, each year in the time line has been subdivided into three categories: exhibitions, publications, and technology. Following the time line is a selected bibliography of exhibition catalogues, books, and articles, and a glossary of common technical terms. Due to limitations of space, it is possible to list only a selection of exhibitions and publications.

The chronology of technical achievements is meant to give an overview of the most significant events. While dates are given as specifically as possible for the introduction of these technologies, many are only approximate. There are several reasons for this; many of the technologies were borrowed from other fields and their true origins are therefore somewhat obscure. Another complication arises from the fact that many of the ideas were "invented" several times for different classes of problems; that is, a new idea was commonly tried first in a research environment, then modified for use by computer professionals, and then changed again before being made available to artists.

Given current concerns with taking art in context, it seems impossible and unwise to separate any art from its economic, historical, social, political, or ethnic context; likewise, it is inadvisable to try to separate computer art from technological development and the intellectual history it implements and influences. The time line is an attempt to present computer art as a part of the interrelated cycle of technological innovation → application of technology → effect on culture → technological opportunities for artists → experimentation → art theorizing → education → intellectual evolution of culture → technological innovation, and around again. By placing this information in a time line we hope to reveal connections between the entries and provide a starting point for further personal investigation by the reader. Finally, the time line is meant to promote communication about events happening in different international cultures and within the realms of art, science, and technology.

Research for the technology portion of the time line and the glossary was done by Chris Dobbs; others who contributed include Jane Veeder, Justin P. West, Patric Prince, Suzan Shutan, Tekla McInerney, and Terry Gips.

## Time Line

Note: An asterisk after an exhibition listing means that a catalogue was produced. Complete citations for exhibition catalogues, articles, and books appear in the bibliography. Additional books and articles are listed in the bibliography but not mentioned in the time line.

## 1945–1959

### ▼ Technology

**1945**
Electronic Numerical Integrator And Computer (ENIAC) is completed (developed by John W. Mauchly and J. Presper Eckert)—the first general-purpose fully electronic computer.

**1946**
First point plotters are developed by Electronics Associates, Inc.
Xerox model D, first commercial dry copier, is marketed.
"Light Gun," precursor of the light pen, is developed by the military for the Whirlwind project.

**1950**
RCA develops a version of color television compatible with black-and-white technology (to become NTSC).

**1951**
CRTs begin to be used as output devices for computers.

**1952**
Ben Laposky photographs an image from an analog screen.

**1954**
D. Ross creates "Scope Input Program" on Whirlwind, the first example of free-hand drawing with a computer.

**mid-1950s**
Line drawing plotters are developed by Benson-Lehner and Electronic Associates, Inc.

**1959**
Massachusetts Institute of Technology (MIT) Lincoln Labs develops first light pen for the TX-2 computer.
**late 1950s**
California Computer Products (CAL-COMP) develops plotters using stepping motors and moving-paper/fixed-pen designs.

## 1960

### ▼ Publications
Dennis Gabor, "Inventing the Future."

### ▼ Technology
William Fetter coins the term "computer graphics" to refer to plotter drawings.

## 1962

### ▼ Technology
W. Clark and C. Molnar of MIT design the LINC (Laboratory Instrument Computer)—the first work station.

I. Sutherland develops his "Sketchpad" system, the first truly interactive computer-graphics system.

## 1963

### ▼ Technology
L. Roberts develops the first practical hidden-line removal algorithm.

ASCII (American Standard Code for Information Interchange) is established as a standard.

## 1964

### ▼ Technology
John Kemeny and Thomas Kurtz develop BASIC (Beginner's All-Purpose Symbolic Instruction Code) programming language.
Douglas Engelbart invents the mouse.

Rand Corporation develops the first positioning tablet.
Kenneth Knowlton writes BEFLIX, the first general-purpose programming language for computer animation.
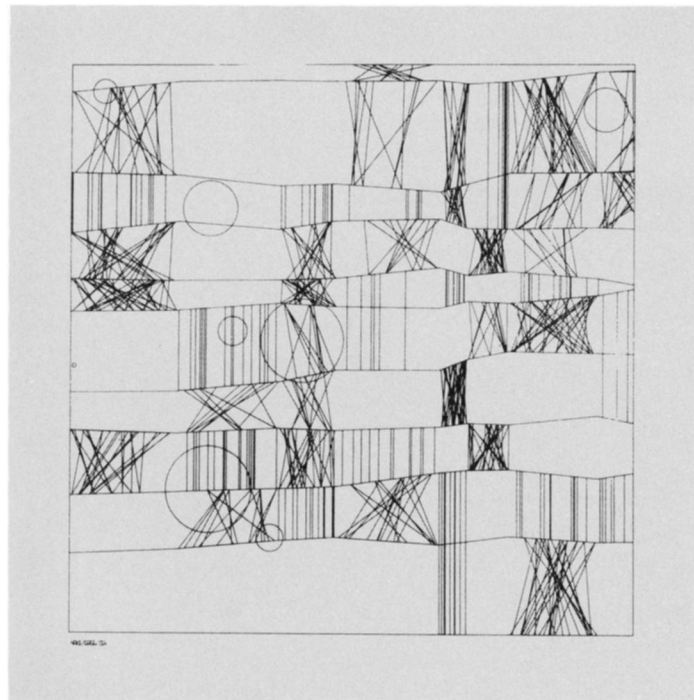
## 1965

### ▼ Exhibitions
"Maughan S. Mason, Bela Julesz and Michael Noll," Las Vegas, Nev.: Fall Joint Computer Conference.
"Nam June Paik: Electronic Art," New York: Galeria Bonino.*
"Georg Nees and Frieder Nake," Stuttgart: Niedlichs Galerie.
"World Exhibition of Computer Graphics," New York: Howard Wise Gallery.

### ▼ Publications
Gyorgy Kepes, ed., *Structure in Art and Science*.
Kenneth Knowlton, "Computer-Produced Movies."
Marshall McLuhan, *Understanding Media: The Extensions of Man*.

### ▼ Technology
Sony releases Portapak, the first inexpensive, nonbroadcast-quality, portable black-and-white video camera.



Frieder Nake, *Hommage to Paul Klee*, 1965, silkscreen on paper, 20 × 20 inches. Private collection.

## 1966

### ▼ Exhibitions
"P. Hertwig, K. Alsleben, Frieder Nake and Georg Nees," Frankfurt am Main, Germany: Galerie d.

### ▼ Publications
Allon Schoener, "2066 and ALL That." *EAT News*, newsletter of Experiments in Art and Technology, is founded.

### ▼ Technology
Experiments in Art and Technology (EAT) is founded by Robert Rauschenberg and Billy Klüver (physicist in laser research at Bell Labs) to promote collaborations by artists and scientists.
F. Alterio and R. Dunlarey of Teletype Corporation develop Inktronic, the first ink-jet printer.

## 1967

### ▼ Publications
*Exakte Asthetik*, special issue on "Art from the Computer."
Edmund C. Berkeley, "Computer Art: Turning Point."
Michael Noll, "The Digital Computer as a Creative Medium."

### ▼ Technology
Center for Advanced Visual Studies (CAVS) is established at MIT by Gyorgy Kepes to provide collaborative environment for artists and scientists.
R. Masters and H. Fretheim of Control Data Corporation develop first touch-sensitive screen.

## 1968

### ▼ Exhibitions
"Cybernetic Serendipity: The Computer and the Arts," London: Institute of Contemporary Art.*
"On the Path to Computer Art," Berlin: the parallel group in conjunction with a joint conference of MIT and the Technical University, Berlin.
"Some More Beginnings: An Exhibition of Submitted Works Involving Technical Materials and Processes," New York: Brooklyn Museum.*
"The Machine, as Seen at the End of the Mechanical Age," New York: Museum of Modern Art.*

### ▼ Publications
Jack Burnham, *Beyond Modern Sculpture: The Effects of Science and Technology on the Sculpture of This Century.*
Kawano Hiroshi, "The Aesthetic for Computer Art."
Douglas Davis, "Art and Technology: The New Combine."
*Leonardo* begins publication. (Numerous articles on computer art have appeared in this journal, which continues to be published.)

### ▼ Technology
Oki Electric Industry Company of Japan develops a dot-matrix printer in order to produce Oriental characters.
Ilford introduces the Cibachrome process.
Robert Mallary develops TRAN2, the first program for the computer-aided design of sculpture.
First attempts at 2-D animation software take place.



Robert Mallary, *Quad III*, 1968, laminated wood veneer, 86 × 16 × 16 inches. Private collection.

## ▼ Exhibitions

"Computerkunst—On the Eve of Tomorrow," Hanover, Munich, Hamburg, Oslo, Brussels, Rome, and Tokyo.
"Event One," London: Computer Arts Society.
Galerie Franzius—a gallery specializing in computer-graphics art—is founded in Munich.
"Tendencija 4," Zagreb: Museum of Modern Art.

## ▼ Publications

Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction" (1955) appears in first English translation.
Robert Mallary, "Computer Sculpture: Six Levels of Cybernetics."

## ▼ Exhibitions

"Computer Graphics Exhibition," Madrid: Mathematical Institute of the University of Madrid.
"Interactive Sound and Visual Systems," Columbus: College of Arts, Ohio State University.*
"Software, Information Technology: Its New Meaning for Art," New York: Jewish Museum.*
Venice Biennale, includes computer-graphics works by A. Lecci, Frieder Nake, Georg Nees, H. Ph. Peterson, Herbert Franke, and the Computer Technique Group of Japan.

## ▼ Publications

John Canaday, "Less Art, More Computer."
Gunther Pfeiffer, "Art and Computer."
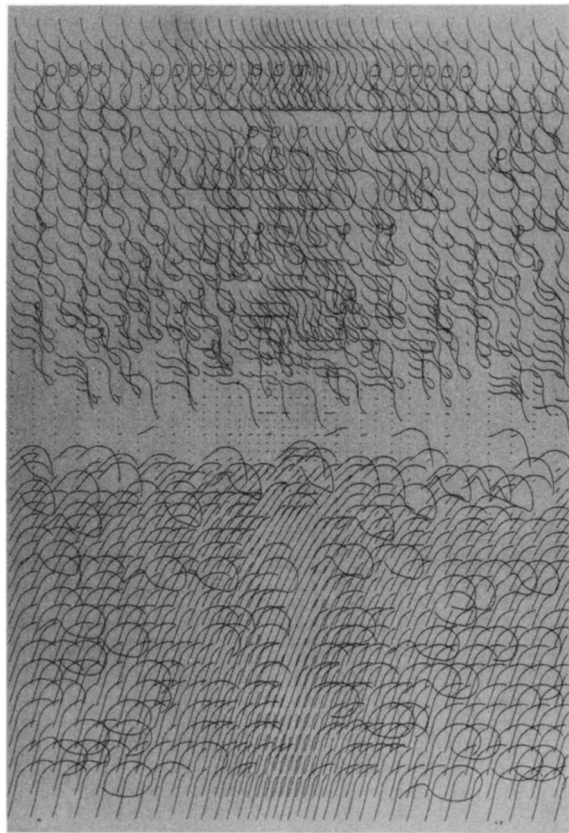Jasia Reichardt, *The Computer in Art*.
Gene Youngblood, *Expanded Cinema*.

## ▼ Technology

Popularity of raster displays increases; vector displays decrease.
Color videotape recorders become available.
Nam June Paik and Shuya Abe develop Paik/Abe video synthesizer.



Collette and Charles Bangert, *Land Lines*, 1970, computer plotter and ink drawing on paper, 32 × 23 inches. Private collection.

## ▼ Exhibitions

"Arteonica," São Paulo.
"Arte y Cibernetica," Buenos Aires: Centro de Estudios de Arte y Comunicacion.
"Eighth European Systems-Engineering Symposium," Madrid: Palacio de Oriente.*
"Exhibition of Computer Art," Kansas City, Mo.: Nelson Gallery of Art.
"Manfred Mohr: Computer Graphics," Paris: Musée d'Art Moderne.

"Technics and Creativity," New York: Museum of Modern Art.*

## ▼ Publications

Jack Burnham, "Problems of Criticism: Art and Technology."
Herbert W. Franke, *Computer Graphics, Computer Art*.
Jasia Reichardt, ed., *Cybernetics, Art, and Ideas*.
John Whitney, "A Computer Art for the Video Picture Wall."

## ▼ Technology

First microprocessor is developed by Intel.
Michael Noll develops first random-access frame buffer.
Thomas Defanti develops GRASS (Graphics Symbiosis System), the first easy-to-program animation language.

## 1972

### ▼ Exhibitions
"Grenzgebiete der bildenden Kunst,"
Stuttgart: Staatsgalerie.
"Multiple Interaction," Chicago:
Museum of Science and Industry.*

### ▼ Publications
Sonia Landy Sheridan, "Generative
Systems."

### ▼ Technology
Noland Bushnell invents PONG—the
first videogame; he founds Atari.
Dan Sandin builds the Image Processor
and distributes plans for this user-built
artist-oriented video synthesizer.

## 1973

### ▼ Exhibitions
"Art y Computadoras," Buenos Aires:
organized by Jorge Glusberg as part of
the first International Conference on
Computing in the Humanities (ICCH)
(held also in 1975 and 1977).
"Art et l'ordinateur," Bordeaux, France.
"The First International Festival of Com-
puter Art," New York: The Kitchen.

"Interaction, Machine: Man: Society,"
Edinburgh: Computer Art Society.

### ▼ Publications
Douglas Davis, *Art and the Future: A
History/Prophecy of the Collaboration be-
tween Science, Technology and Art.*
William Newman and Robert Sproull,
*Principles of Interactive Computer
Graphics.*

### ▼ Technology
Videodiscs developed.
Thomas DeFanti and Dan Sandin estab-
lish the Electronic Visualization Lab at
the University of Illinois at Chicago.

## 1974

### ▼ Exhibitions
"Aesthetik als Informationsverar-
beitung," Vienna and New York.
"Art et informatique," Angers, France.
"Bat-Sheva-Seminar on the Interaction of
Art and Science," Jerusalem.
"International Exhibition of Computer
Graphics," Montreal: Museum of Fine
Arts.*

### ▼ Publications
Stewart Kranz, *Science and Technology
in the Arts: A Tour through the Realm of
Science/Art.*

### ▼ Technology
Bally introduces "Baseball" and "Gun-
fight," the first videogames with ani-
mated human characters.
Sony introduces the Mavica (Magnetic
Video Card) Video Card and Player—
precursor of Mavica Videodisc.
First attempts at 3-D modeling and ani-
mation software take place.

## 1975

### ▼ Exhibitions
"B. Bek, V. Ziljak," Zagreb: Galerija
Suvremene Umjetnosti.
"First Electronic Visualization Event,"
Chicago: University of Illinois at Chi-
cago Circle (interactive computer perfor-
mances are also held in 1976 and 1978).

### ▼ Publications
James Gips, *Shape Grammars and Their
Uses: Artificial Perception, Shape Gener-
ation and Computer Aesthetics.*
George Stiny, *Pictorial and Formal As-
pects of Shape and Shape Grammars.*

### ▼ Technology
Betamax—first home half-inch video-
cassette recorder—is introduced.
First truly personal computer, Altair
Microcomputer, becomes available for
$350.
Alvy Ray Smith (at New York Institute of
Technology) develops PAINT, the proto-
type of most modern paint programs.
Benoit Mandelbrot begins development
of the mathematics of fractal geometry.
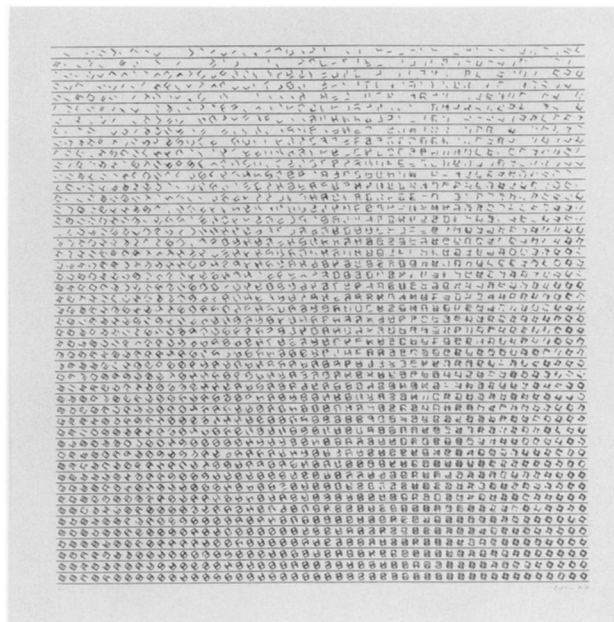


Manfred Mohr, *P-155 Cubic Limit*, 1974–76, silkscreen
on paper, 27½ × 27½ inches. Private collection.

▼ *Publications*
Ruth Leavitt, ed., *Artist and Computer*.
Robert Russett and Cecile Starr, *Experimental Animation: Origins of a New Art*.

▼ *Technology*
Steve Jobs and Steve Wozniak develop the Apple I and found Apple Corporation.

James Blinn develops "bump-mapping" algorithm for mapping texture onto virtual surfaces.
Society of Motion Picture and Television Engineers (SMPTE) forms High-Definition Television (HDTV) study group.

▼ *Exhibitions*
"Computer Genesis: A Vision of the '70's," Syracuse, N.Y.: Joe and Emily Lowe Art Gallery, Syracuse University.*
"L'Ordinateur et les arts visuels," Paris: Swedish Cultural Center.

▼ *Publications*
Charles Csuri, "3-D Computer Animation."

▼ *Technology*
Apple introduces the Apple II.
Alan Kay and Adele Goldberg of Xerox Palo Alto Research Center (PARC) publish "Personal Dynamic Media," which introduces the idea of the "Dynabook" and contains the original ideas embodied in the Macintosh.
Victor Company introduces VHS (Video Home System) format.
Half-inch video cassettes emerge as the consumer format of choice.

▼ *Exhibitions*
"Art and the Computer," Worcester, Mass.: Worcester Art Museum.
"Artiste et informatique," Paris: Swedish Cultural Center.
"Energized Artscience," Chicago: Museum of Science and Industry.*
"The Vasulka's: Steina: Machine Vision; Woody: Description," Buffalo, N.Y.: Albright-Knox Art Gallery.

▼ *Publications*
*Computer Graphics World* begins publication.

▼ *Technology*
Thomas DeFanti develops ZGRASS, a programming language for artists and educators.
Magnavox introduces the laser-videodisc player.

"Space Invaders," "Asteroids," and "Pac Man" spark the videogame craze.
Aspen Movie Map Project—a videodisc-based project that allows a user to drive around a database of Aspen, turn corners, change seasons, and go into buildings—is designed by Architecture Machine Group at MIT.
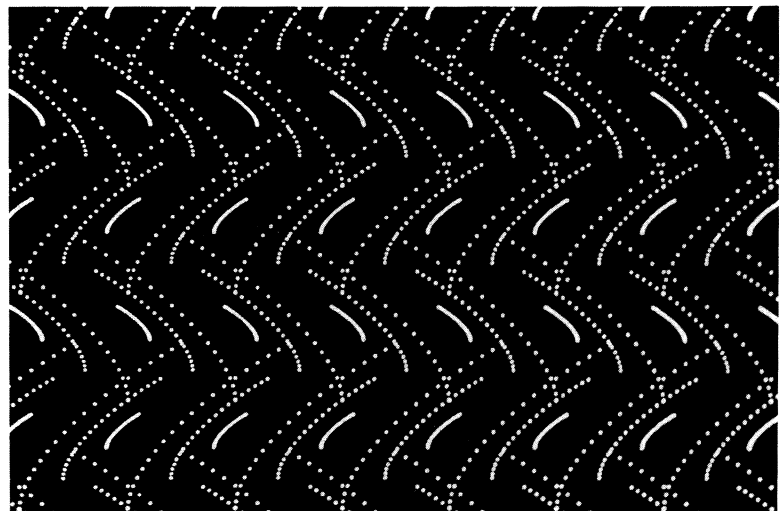
▼ *Exhibitions*
"Ars Electronica," Linz, Austria: International Bruckner Festival is initiated and continues as a yearly event.
"Artiste et ordinateur," Paris: Swedish Cultural Center.
"Cybernetic Symbiosis," Berkeley: Lawrence Hall of Science.

▼ *Publications*
Frank J. Malina, ed., *Visual Art, Mathematics and Computers: Selections from the Journal Leonardo*.

▼ *Technology*
Scitex Color System—allowing for electronic image color correction, text input, and layout design and manipulation—is developed.



Larry Cuba, *Two Space*, 1979, still frame from film.

## ▼ Exhibitions

"Art In/Art Out," Chicago: Ukrainian Institute of Modern Art.
"International Festival voor Elektronische Muziek, Video en Computer Art," Brussels.
"Video Art: The Electronic Medium," Chicago: Museum of Contemporary Art.
"Struycken: Structures—Elements 1969–1980," Rotterdam: Museum Boymans-van Beuningen.*

## ▼ Publications

David Topper and John H. Holloway, "Interrelationships between Visual Arts, Science and Technology: A Bibliography."
John Whitney, *Digital Harmony: On the Complementarity of Music and Visual Art.*

## ▼ Technology

Turner Whitted develops first ray tracer.
3M offers Scan-A-Mural service.
Quantel introduces its first digital video-effects device.
First "Symposium on Small Computers in the Arts" is held in Philadelphia.

## ▼ Exhibitions

"Computer Culture 81," Toronto: Ontario College of Art.
"High Technology Art: A Congressional Exhibition," Washington, D.C.: Library of Congress.
"SIGGRAPH '81 Art Show" is inaugurated in Dallas. (Exhibitions are now annual events, sometimes with a special focus. A catalogue and a slide set are produced.)

## ▼ Publications

*Symposium on Small Computers in the Arts* (first conference proceedings).

## ▼ Technology

IBM introduces the PC.
Music Television (MTV), the first 24-hour satellite-distributed cable-television program based on the visual interpretation of popular music ("rock videos"), is introduced.



Bill Viola, *Hatu Yume (First Dream)*, 1981, still frame from video. Courtesy Museum of Modern Art, New York.
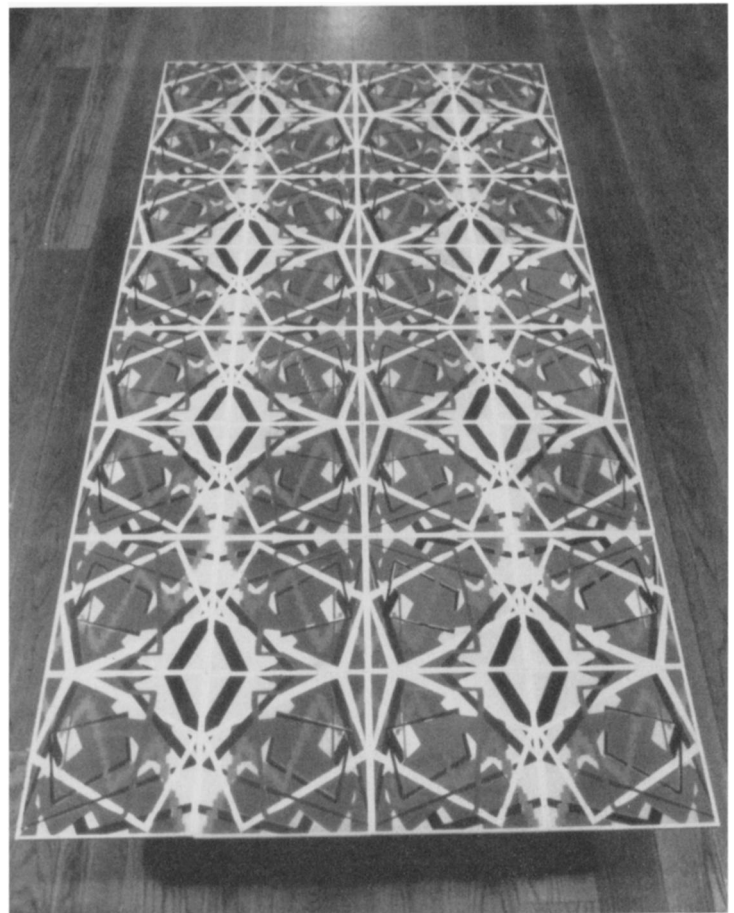


Darcy Gerbarg, *May I*, 1981, ceramic tiles, 100 × 50 inches. Collection of the artist.

## ▼ Exhibitions

"Art and the Computer," New York: Hansen Gallery.
"Artists/Computers/Art," London: Canada House Gallery; Paris: Centre Culturel Canadien.*
"L'Art et l'ordinateur," Paris: Compagnie Internationale de Service en Informatique.
"Nam June Paik," New York: Whitney Museum of American Art.*

## ▼ Publications

Donald Greenberg, Aaron Marcus, Allan H. Schmidt, and Vernon Gorter, *The Computer Image*.
Yochiro Kawaguchi, *Digital Image*.

## ▼ Technology

Ampex introduces the ADO digital-video-effects device, the first system able to move two-dimensional images in three dimensions.
The Sony Mavica—the first still-video camera to be able to store images on a magnetic disc—is invented.

## ▼ Exhibitions

"The Computer and Its Influence on Art and Design," Lincoln, Nebr.: Sheldon Memorial Art Gallery.*
"DIGICON '83"—International Conference of Computer Arts, Vancouver.
"Electra: L'Electricité et l'électronique dans l'art au XXe siècle," Paris: Musée d'Art Moderne de la Ville de Paris.*
"Exhibition of Computer Graphics in Collaboration with SIGGRAPH '83 Exhibition of Computer Art," Tokyo: Isetan Museum and Hakuhodo, Inc.*
"Exposition d'art photo/électrique," La Chartreuse, Villeneuve-les-Avignon, France: Computer Culture.*

## ▼ Publications

Jean Baudrillard, *Simulations*.
Hal Foster, ed., *The Anti-Aesthetic: Essays on Postmodern Culture*.
Lucinda Furlong, "Notes toward a History of Image-Processed Video: Eric Siegel, Stephen Beck, Dan Sandin, Steve Rutt, Bill and Louise Etra."
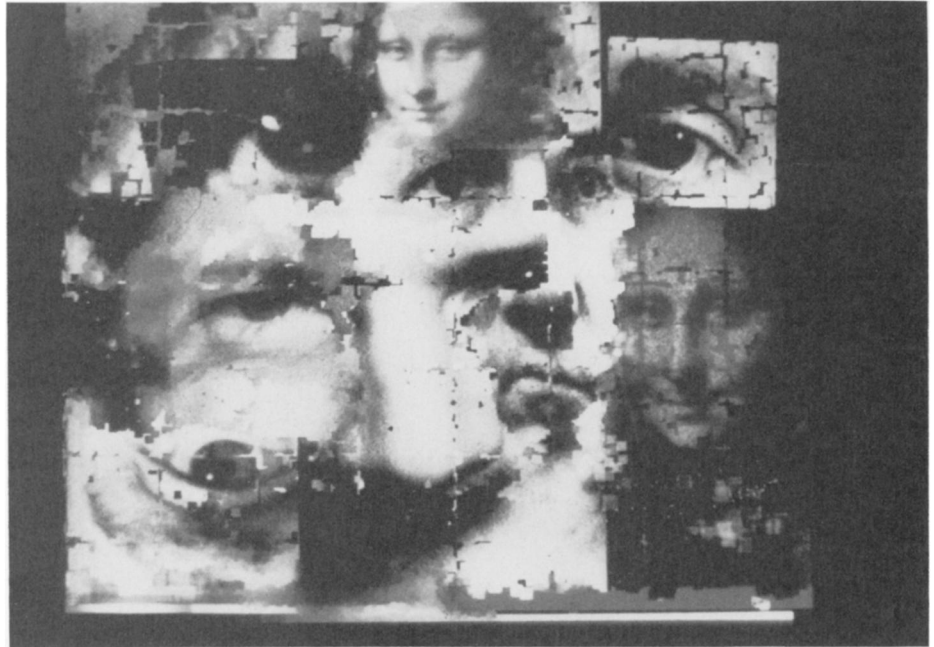Grace Glueck, "Portrait of an Artist as a Young Computer."
Myron Krueger, *Artificial Reality*.
Robert Scott Root-Bernstein, "Paradigms and Revolutions in Science and Art: The Challenge of Interpretation."
Gene Youngblood, "Computer Art as a Way of Life."

## ▼ Technology

Apple introduces LISA (Local Integrated Software Architecture) and Apple IIe.



Alyce Kaprow, *Fazes*, 1983, photograph, 16 × 20 inches. Private collection.

## 1984

### ▼ Exhibitions

"Artist as a Young Machine," Toronto: Ontario Science Center.
"CADRE '84," San Jose, Calif.: San Jose State University Art Department.*
"Immagini da Computer, Mostra di Computer Grafica," Prato, Italy.*

### ▼ Publications

Stan Augarten, *Bit by Bit: An Illustrated History of Computers*.
Herbert W. Franke, *Computergrafik-Galerie; Bilder nach Programm: Kunst im elektronischen Zeitalter*.
Hiroshi Inose and John Peirce, *Information Technology and Civilization*.
Judy E. Sachter, "The Basic Concepts of Three-Dimensional Computer Graphics for Artists."
Lee Silverman, "Inside the Loop: Computer Graphics within the Technological Highway."
Brian Wallis, ed., *Art after Modernism: Rethinking Representation*.
Thomas Defanti, "The Mass Impact of Videogame Technology."

### ▼ Technology

Apple introduces the Macintosh with a commercial that emphasizes its totalitarian control of information. This 60-second spot airs only once but is replayed as a news item.
Canon introduces the first consumer-grade laser-print engine.
IBM develops a one-million-bit RAM (random-access memory).
Mitsubishi video printer is introduced; it prints black-and-white images from video signals.
Wavefront Technologies introduces first comprehensive, commercially available software system incorporating modeling, motion choreography, and rendering.
(All 3-D animation software had been available only in research areas of industry and academia.)

## 1985

### ▼ Exhibitions

"The Artist and the Computer II," Louisville, Ky.: Louisville Art Gallery.*
"Emerging Expressions," New York: Bronx Museum of the Arts.
"SIGGRAPH Traveling Art Show 1985," Tokyo: Hakuhodo, Inc.*

### ▼ Publications

Roy Ascott, "Concerning Nets and Spurs."
Katherine Dieckmann, "Electra Myths: Video, Modernism, Postmodernism."
Frank Dietrich, "Visual Intelligence: The First Decade of Computer Art (1965–1975)."
Lucinda Furlong, "Tracking Video Art: 'Image Processing' as a Genre."
Copper Giloth and Jane Veeder, "The Paint Problem."
Joan L. Kirsch, "When Will Computer Art Be Taken Seriously?"
Barbara London, "Video: A Selected Chronology, 1963–1983."
Joachim Schmid, "The Electronic Photographer is Coming."
*Visual Computer* begins publication.

### ▼ Technology

Amiga PC is introduced and used by many artists and educators as a personal instrument.



Jane Veeder, *Vizgame*, 1985, video screen image interactive installation. Collection of the artist.

## 1986

### ▼ Exhibitions

"artware: Kunst und Elektronik," Hanover: Messe AG and Siemens AG (first exhibition; others in 1987, 1988, 1989, 1990).*
"The Computer as an Art Tool," Greenwich, Conn.: Hurlbutt Gallery.
"Images Digital: Computer Artists in Germany," Munich: Galerie der Kuenstler.*

### ▼ Publications

René Berger and Lloyd Eby, eds., *Art and Technology*.
Nancy Burson, Richard Carling, and David Kramlich, *Composites: Computer-Generated Portraits*.
Isaac Victor Kerlow and Judson Rosebush, *Computer Graphics for Designers and Artists*.
R. Lucas, "Evolving Aesthetic Criteria for Computer-Generated Art."

### ▼ Technology

Megaprint, a laser-scanning computer-airbrush system, produces billboard-scale prints.

## 1987

### ▼ Exhibitions

"Computer Assisted: The Computer in Contemporary Art," Reading, Pa.: Freedman Gallery, Albright College.*
"Computers and Art," Syracuse: Everson Museum of Art.
"The Interactive Image," Chicago: Museum of Science and Industry.
"The Second Emerging Expression Biennial: The Artist and Computer," New York: Bronx Museum of the Arts.*

### ▼ Publications

Cynthia Goodman, *Digital Visions*.
Hal Foster, ed., *Discussions in Contemporary Culture: Number One*.
Catherine Richards, "Virtual Worlds, Digital Images."

### ▼ Technology

Apple introduces the Mac II.
Scanners for PCs become available.
AT&T shows the Pixel Machine at SIGGRAPH, demonstrating its capability to manipulate ray-traced objects in real time.
Hypercard—a personal-computer implementation of hypermedia concepts—is released by Apple.
SMPTE Working Group on High-Definition Electronic Production gives unanimous endorsement to the 1125/60 HDTV production standard.
The Fine Art, Science, and Technology (F.A.S.T.) Electronic Bulletin Board is founded by Ray Lauzzana at the University of Massachusetts at Amherst.

## 1988

### ▼ Exhibitions

"Computers and Art," New York: IBM Gallery of Science and Art.
"Digital Photography: Captured Images, Volatile Memory, and New Montage," San Francisco: SF Camerawork.*

### ▼ Publications

Timothy Binkley, "Camera Fantasia."
Christopher Burnett, "Computers and Art in the Age of the World Picture."
Timothy Druckrey, "User Friendly?"
David Ross, *The Art of David Em: 100 Computer Paintings*.
Wim Van Der Plas, ed., *Electronic Art*.

### ▼ Technology

FAX machines are mass marketed.

## ▼ Exhibitions

"Computers and Photography," Rochester, N.Y.: Pyramid Arts Center.
"Jenny Holzer," New York: Solomon R. Guggenheim Museum.*
"ImageWorld," New York: Whitney Museum of American Art.*
"The Techno/Logical Imagination: Machines in the Garden of Art," Minneapolis: Intermedia Arts Minnesota and the Minneapolis College of Art and Design.*
"Micro-Macro: The Work of Art in the Age of the Microcomputer," New York: Bertha and Karl Leubsdorf Art Gallery at Hunter College.

## ▼ Publications

Edward Barrett, *The Society of Text: Hypertext, Hypermedia, and the Social Construction of Information*.
Andrew S. Glassner, *3D Computer Graphics: A User's Guide for Artists and Designers*.
John Lansdown and Rae A. Earnshaw, eds., *Computers in Art, Design, and Animation*.
Margot Lovejoy, *Postmodern Currents: Art and Artists in the Age of Electronic Media*.

Martha Rosler, "Image Simulations, Computer Manipulations: Some Considerations."
*Leonardo* begins publication of F.A.S.T. Electronic Bulletin Board.

## ▼ Technology

Intel introduces the 80860 microprocessor chip—equivalent power of a Cray 1 supercomputer.
Mass marketing of still video cameras begins.
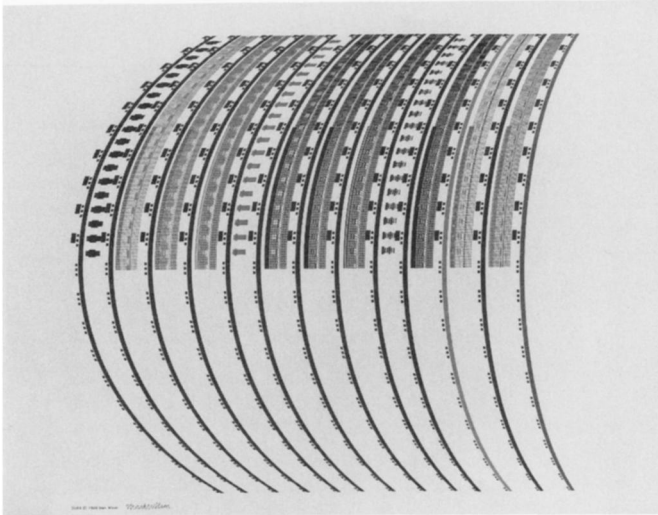


Mark Wilson, *30J89*, 1989, acrylic on canvas, 36 × 48 inches. Collection of the artist.
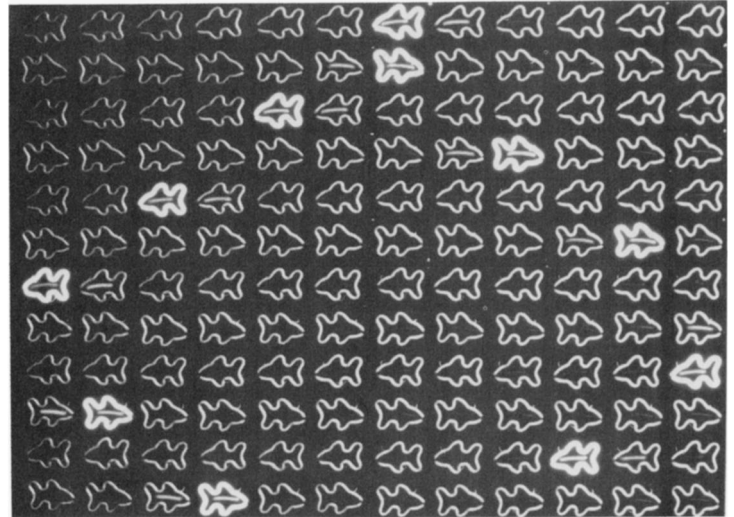


Karl Hauser, *wall-o-fish*, 1989, computer-animated neon, 60 × 84 inches. Collection of the artist.

## ▼ Exhibitions

"Computers and the Creative Process," Eugene: University of Oregon Museum of Art.
Venice Biennale, United States Pavilion—Jenny Holzer.

## ▼ Publications

Terry Gips, "Critical Questions for Computer Artists of the 1990's."
Renee LeWinter and Cynthia Baron, "Artistic Challenge."
Fred Ritchin, *In Our Own Image: The Coming Revolution in Photography*.
Dorothy Spencer, "Computer Art—An Oxymoron? Views from the Mainstream."
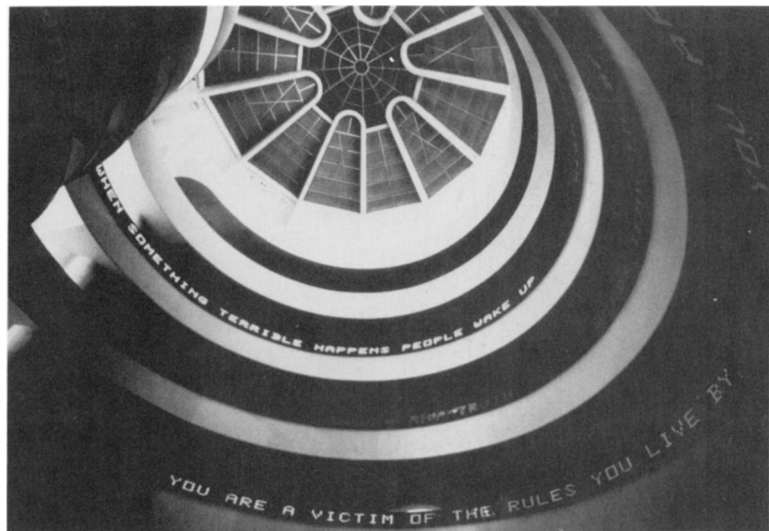


Jenny Holzer, sign installation at the Solomon R. Guggenheim Museum, New York, 1989–90, electronic lightboards. Courtesy Barbara Gladstone Gallery, New York.

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*B. Bek, V. Ziljak* (Zagreb: Galerija Suvremene Umjetnosti, 1975).

Ridell T. Breval, L. Bergquist, B. E. Bengtsson, and S. Henriksson, *Artist and Computer* (Paris: Centre Culturel Suédois, 1979).

Jack Burnham, *Software, Information Technology: Its New Meaning for Art* (New York: Jewish Museum, 1970).

*CADRE '84* (San Jose, Calif.: San Jose State University Art Department, 1984).

Luis R. Cancel, *The Second Emerging Expression Biennial: The Artist and Computer* (New York: Bronx Museum of the Arts, 1987).

*Computer Genesis: A Vision of the '70's* (Syracuse, N.Y.: Joe and Emily Lowe Art Gallery, Syracuse University, 1977).

Charles Csuri, *Interactive Sound and Visual Systems* (Columbus: College of Arts, Ohio State University, 1970).

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# Glossary

**Algorithm**
A set of well-defined instructions for the solution of a problem.

**Analog**
A scale of measure that is continuous, like the volume control on a stereo, or a thermometer. The term refers also to signals that have not been sampled.

**Artificial intelligence**
The scientific field concerned with creating computer systems that can achieve "human" intellectual faculties such as the abilities to perceive, reason, and learn.

**Computer animation**
Use of the computer to make images with the illusion of movement.

**CRT**
Cathode ray tube. The picture tube of a television set, video monitor, or computer display.

**Cursor**
A small graphic symbol used as a pointer to indicate position on a display screen. The movement of the cursor is controlled by a keyboard, mouse, light pen, or tablet stylus.

**DataGlove**
A glove containing sensors, worn on the hand to detect the motion and position of the hand and feed that information to a computer. It is useful for virtual-reality applications.

**DataSuit**
The extension of the DataGlove for the whole body.

**Digital**
Using discrete numbers to represent information. On computers, these numbers are combinations of 0 and 1.

**Digital processing**
The task of taking digital information and changing ("processing") it through the use of an algorithm.

**Digitizer**
An input device used to transform a graphic representation into a digital representation so that it can be processed by a computer. Types include video digitizers, laser scanners, and tablets.

**Display**
An output device that contains a CRT and interprets data from the computer, showing it as text and images. A computer screen is a display.

**Dot-matrix printer**
A printer that uses tiny hammers to strike an inked ribbon to produce dots on paper. Many dots together make up an image.

**Film recorder**
An output device that records data onto photographic film or paper.

**Fractals**
A term, coined by Benoit Mandelbrot, for a type of mathematics very useful for understanding and defining certain natural shapes and phenomena.

**Frame buffer**
A special type of computer memory that stores the image data required for a raster display.

**Graftal**
A type of modeling that creates plants and trees by describing them in mathematical terms. Alvy Ray Smith developed these algorithms based on the earlier work of Aristid Lindenmayer.

**Hardware**
The physical components or equipment that make up a computer system, such as scanners, printers, and displays.

**HDTV**
High-definition television. A proposed television system with significantly better picture quality than that of the current broadcast standard.

**Hypermedia**
An extension of the idea of hypertext to include other kinds of information, such as video images and sound.

**Hypertext**
A term coined by Ted Nelson (based on a 1945 article by Vanavar Bush) for an environment where information can be linked freely across conventional subject boundaries. An essential concept is that of "authoring," the ability of each user to easily reorganize the information into a customized body.

**Ink-jet printer**
A printing device that creates an image by spraying a thin stream of ink onto paper. Colored ink can be used, resulting in color images.

**Interactive**
As applied to computer art, any computer, device, program, or artwork that relies on active communication with a human being.

**Laser printer**
A printing device that uses a laser beam to place images on a rotating drum. The drum picks up a toner powder on the laser-exposed areas, which are then pressed and fused into paper, forming the image.

**Laser scanner**
A digitizer that uses a laser beam for the conversion of an image into digital information.

**Light pen**
An input device, much like a writing pen, that is used to draw and manipulate information on a computer display by touching the tip of the pen to the display.

**Microprocessor**
The arithmetic, logic, and control elements required for processing information, usually contained on one integrated-circuit chip. Microprocessors are used inside most personal computers and in a wide variety of specialized applications, such as computer-controlled light signs.

**Mouse**
A device, connected to a computer by a cable, for moving a cursor or other object around on the display screen. As the mouse moves, the cursor moves correspondingly on the screen.

**Network**
A system of interconnected computers and other hardware that allow for the exchange of information. Networks can link computers in the same room or in various parts of the world.

**NTSC**
National Television Standards Committee. The standard for broadcast color television used primarily in North, Central, and South America, and Japan.

**Pixel**
An acronym for "picture element." The smallest unit on the display screen that can be stored, displayed, or addressed. Pixels are the tiny dots that are seen when an image displayed on a computer screen is examined closely.

**Plotter**
An output device that draws lines or points on paper under the control of a computer. It was used extensively for early computer art.

**Printer**
An output device for the production of text and images that works much like a typewriter but is given instructions from a computer. Dot-matrix, ink-jet, laser, and thermal are the major types of printers.

**Program**
A set of instructions, written in a programming language, used to instruct a computer to carry out specific activities or tasks (algorithms).

**Programming language**
A scheme of formal notation used to spell out instructions for the computer. Programming languages include BASIC, Pascal, and C.

**Raster display**
A display device that stores and displays an image (data) as a two-dimensional grid of pixels.

**Ray tracer**
A computer program that produces realistic images from geometric models of objects. The surroundings appear in the surfaces of the reflective objects, enhancing the realism of the scene.

**Scan-a-Mural**
A service (offered for several years by 3M Corporation and now offered by Computer Image Systems) whereby a computer image can be transferred to a large-scale canvas.

**Scientific visualization**
Use of computer graphics and animation techniques to give visual form to complex numerical data.

**Software**
Another name for programs.

**Still-video camera**
A camera that does not require film but rather makes an electronic record of an image and stores it on a small magnetic disk. The image can then be displayed on a video monitor or put into a computer.

**Tablet**
A digitizer, normally consisting of a flat tablet, on which a pattern is traced over with a penlike stylus or other cursor device. The patterns traced by the operator are automatically entered into the computer's memory for subsequent processing.

**Thermal printer**
A printer that produces output on heat-sensitive paper. It uses heat to melt wire particles that contain ink, which are then transferred to paper.

**Three-dimensional modeling**
The use of a computer system to create a three-dimensional object by defining its shape, dimensions, color, and surface texture.

**Touch-sensitive screen**
A display screen on which the user can enter commands by pressing designated areas with a finger or other object. The screen can detect the position where it is touched, and the computer then performs the function indicated.

**Vector display**
A display in which images are drawn on the screen of a CRT by a beam that constructs a series of lines, or "vectors," of any length and at any angle.

**Video digitizer**
A digitizer consisting of a video camera with specialized hardware and software that enables the conversion of an image into digital information.

**Virtual reality**
A computer-generated interactive environment featuring stereoscopic 3-D graphic scenes. One or more players are immersed in this environment by headgear presenting a video monitor to each eye and blocking out the natural world. Interaction is provided by means of a DataGlove, which conveys gestural information to the computer. Current applications include telepresent operators in remote or dangerous environments, e.g., space and research in cognition and human interaction. Also called virtual environment.

**Virtual surface**
The surface of an imaginary object defined within a computer.

**Work station**
A relatively small but powerful configuration of computer equipment designed to be used by one person.

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