During the twentieth century, punched or Hollerith cards, named after a designer who innovated a mechanism for tabulating similar cards during the 1890 United States census, were indispensable for programming purposes and became ubiquitous in the computer industry. The punched holes in these cards, prepared using a keypunch machine, are switches: a hole means a signal is on, while solid paper means a signal is off. Complex programs required hundreds or thousands of punch cards in a deck to operate. The cards have a missing corner designed to prevent them from being inserted into machines incorrectly. Punch-card technology dates from the nineteenth century, when a “chain of cards” was used to control the patterns woven by a Jacquard loom. Punch cards were gradually replaced with magnetic tape storage, and IBM stopped producing them in the mid-1980s.

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IBM
Punch
Cards

Hummingbird is one of the earliest computer-animated films by the artist and programmer Charles Csuri. To produce *Hummingbird*, over thirty thousand individual images generated by a computer were drawn directly on film using a microfilm plotter. “To facilitate control over the motion of some sequences,” Csuri explained, “the programs were written to read all the controlling parameters from cards, one card for each frame,” indicating just how labor-intensive early forms of computer animation could be. This film was acquired by the Museum in 1968, making it one of the earliest computer-generated artworks to enter the collection.

Charles Csuri,
Hummingbird

Thinking Machines
Extended labels

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Olivetti Programma 101

This commercial programmable computer by Olivetti was designed as a desktop equivalent to larger, more powerful mainframe computers previously produced by the corporation. Despite limited RAM (Random Access Memory), the Programma 101 could make calculations and perform logical operations. It used a small ticker-tape printer as an output. Operated with a simple programming language and designed with the user in mind, much like Olivetti's famed typewriters, the 101 is an important precursor, in scale, to later desktop personal computers. Though manufactured in Italy, Programma 101 computers were successfully marketed in the United States, with some used by NASA during the Apollo 11 program in 1969.

Three Exhibition Posters

In 1969, Vladimir Bonačić, a member of the nonaligned movement New Tendencies, founded in the former Yugoslavia and a key forum for questioning the relationship between art and technology, stated, "The computer must not remain simply as a tool for the simulation of what exists in a new form. . . . The computer gives us a new substance, it uncovers a new world before our eyes." This attitude was evident among experimental practices throughout the 1960s, which were frequently gathered in exhibitions—like the ones promoted by these posters—highlighting the importance of emerging computing technology to artmaking.

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This kinetic sculpture is composed of individual units that function independently and collectively. Colombo designed it as an “open system” in which “genuine change take[s] place,” extending the interactivity of the work of art. Strongly influenced by cybernetic and computational thinking, the artist aimed to create a mechanical, programmed sculpture that would stimulate the viewer’s perception.

During the postwar years, Italy experienced rapid industrialization and economic prosperity, and companies like Olivetti collaborated with artists and designers. In 1962, Colombo participated in the Olivetti-sponsored exhibition *Arte programmata: arte cinetica, opera moltiplicate, opera aperta* (Programmed art: Kinetic art, multiplies, open art works), which granted participating artists access to technological resources and allowed the company to solidify its reputation for cutting-edge design and technical sophistication.

This work will alternate between being on and off every twenty minutes.

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Gianni Colombo,
Pulsating
Structuralization

In 1969, composers John Cage and Lejaren Hiller produced *HPSCHD* at the University of Illinois at Urbana-Champaign using an ILLIAC II supercomputer. They described the event as an "indeterminate concert of any agreed-upon length having two to fifty-nine channels with loud-speakers around the audience." Trained as a scientist, Hiller had experimented since the 1950s with computing and had used computers to facilitate compositional decisions for numerous scores; Cage, too, was interested in advanced technologies throughout his career.

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The composition consists of seven solos for harpsichord—a fragment of which, noted in Cage's hand, is seen here—and fifty-two computer-generated audiotapes. The harpsichord solos were produced by rewriting existing classical compositions using a FORTRAN computer program based on the chance operations governed by the *I-Ching*, an ancient Chinese text originally used for divination. On view here are a visualization of the *HPSCHD* system and a map of the *I-Ching* program.

John Cage and
Lejaren Hiller,
HPSCHD

Nonesuch Records released a recording of *HPSCHD* as a commercial LP in 1969. In order to retain the indeterminate nature of the original *HPSCHD* performance, Cage and Hiller created a new computer program called KNOBS, which they used to produce a set of random and unique instructions for each of the ten thousand copies of the record. These stipulated settings for volume, treble, and bass were to be changed every five seconds, allowing individual listeners to have distinct acoustic experiences.

In 1964, experimental filmmaker Stan VanDerBeek began producing a series of films, each called *Poemfield*, at Bell Laboratories in Murray Hill, New Jersey, where other artists at the forefront of computational art, notably Lillian Schwartz, were working in the same period. He partnered with Ken Knowlton, an artist and physicist, who had advanced the programming language BEFLIX, which was specialized for use in film animation. Using an IBM 7094 computer and an S-C 2040, an apparatus designed to output text and images from mainframe computers, they made *Poemfield No. 1*, a black-and-white film that could be edited and colorized. VanDerBeek created various versions of each *Poemfield*, in which animated words produce visual poems that unfold over time.

Despite the room for human error inherent to early computer animation, VanDerBeek noted that the medium was astounding for the freedom it afforded the artist: “So long as he is clear in his mind as to what he wants, eventually he can realize his movie or work on some computer, somewhere.”

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Poemfield #1, Stan VanDerBeek (label for both film and case of archival materials)

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A House of Dust, by Alison Knowles, an artist affiliated with Fluxus, is among the earliest computerized poems. It consists of quatrains beginning with the phrase “a house of” and completed with selections from randomized lists of materials, sites, light sources, and inhabitants. Knowles worked with James Tenney, then a composer-in-residence at Bell Laboratories, to produce the poem. He programmed the four lists in the FORTRAN IV language operated on a Siemens 4004 computer. The process generated four hundred stanzas before repeating itself. Printed on striped green form paper, the poem unfolds as a continuous scroll without beginning or end. In 1968, Knowles translated the poem into a physical structure that formed a component of her pedagogical practice at CalArts in Burbank, California.

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Alison Knowles, A House of Dust

Cordeiro immigrated to Brazil from Rome in 1946 and became one of the first artists in Latin America to make art with a computer, beginning at the University of São Paulo in 1968 working on an IBM 360/44 with the physicist Giorgio Moscati. His extensive work with computers consisted primarily of photographs that were digitized and printed using alphanumeric characters. This work is based on a photograph taken in São Paulo of a demonstration against the military dictatorship and belongs to a series depicting large crowds. The image presages the importance of computer technology to the administration of national populations and to alternative forms of political organization.

Gente Ampli*2, Waldemar Cordeiro

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These drawings are some of Horwitz's earliest notations with Sonakinatography, a form of conceptual drawing she developed to code and annotate movement, centered around the number eight. In 1968, Horwitz submitted a proposal to the Art and Technology Program (1967–71) at the Los Angeles County Museum of Art for a large kinetic sculpture in which eight illuminated beams would move in relation to each other. Her proposal was accepted but, unlike the work of male participants, was never realized. She continued developing drawings by hand that could act as ciphers for coordinated movements and music. The critic Lucy Lippard noted, "Horwitz does not use a computer, choosing to become the machine herself, sacrificing perhaps some of the illogic or post-logic that art continues to need as nourishment."

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Sonakinatography drawings, Channa Horwitz

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Radical Software, the journal of the countercultural think tank Raindance Corporation (1969–93), explored the potent relationships between media and ecology and aimed to strengthen the expanding networks of people around the world using video technology. The publication was cofounded by Beryl Korot, Phylis Gershuny Segura, and Ira Schneider, and the first two issues were edited by Korot and Segura.

The first four issues incorporated bold designs referencing distributive information channels and computer graphics, including one by the architecture collective Ant Farm. The contributors included the magazine's editors, artists Aldo Tambellini and Jud Yalkut, and influential thinkers R. Buckminster Fuller and Gene Youngblood. The issues contain examples of early computer art by the Computer Technique Group of Japan and the artist Manfred Mohr as well as listings for groups that sought enhanced access to video technology.

Radical Software
(case label for first 4 issues or radical software + ipad)

[some graphic indication that the iPad features issue #1 and can be interacted with by the public]

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Architect Cedric Price was commissioned by Howard Gilman to create a facility for visiting artists as well as theater and dance performances at the Gilman Paper Corporation's White Oak Plantation in Florida. Price conceived the Generator Project as a series of participatory structures powered by artificially intelligent systems. By means of a custom-made computer, a visitor might combine any of the 150 four-by-four-meter, fully serviced, and air-conditioned cubes, each fitted with a logic chip—along with walls, screens, gangways, and communication systems—into a "neutral" structure. A mobile crane would then place these elements in different configurations atop a grid of concrete foundation pads.

The computer would encourage visitors to continually refine their designs with four programs: The first would produce layout drawings while establishing work schedules for the crane driver realizing them. The second would provide a database for distributing site elements. The third and last would allow users to improve the overall site while allowing the computer "to start dreaming up unsolicited plans."

Though the structures were never built, Price's ambitious project represents one of the most storied attempts to use computers in the service of an adaptable, flexible, and ultimately responsive architecture. Price sought to construct a feedback system that could resist stasis and change at any moment. As a result, the Generator Project utilizes technology toward playful and experimental ends.

Generator Project,
Cedric Price

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Month III (March) is a series of drawings based on the addition of the digits that make up a date (day + month + year). Darboven is known for conceptual works that track the passage of time and cultural history by collating written and labor-intensive mathematical drawings. Without directly engaging computer technology, the work seen here evokes computational thinking in its use of numerical processes to recode personal histories. Memory has been reformatted as calculable. The drawings recall the labor of human computers, who completed calculations for scientific or industrial processes before the widespread adoption of digital computers, though Darboven works toward resolutely conceptual rather than practical ends. Important historical parallels between early computer art and contemporaneous Conceptual art have been conceived and questioned since the 1960s, and Darboven's work suggests the important overlap between these practices.

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Month III (March),
Hanne Darboven

Concerned with the intersections of abstract aesthetics with information and technology, Molnár was an active member of a large circle of colleagues invested in advancements in computing. She first used mainframe computers to produce plotter drawings in 1968. Before she was able to work with computers, Molnár activated what she called a “machine imaginaire,” producing artworks by hand that followed computational processes. The drawings exhibited here date from her “machine réelle” period, in which she worked consistently with a computer and plotter. However, as indicated by two drawings titled *A la recherche de Paul Klee* (Searching for Paul Klee), one produced by hand and one with a plotter, the artist used these tools to expand a practice informed by precise techniques that included specific rules for each drawing. Molnár was able to efficiently generate meticulous works with the accuracy afforded by a computer, freeing her up to experiment with a variety of forms and colors.

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Vera Molnár, 5 drawings

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BM 2112-60
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Thinking Machines Corporation, headquartered in Cambridge, Massachusetts, designed and produced a series of parallel supercomputers called Connection Machines, including the CM-2, in the 1980s. Guided by the company's founders, Danny Hillis and Sheryl Handler, a team configured the CM-1 as a system of microprocessors. The CM-2 that followed possessed robust computing power for the time and was therefore initially produced for large-scale commercial applications, including artificial intelligence. Innovative for its unique design profile, the CM-2 was powered by up to 512MB of RAM and a hard disk that stored up to 25GB.

Led by artist and designer Tamiko Thiel, the design team for the CM-2 created a "cube of cubes" or "hypercube" network divided into eight smaller cubes holding sixteen printed circuit boards, then sheathed two sides of its exterior in LED lights. When a red LED is on, it indicates that its corresponding processor is working while allowing users to determine hardware problems. However, to increase the stimulating character of the machine's visual display, a number of programs for the CM-2 were intended to enhance the blinking lights for decorative effect. The resulting pattern of flashes recalls earlier forms of programming computers in addition to images from science fiction.

CM-2
Supercomputer

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BM 2112-60
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"When you deal with difficult philosophical concepts," Denes has said, "you have to make your images visible to get the viewer." This drawing encapsulates Denes's critical mode of art production, which she calls "Visual Philosophy." Made through rigorous conceptual processes, Denes's expansive and diverse works contend with complex ideas about nature. Hand-drawn, this work combines two of the artist's most consistent themes—the snail and the pyramid—to visualize new world systems and their attendant architectures. Denes adheres to a logic of natural and manmade systems, using her art to reconfigure social spaces and relationships, and has worked with institutions including Carnegie Mellon, MIT, and Bell Laboratories since the 1960s in order to access new technologies. This drawing presents an ecology of endless possibilities in which we are all ensnared, much like the organized networks wrought by computing culture.

Snail Pyramid,
Agnes Denes

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In 1984, the artist Richard Hamilton was invited by Thomas Jablonski of Ohio Scientific to design a state-of-the-art computer. The result was the black box DIAB DS-101. Hamilton designed both the exterior hardware of the computer and the UNIX operating system that runs it. In the 1950s, Hamilton was a member of the London-based Independent Group (which also included the artist Eduardo Paolozzi, whose work is on view in this exhibition), known for its focus on mass culture, new technologies, and postwar economics. In many ways, Hamilton's computer represents the apotheosis of new technologies and their significance to his generation of artists.

DIAB DS-101,
Richard Hamilton

In the 1980s, the Massachusetts Institute of Technology (MIT) invited Friedlander to make a series of photographs on the theme of technology. He photographed office workers gazing at their computers from the vantage of the object itself, inverting the relationship between the viewer and screen. Friedlander also documented factory workers at the Cray Company in Chippewa Falls, Wisconsin, which manufactured large-scale supercomputers. His observations of work and computation coincided with the transformation of industrial society by the proliferation of small-scale computer technology. As work throughout the United States was increasingly mediated by the computer, new paradigms for labor arose whose effects are increasingly felt today.

Lee Friedlander,
Boston,
Massachusetts and
Chippewa Falls,
Wisconsin

Text and Commentary is one of the earliest multichannel video installations. The five channels show Korot weaving on a loom; the resulting textiles can be seen directly across from the monitors. The installation is bracketed by Korot's drawings and pictographic scores, which served as the basis for the production of the textiles and the editing of the videos. Korot recognized that the loom was an early form of computing and communications technology. The tradition of weaving, according to Korot, with its transmission of spatial codes and patterns across generations, achieved the storage and distribution of information to which the computer aspired.

Historically, the Jacquard loom used punch cards to control its operations and has been recognized as an important precursor to computing technology. At different times in history, weaving and computing have been considered women's work. Korot examines these forms of labor from a feminist viewpoint, affirming their social significance in an installation that encompasses design, computing technology, and, crucially, the then-new medium of video and its attendant feedback systems.

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Text and Commentary, Beryl Korot