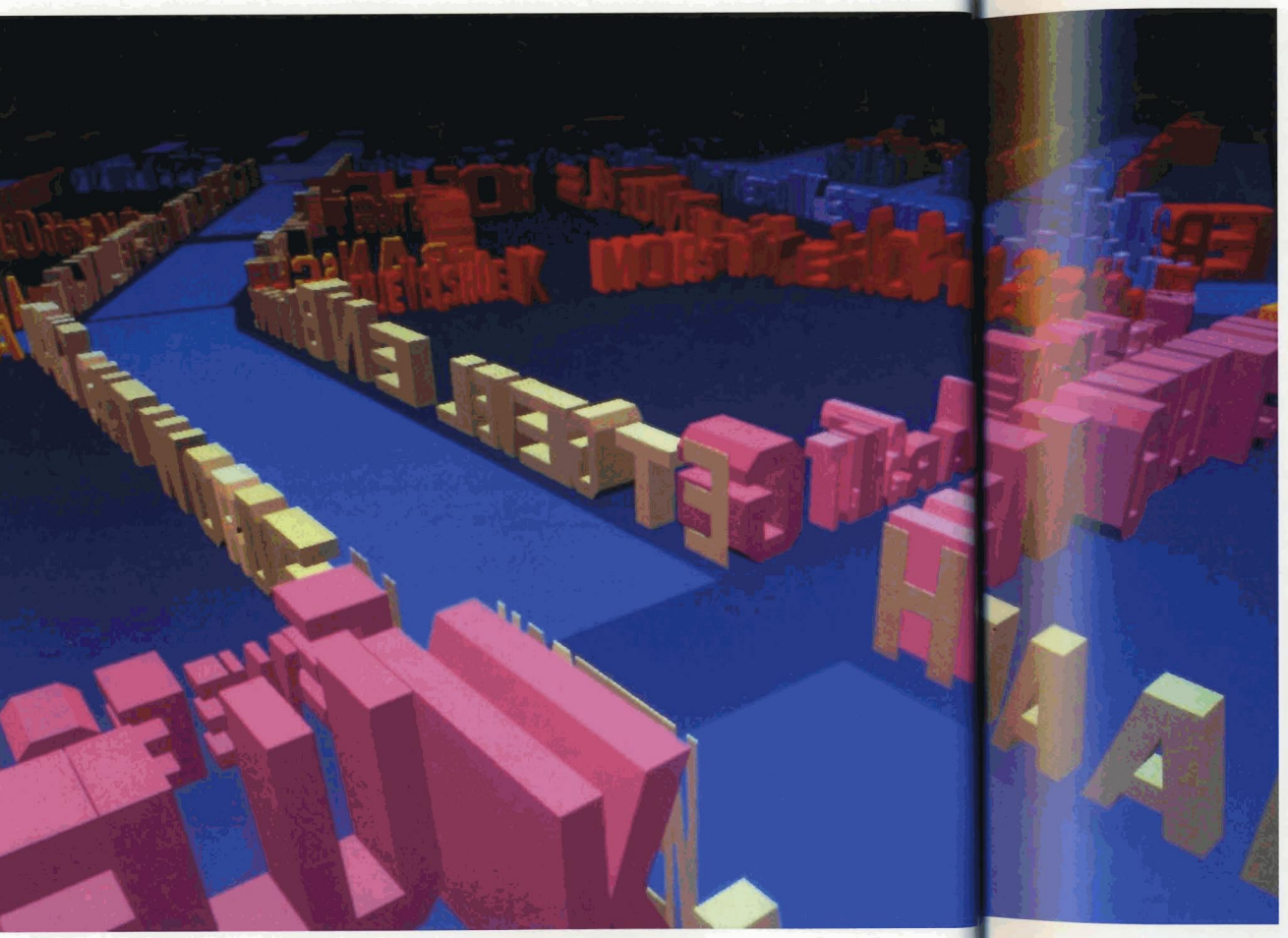


2. **Jeffrey Shaw**, *The Legible City (Amsterdam)*, 1990

Introduction

The 1990s witnessed a technological development of unprecedented speed for the digital medium – the so-called 'digital revolution'. Even though the foundations of many digital technologies had been laid up to sixty years earlier, these technologies became seemingly ubiquitous during the last decade of the twentieth century: hardware and software became more refined and affordable, and the advent of the World Wide Web in the mid-1990s added a layer of 'global connectivity'. Artists have always been among the first to reflect on the culture and technology of their time, and decades before the digital revolution had been officially proclaimed, they were experimenting with the digital medium. At first, the fruits of their labours were mostly exhibited at conferences, festivals, and symposia devoted to technology or electronic media, and were considered peripheral, at best, to the mainstream art world. But by the end of the century, 'digital art' had become an established term, and museums and galleries around the world had started to collect and organize major exhibitions of digital work.

The terminology for technological art forms has always been extremely fluid and what is now known as digital art has undergone several name changes since it first emerged: once referred to as 'computer art' (since the 1970s) and then 'multimedia art', digital art now takes its place under the umbrella term 'new media art', which at the end of the twentieth century was used mostly for film and video, as well as sound art and other hybrid forms. The qualifier of choice here – 'new' – points to the fleeting nature of the terminology. But the claim of novelty also begs the question, what exactly is supposed to be considered 'new' about the digital medium? Some of the concepts explored in digital art date back almost a century, and many others have been previously addressed in various 'traditional' arts. What is in fact new is that digital technology has now reached such a stage of development that it offers entirely new possibilities for the creation and experience of art. Some of these possibilities will be outlined here.

The term 'digital art' has itself become an umbrella for such a broad range of artistic works and practices that it does not describe one unified set of aesthetics. This book will provide a

survey of the multiple forms of digital art, the basic characteristics of their aesthetic language, and their technological and art-historical evolution. One of the basic but crucial distinctions made here is that between art that uses digital technologies as a *tool* for the creation of traditional art objects – such as a photograph, print, sculpture, or music – and art that employs these technologies as its very own *medium*, being produced, stored, and presented exclusively in the digital format and making use of its interactive or participatory features. While both of these kinds of art share some of the inherent characteristics of digital technology, they are often distinctly different in their manifestations and aesthetics. These two broad categories are not meant as a definitive classification but rather as a preliminary diagram of a territory that is by its nature extremely hybrid. While definitions and categories may be helpful in identifying certain distinguishing characteristics of a medium, they can also be dangerous in setting up predefined limits for approaching and understanding an art form, particularly when it is still constantly evolving, as is the case with digital art. While this book tries to be as inclusive as possible when it comes to the various manifestations of digital art and the ways in which they expand and challenge artistic practice, it still presents only a small selection of the broad range of digital work that has been created. Many of the forms and themes of digital art outlined in the following pages could easily be subjects of entire books of their own.

A short history of technology and art

For obvious reasons, the history of digital art has been shaped as much by the history of science and technology as by art-historical influences. The technological history of digital art is inextricably linked to the military-industrial complex and to research centres, as well as to consumer culture and its associated technologies (a fact that plays a prominent role in many of the artworks discussed in this book). Computers were essentially 'born' in an academic and research environment, and still today research universities and centres play a major role in the production of some forms of digital art.

In 1945, *Atlantic Monthly* published the article 'As We May Think' by army scientist Vannevar Bush, an essay that had a profound influence on the history of computing. The article described a device called the Memex, a desk with translucent screens that would allow users to browse documents and create their own trail through a body of documentation. Bush envisioned that the Memex's contents – books, periodicals, images – could be purchased on microfilm, ready for insertion, and that there would also be possibilities for direct data entry by the user. The Memex was never built, but it can be seen as a conceptual ancestor to the potential of electronically linked materials and, ultimately, to the Internet as a huge, globally accessible, linked database. It was essentially an analogue device, but in 1946, the University of Pennsylvania presented the world's first digital computer, known as ENIAC (Electronic Numerical Integrator and Computer), which took up the space of a whole room; and 1951 saw the patenting of the first commercially available digital computer, UNIVAC, which was capable of processing numerical as well as textual data. The 1940s also marked the beginnings of the science of 'cybernetics' (from the Greek term *kybernetes*, meaning 'governor' or 'steersman'). American mathematician Norbert Wiener (1894–1964) coined the term for the comparative study of different communication and control systems, such as the computer and the human brain. Wiener's theories formed the basis for an understanding of the so-called man–machine symbiosis, a concept later explored by a number of digital artists.

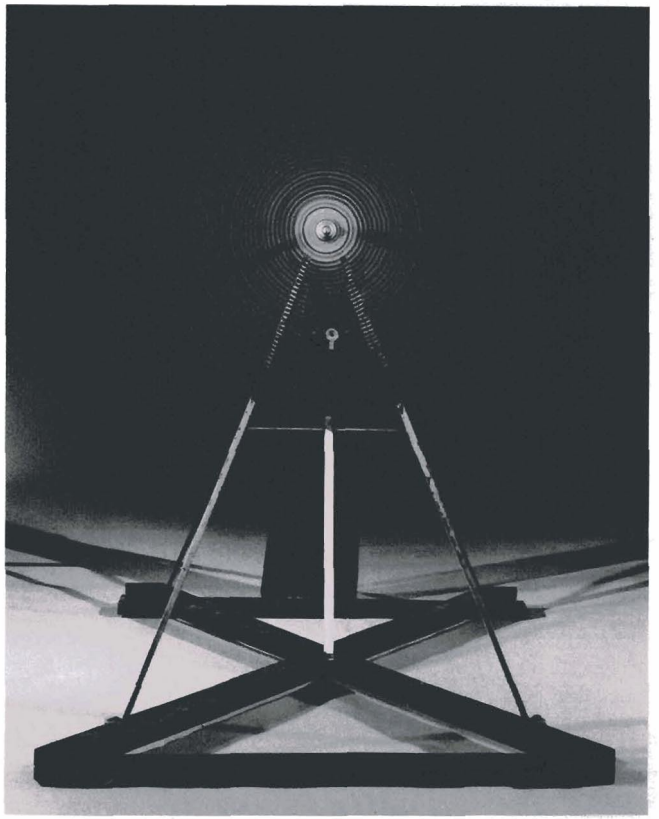
The 1960s turned out to be a particularly important decade for the history of digital technologies – a time when the groundwork for much of today's technology and its artistic exploration

3. **UNIVAC**, date unknown. The UNIVAC (Universal Automatic Computer) was used successfully to predict that Dwight D. Eisenhower would win the 1952 US presidential election.

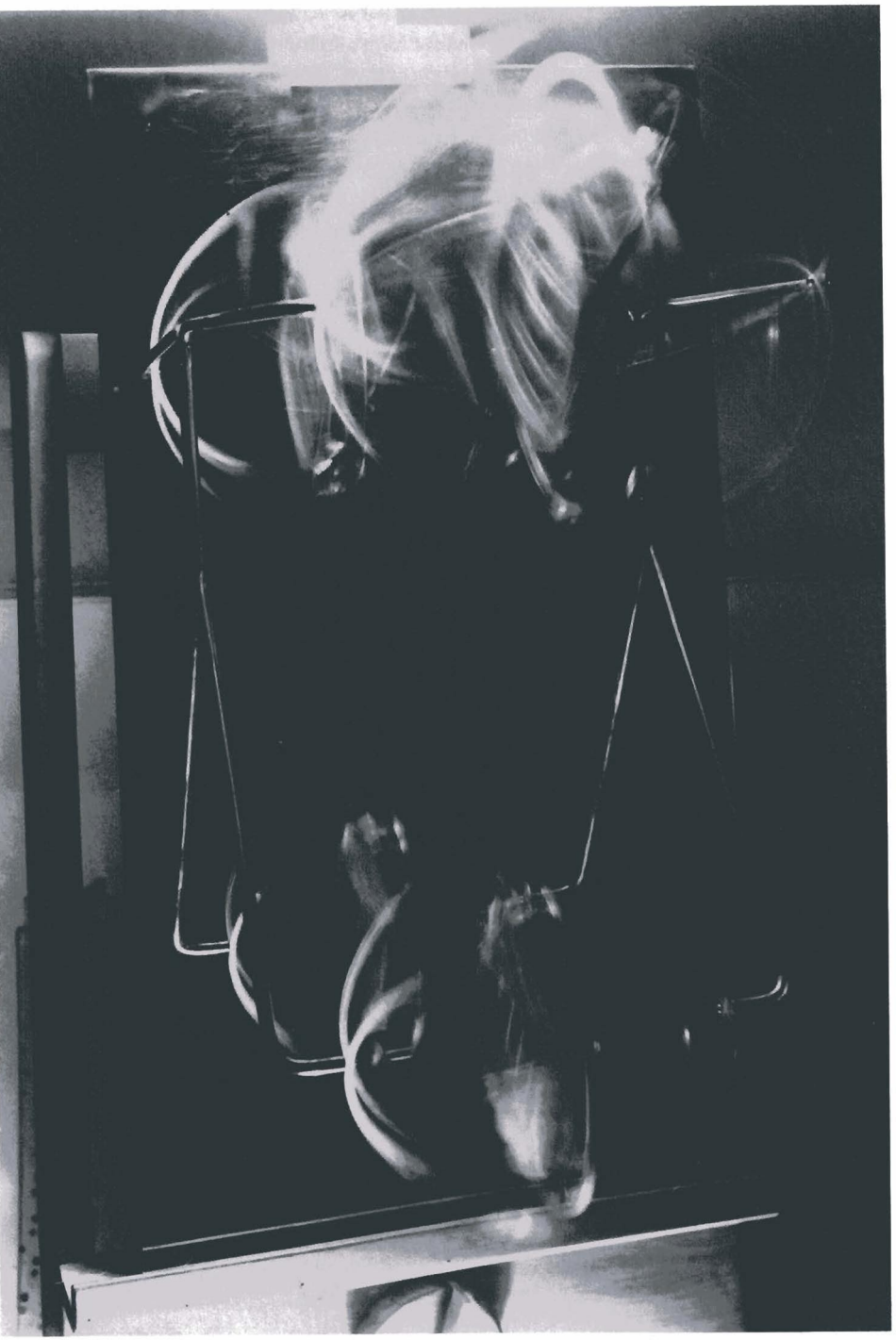
was laid. Vannevar Bush's basic ideas were carried to a further level by American Theodor Nelson who, in 1961, created the words 'hypertext' and 'hypermedia' for a space of writing and reading where texts, images, and sounds could be electronically interconnected and linked by anyone contributing to a networked 'docuverse'. Nelson's hyperlinked environment was branching and nonlinear, allowing readers/writers to choose their own path through the information. His concepts obviously anticipated the networked transfer of files and messages over the Internet, which originated around the same time (and, indeed, the World Wide Web as a global network of linked webpages, which was developed in the 1990s). Earlier, in 1957, the USSR's launch of Sputnik at the height of the Cold War had prompted the United States to create the Advanced Research Projects Agency (ARPA) within the Department of Defense in order to maintain a leading position in technology. In 1964, the RAND corporation, the foremost Cold War think-tank, developed a proposal for ARPA that conceptualized the Internet as a communication network without central authority that would be safe from a nuclear attack. By 1969, the infant network – named ARPANET, after its Pentagon sponsor – was formed by four of the 'supercomputers' of the time: at the University of California at Los Angeles, the University of California at Santa Barbara, the Stanford Research Institute, and the University of Utah.

The end of the decade saw the birth of yet another important concept in computer technology and culture: the information space and 'interface'. In late 1968, Douglas Engelbart from the Stanford Research Institute introduced the ideas of bitmapping, windows, and direct manipulation through a mouse. His concept of bitmapping was groundbreaking in that it established a connection between the electrons floating through a computer's processor and an image on the computer screen. A computer processes in pulses of electricity that manifest themselves in either an 'on' or 'off' state, commonly referred to as the binaries 'one' and 'zero'. In bitmapping, each pixel of the computer screen is assigned to small units of the computer's memory, bits, which can also manifest themselves as 'on' or 'off' and be described as 'zero' or 'one'. The computer screen could thus be imagined as a grid of pixels that are either on or off, lit up or dark, and that create a two-dimensional space. The direct manipulation of this space by pointing or dragging was made possible by Engelbart's invention of the mouse, the extension of the user's hand into dataspace. The basic concepts of Engelbart and his colleague Ivan Sutherland were further developed in the 1970s by Alan Kay and a team of researchers at Xerox PARC in Palo Alto, California, and resulted in the creation of the Graphic User Interface (GUI) and the 'desktop' metaphor with its layered 'windows' on the screen. The desktop metaphor would finally be popularized by Apple's Macintosh, 'the computer for the rest of us', as it was marketed by its creators in 1983.

Digital art did not develop in an art-historical vacuum either, but has strong connections to previous art movements, among them Dada, Fluxus, and conceptual art. The importance of these movements for digital art resides in their emphasis on formal instructions and in their focus on concept, event, and audience participation, as opposed to unified material objects. Dadaist poetry aestheticized the construction of poems out of random variations of words and lines, using formal instructions to create an artifice that resulted from an interplay of randomness and control. This idea of rules being a process for creating art has a



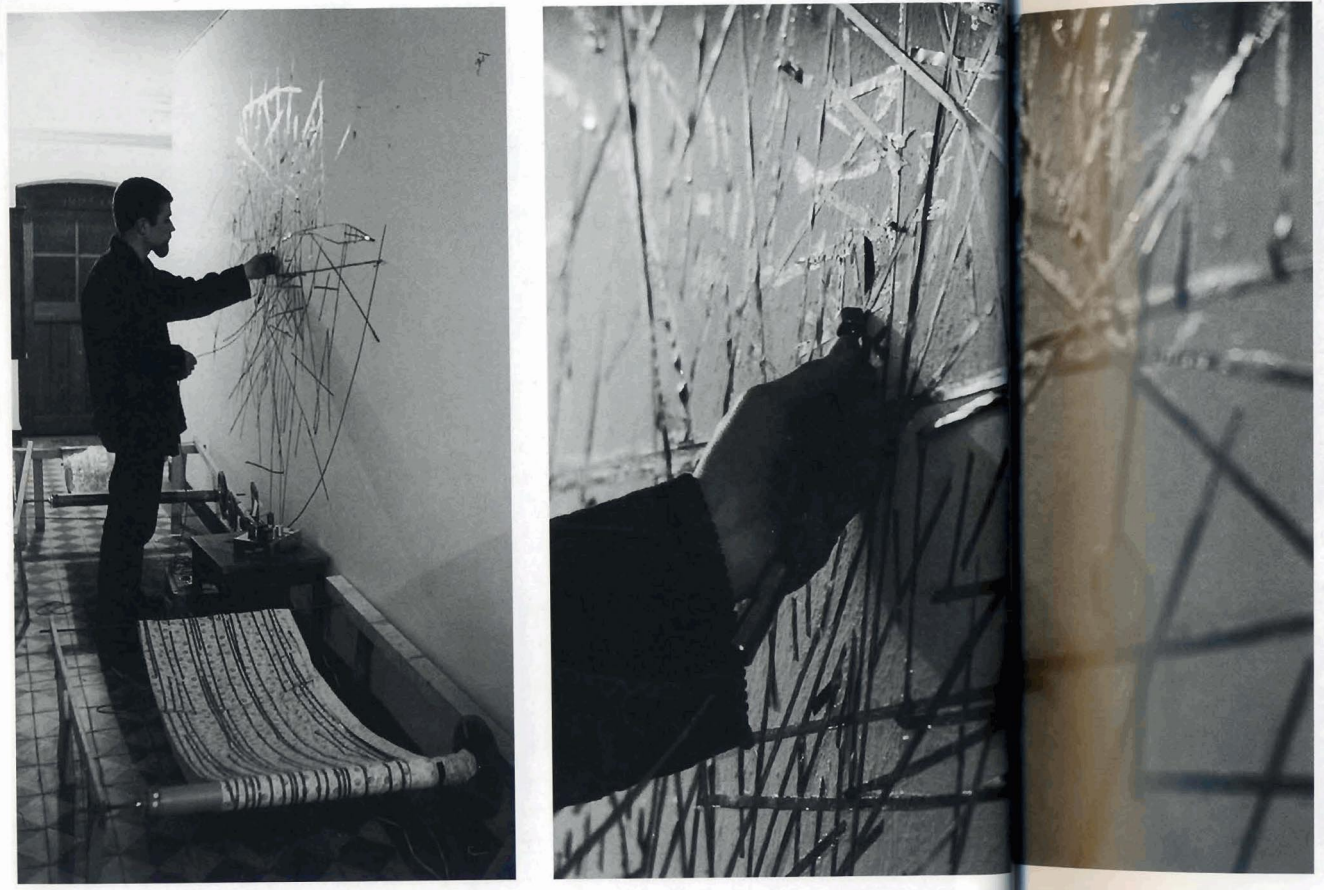
4. **Marcel Duchamp**, *Rotary Glass Plates (Precision Optics [in motion])*, 1920. Duchamp's rotating device was an early example of interactive art. It requires the viewer to turn on the machine and stand at a distance of one metre.



5. **László Moholy-Nagy**, *Kinetic sculpture moving*, c. 1933

clear connection with the algorithms that form the basis of all software and every computer operation: a procedure of formal instructions that accomplish a 'result' in a finite number of steps. Just as with Dadaist poetry, the basis of any form of computer art is the instruction as a conceptual element. The notions of interaction and 'virtuality' in art were also explored early on by artists such as Marcel Duchamp and László Moholy-Nagy in relation to objects and their optical effects. Duchamp's *Rotary Glass Plates (Precision Optics)*, created in 1920 with Man Ray, consisted of an optical machine and invited users to turn on the apparatus and stand at a certain distance from it in order to see the effect unfold, while the influence of Moholy-Nagy's kinetic light sculptures and his idea of virtual volumes – 'the outline or trajectory presented by an object in motion' – can be traced in numerous digital installations. Duchamp's work, in particular, has been extremely influential in the realm of digital art: the shift from object to concept embodied in many of his works can be seen as a predecessor of the 'virtual object' as a structure in process, and his readymades connect with the appropriation and manipulation of 'found' (copied) images that play a dominant role in many digital artworks. Duchamp himself described his work *L.H.O.O.Q.* (1919), a reproduction of the *Mona Lisa* on which he drew a moustache and goatee, as 'a combination readymade and iconoclastic dadaism'. The combinatorial and strict rule-based processes of Dadaist poetry also resurfaced in the works of OULIPO (Ouvroir de Littérature Potentielle), the French literary and artistic association founded in 1960 by Raymond Queneau and François Le Lionnais, who argued that all creative inspiration should be subject to calculation and become an intellectual game, and whose experimental concepts of combination compare to the reconfiguration of media elements in many later computer-generated environments.

The events and happenings of the international Fluxus group of artists, musicians, and performers in the 1960s were also often based on the execution of precise instructions. Their fusion of audience participation and event as the smallest unit of a situation in many ways anticipated the interactive, event-based nature of some computer artworks. The concepts of the 'found' element and instructions in relation to randomness also formed the basis of the musical compositions of vanguard American composer John Cage, whose work in the 1950s and '60s is most relevant to a history of digital art, and in many ways anticipated numerous experiments in interactive art. Cage described structure in music

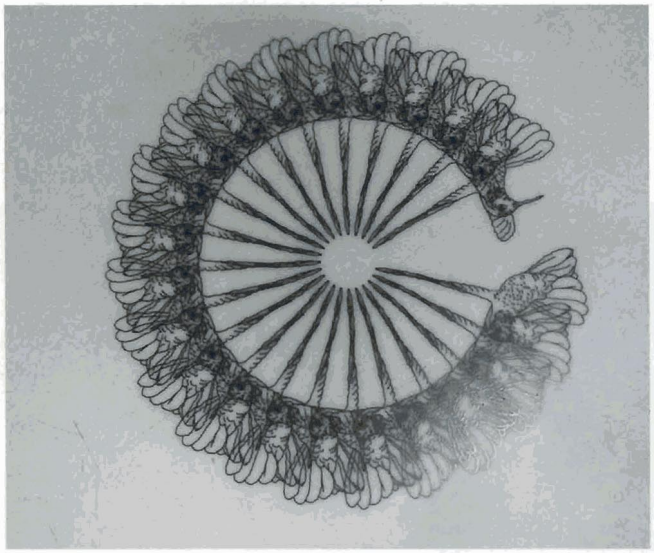


6. **Nam June Paik**,
Random Access, 1963

as 'its divisibility into successive parts', and often filled the predefined structural parts of his compositions with found, pre-existing sounds. Not surprisingly, Cage was an admirer of Duchamp's and paid homage to him in several of his pieces.

The element of a 'controlled randomness' that emerges in Dada, OULIPO, and the works of Duchamp and Cage points to one of the basic principles and most common paradigms of the digital medium: the concept of random access as a basis for processing and assembling information. American digital artist Grahame Weinbren has stated that 'the digital revolution is a revolution of random access' – a revolution based on the possibilities of instant access to media elements that can be reshuffled in seemingly infinite combinations. Korean artist Nam June Paik had anticipated this very idea in his 1963 installation *Random Access*, in which he stuck more than fifty strips of audio tape to a wall and asked users to 'play' the segments by means of a playback head that Paik had taken out of a reel-to-reel tape deck and wired to a pair of speakers.

Computers were used for the creation of artworks as early as the 1960s. Michael A. Noll, a researcher at Bell Laboratories in New Jersey, created some of the earliest computer-generated images – among them *Gaussian Quadratic* (1963) – which were exhibited in 1965 as part of the exhibition 'Computer-Generated Pictures' at the Howard Wise Gallery in New York. Bela Julesz, whose work was also included in the exhibition, and the Germans Georg Nees and Frieder Nake, were among the other early practitioners of the medium. Although their works resembled abstract drawings and seemingly replicated aesthetic forms of expression that were very familiar from traditional media, they captured essential aesthetics of the digital medium in outlining the basic mathematical functions that drive any process of 'digital drawing'. The works of John Whitney, Charles Csuri, and Vera Molnar in the 1960s remain influential today for their investigations of the computer-generated transformations of visuals through mathematical functions. Whitney (1917–96), widely considered 'the father of computer graphics', used old analogue military computing equipment to create his short film *Catalog* (1961), a catalogue of the effects he had been working on for years. Whitney's later films *Permutations* (1967) and *Arabesque* (1975) secured his reputation as a pioneer of computer filmmaking. Whitney also collaborated with his brother James (1922–82), a painter, on several experimental films. Csuri, whose film *Hummingbird* (1967) is a landmark of computer-generated



7. **Charles Csuri**, *Hummingbird*, 1967. This sequence, *22 Birds in a Circle*, was also produced as a print on plotter paper and silkscreened onto plexiglas.

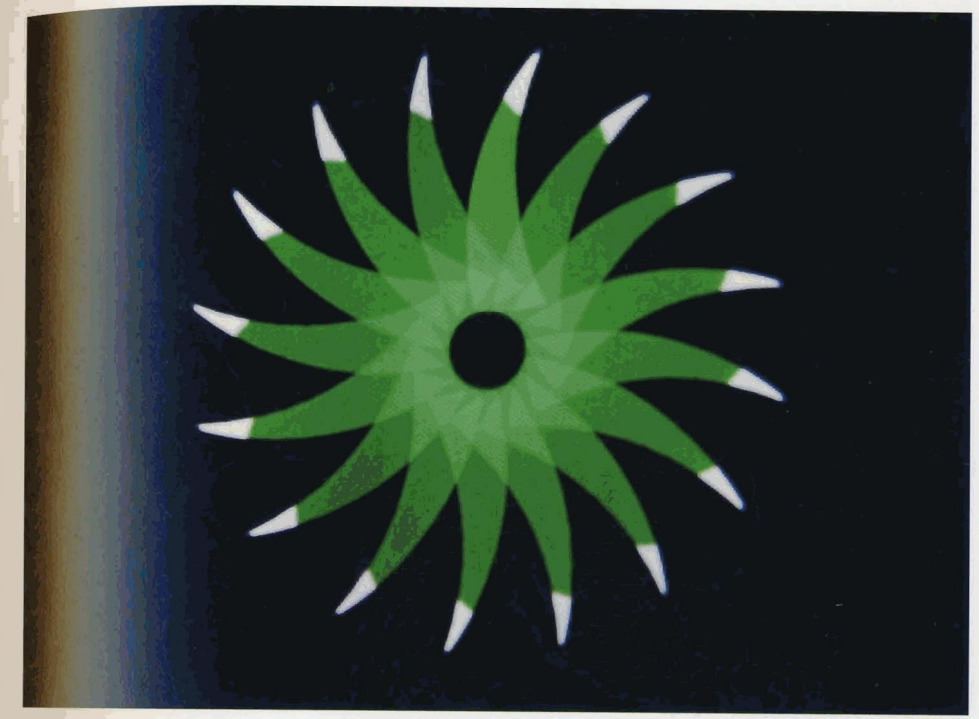
'animation', began creating his first digital images in 1964 with an IBM 7094 computer. The output of the IBM 7094 consisted of 4 × 7 inch 'punch cards' with holes, which contained information for driving a drum plotter, specifying when to pick the pen up, move it, and put it down, as well as when the end of a line had been reached, and so on.

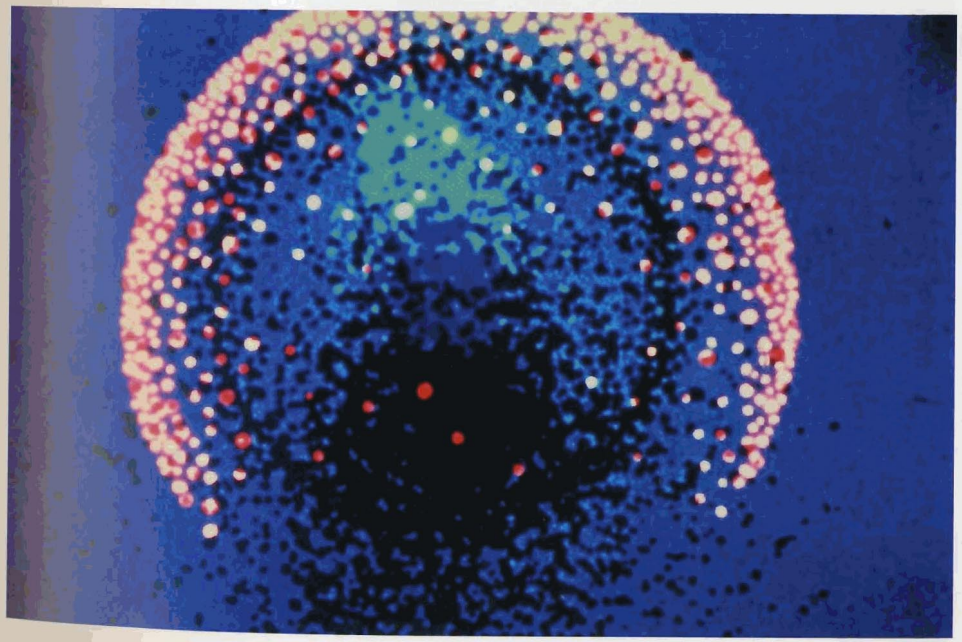
As the industrial age made its transition into the electronic era, artists became increasingly interested in the intersections between art and technology. In 1966, Billy Klüver founded Experiments in Art and Technology (EAT), which – in Klüver's words – was formed out of a desire to 'develop an effective collaboration between engineer and artist'. The joint projects that were developed over a decade between Klüver and artists such as Andy Warhol, Robert Rauschenberg, Jean Tinguely, John Cage, and Jasper Johns were first seen in performances in New York and lastly at the Pepsi-Cola pavilion at the World Expo '70 in Osaka, Japan. EAT was a first instance of the complex collaboration between artists, engineers, programmers, researchers, and scientists that would become a characteristic of digital art. Notably, EAT also received creative support from Bell Labs, which became a greenhouse for artistic experimentation.

Predecessors of today's digital installations were also first exhibited in the 1960s. In 1968, the exhibition 'Cybernetic Serendipity' at the Institute of Contemporary Arts in London presented works – ranging from plotter graphics to light and

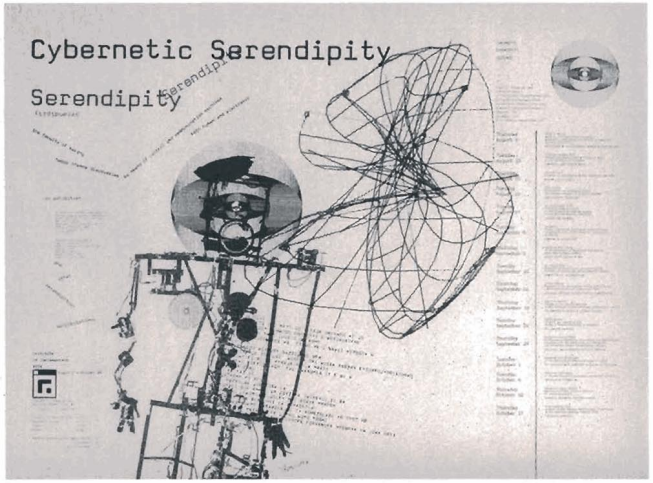
8. (opposite, top) **John Whitney**, *Catalog*, 1961. Whitney's computer was a twelve-foot-high device that could process only pre-existing information. Images had to have been already drawn, photographed, and pasted together before the computer could perform its operations. The result was a seven-minute-long collection of computer graphic effects.

9. (opposite, bottom) **James Whitney**, *Yantra*, 1957. Influenced by psychologist Carl Jung's writings on alchemy, *Yantra*, which takes its name from a creation myth, was an attempt to depict visually a unity of cosmic and psychic states. The film consists of hand-drawn animation, rephotographed on an optical printer.





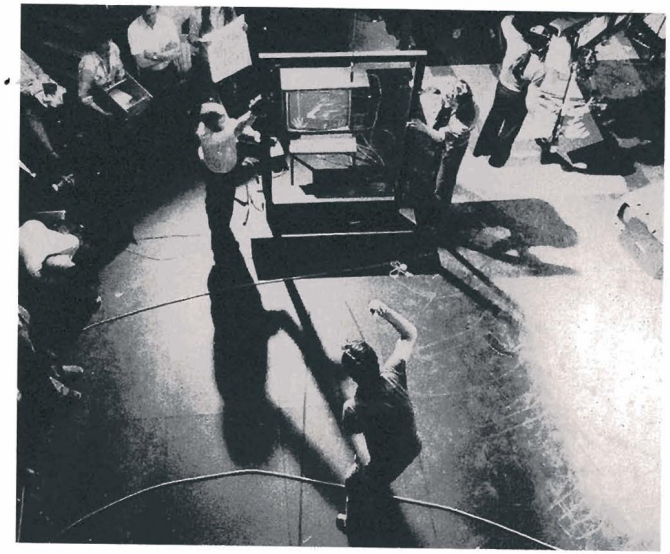
10. Exhibition poster for 'Cybernetic Serendipity', 1968

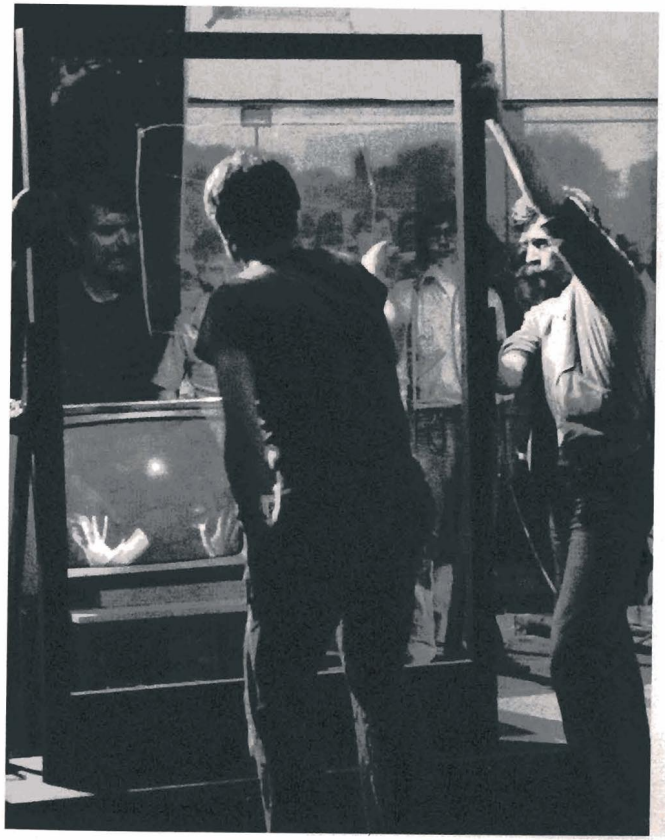


sound 'environments' and sensing 'robots' – that now seem only like the humble origins of digital art (and could be criticized for their clunkiness and overly technical approaches), but which nonetheless anticipated many of the important characteristics of the medium today. Some works focused on the aesthetics of machines and transformation, such as painting machines and pattern or poetry generators. Others were dynamic and process-oriented, exploring possibilities of interaction and the 'open' system as a post-object. In his articles 'Systems Aesthetics' and 'Real Time Systems' (published in *Artforum* in 1968 and 1969, respectively), American art historian and critic Jack Burnham explored a 'systems approach' to art: 'A systems viewpoint is focused on the creation of stable, on-going relationships between organic and non-organic systems.' In modified form, this approach to art as a system still holds a noticeable position in today's critical discourse on digital art. In 1970, Burnham curated an exhibition called 'Software' at the Jewish Museum of New York, which included works such as the prototype of Theodor Nelson's hypertext system *Xanadu*.

Using 'new technology' such as video and satellites, artists in the 1970s also began to experiment with 'live performances' and networks that anticipated the interactions now taking place on the Internet and through the use of 'streaming media', the direct broadcast of video and audio. The focus of these projects ranged from the application of satellites for extending the mass dissemination of a television broadcast to the aesthetic potential of video teleconferencing and the exploration of a real-time virtual space

11. **Douglas Davis**, *The Last 9 Minutes*, 1977





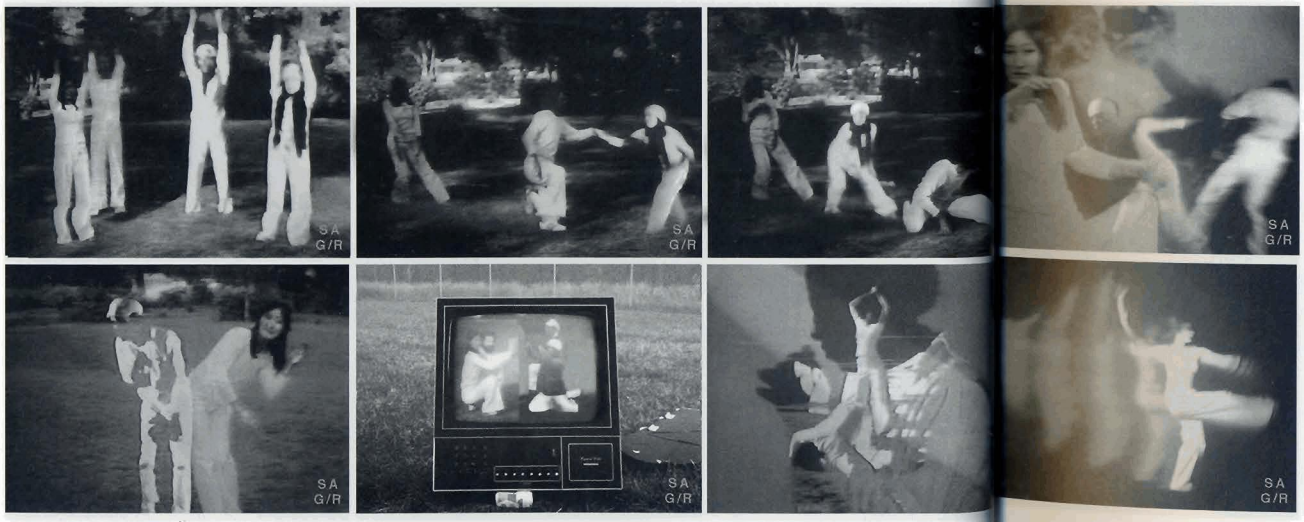
12. **Keith Sonnier and Liza Bear,** *Send/Receive Satelitte Network: Phase II*, 1977

that collapsed geographic boundaries. At the Documenta VI art show in Kassel, Germany, in 1977, Douglas Davis organized a satellite telecast to more than twenty-five countries, which included performances by Davis himself, Nam June Paik, Fluxus artist and musician Charlotte Moorman, and German artist Joseph Beuys. In the same year, a collaboration between artists in New York and San Francisco resulted in *Send/Receive Satellite Network*, a fifteen-hour, two-way, interactive satellite transmission between the two cities. Also in 1977, what became known as 'the world's first interactive satellite dance performance' – a three-location, live-feed composite performance involving performers on the Atlantic and Pacific coasts of the United States – was organized by Kit Galloway and Sherrie Rabinowitz, in conjunction with NASA and the Educational Television Center in Menlo Park, California. The project established what the creators called an 'image as place', a composite reality that immersed performers in remote places into a new form of 'virtual' space. In 1982, the Canadian artist Robert Adrian, who began working with communication technology in 1979 and created projects involving fax, slow-scan TV, and radio, organized the event *The World in 24 Hours*, in which artists in sixteen cities on three continents were connected for twenty-four hours by fax, computers, and videophone and created and exchanged 'multimedia' artworks. These performative events were early explorations of the connectivity that is an inherent characteristic of networked digital art.

Throughout the 1970s and '80s, painters, sculptors, architects, printmakers, photographers, and video and performance artists increasingly began to experiment with new computer imaging techniques. During this period, digital art evolved into multiple strands of practice, ranging from more object-oriented work to pieces that incorporated dynamic and interactive aspects and constituted a process-oriented virtual object. Expanding on the concepts of movements such as Fluxus and conceptual art, digital technologies and interactive media have challenged traditional notions of the artwork, audience, and artist. The artwork is often transformed into an open structure in process that relies on a constant flux of information and engages the viewer/participant in the way a performance might do. The public or audience becomes a participant in the work, reassembling the textual, visual, and aural components of the project. Rather than being the sole 'creator' of a work of art, the artist often plays the role of a mediator or facilitator for audiences' interaction with and

contribution to the artwork. The creation process of digital art itself frequently relies on complex collaborations between an artist and a team of programmers, engineers, scientists, and designers. (Several digital artists are also engineers by training.) Digital art has brought about work that collapses boundaries between disciplines – art, science, technology, and design – and that originates in various fields, including research-and-development labs and academia. From its history to its production and manifestation, digital art tends to defy easy categorization.

As has often been the case, concepts – and sometimes even specifics and aesthetics – of new technologies are partly shaped by science-fiction writers who create visions of a technologized world that are compelling enough to inspire their re-creation in reality. In 1984, William Gibson published his now-legendary novel *Neuromancer* and coined the term 'cyberspace' for a data world and network that people could experience as an organic informational matrix. Today's networked cyberspace is still far away from Gibson's vision, but his *Neuromancer*, as well as Neal Stephenson's novel *Snow Crash*, still informs the dream and sensibilities of the virtual spaces being built today.



13. **Kit Galloway and Sherrie Rabinowitz**, *Satellite Arts*, 1977

The presentation, collection, and preservation of digital art

Digital art made its official entry into the art world only in the late 1990s, when museums and galleries began increasingly to incorporate the art form into their shows and dedicate entire exhibitions to it. Although there had been a number of digital and media art exhibitions over the decades, and some galleries had consistently presented this art, digital-art shows in an institutional context mostly took place at media centres and museums such as NTT's Intercommunication Center (ICC) in Tokyo or the Center for Culture and Media (ZKM) in Karlsruhe, Germany. For the previous two decades, the main exhibition forums for digital art were the Ars Electronica festival (in Linz, Austria), ISEA (Inter-Society for Electronic Arts, based in Canada) and festivals such as EMAF (European Media Arts Festival, Osnabrück, Germany), DEAF (Dutch Electronic Arts Festival), Next 5 Minutes (Amsterdam, Netherlands), Transmediale (Berlin, Germany), and VIPER (Switzerland). But at the beginning of the twenty-first century, an increasing number of exhibition spaces devoted exclusively to 'new media art' has developed worldwide, from Europe to South Korea, Australia, and the United States.

Because of its characteristics, the digital medium poses a number of challenges to the traditional art world, not least in its presentation, collection, and preservation. Digital prints, photography, and sculpture are the kinds of object-oriented work for which museums are equipped, but time-based, interactive digital artworks raise numerous issues. These issues are to a large extent not medium-specific but apply to any time-based and interactive work, be it a video, a performance, or Duchamp's *Rotary Glass Plates*. However, such pieces have always been an exception rather than the rule in the mostly object-based art world. Digital art projects often require audience engagement and do not reveal their content at a glance. They are also often expensive to show and ideally require consistent maintenance. Museum buildings are mostly based on the 'white cube' model rather than being completely wired and equipped with flexible presentation systems. The success of an exhibit and the audience's appreciation of the art is invariably dependent on the effort that an institution puts into the exhibition, both in technical and educational respects.

The presentation of art created for the Internet within a public physical space tends to complicate matters even more. Internet art has been created to be seen by anyone, anywhere, anytime (provided one has access to the Net) and does not need a

museum to be presented or introduced to the public. In the online world, the physical gallery/museum context does not necessarily work as a signifier of status any longer. However, physical art spaces could nonetheless play an important role when it comes to Internet art – providing a context for the work, chronicling its developments, assisting in its preservation, as well as expanding its audience. Various models for presenting net art in an institutional context have been widely debated. Some people have argued that it should be presented only online and that 'it belongs on the Internet' – which is where it resides in any case. The question rather seems to be, should Internet access be possible in public spaces or only from home computers in a private setting? Given the more recent developments in wireless technologies and mobile devices, the Internet might soon be accessible from anywhere. However, this does not erase the fact that Internet art often requires a relatively private engagement over a longer period of time. To create an environment for the latter experience, net art has often been presented in a separate area of a public space, which in turn raises the criticism of 'ghettoization'. The set-up in a separate 'lounge area' has the advantage of inviting people to spend more time with a piece, but it prevents the art from being seen in the context of more traditional media and entering into a dialogue with them. Ultimately, the exhibition environment should be defined by what an artwork requires. As the technology keeps developing rapidly and is increasingly integrated into our daily lives, we are in all likelihood going to see new ways of interacting with and relating to digital art.

The collection (and therefore the sale) of digital art is yet another topic that has been hotly debated since the art form began to register on the radar of the art market. The value of art – at least when it comes to the traditional model – is inextricably linked to its economic value, but the 'scarcity equals value' model does not necessarily work when it comes to digital art. It is less problematic when it comes to digital installations, which ultimately are objects, or software art (which sometimes comes with its own unique custom hardware). The model of limited editions established by photography has been adopted by some digital artists whose work consists mostly of software, and this has allowed their art to enter the collections of major museums around the world. In the context of collecting, Internet art is the most problematic form since it is accessible to anyone with a network connection. Nevertheless, net art is increasingly being commissioned and collected by museums, with the source code of

the work being hosted on the respective museum's server. A major difference between this and the museum's other holdings is that the work stays on view permanently and not only when the museum decides to mount it in a gallery.

The process of collecting art also entails the responsibility of maintaining it, which may be one of the biggest challenges that digital art poses. Digital art is often referred to as ephemeral and unstable, a label that is only partially accurate. Any time-based art piece, such as a performance, is essentially ephemeral and often continues to exist after the event only in its documentation. Process-oriented digital artworks certainly are ephemeral, but digital technology also allows for enhanced possibilities of recording; the whole process of a time-based digital artwork can potentially be recorded as an archive. Bits and bytes are in fact more stable than paint, film, or videotape. As long as one has the instructions to compile the code – for example as a print-out on paper – the work itself is not lost. What makes digital art unstable are the rapid changes and developments in hardware and software, from changes in operating systems to increasing screen resolution and upgrades of Web browsers. Collecting software and hardware as it continues to be developed is obviously the least elegant solution to preservation. Two basic preservation strategies are so-called 'emulators', programs that allow one to 're-create' software or operating systems, and migration, an upgrade to the next version of hardware/software. Initiatives aimed at preserving digital art are currently being developed by governments, national and international organizations, as well as institutions. The success of these initiatives will depend largely on standardization, which requires a continuous dialogue between all the parties involved.

Digital art has made enormous developments since the early 1990s and there is no doubt that it is here to stay. The expansion of digital technologies and their impact on our lives and cultures will induce the creation of even more artworks that reflect and critically engage with this cultural phenomenon. Whether digital art will find a permanent home in museums and art institutions or exist in different contexts – supported and presented by a growing number of art-and-technology centres and research-and-development labs – remains to be seen however.