

Georg Nees, 23-Ecke (Polygons of 23 Vertices), 1965, ink on paper, 11 $\frac{1}{8}$ x 8 $\frac{1}{4}$ in. (29.7 x 21 cm) (artwork © Georg Nees).

The work was first published in *rot 19* on the occasion of the Generative Computergrafik, Stuttgart, February 1965.

A Klee painting named *Angelus Novus* shows an angel looking as though he is about to move away from something he is fixedly contemplating. His eyes are staring, his mouth is open, his wings are spread. This is how one pictures the angel of history. His face is turned toward the past. Where we perceive a chain of events, he sees one single catastrophe which keeps piling wreckage upon wreckage and hurls it in front of his feet. The angel would like to stay, awaken the dead, and make whole what has been smashed. But a storm is blowing in from Paradise; it has got caught in his wings with such violence that the angel can no longer close them. This storm irresistibly propels him into the future to which his back is turned . . .¹

Frieder Nake

The Semiotic Engine: Notes on the History of Algorithmic Images in Europe

What the angel is looking back to becomes history; it becomes history only through his looking. This compelling picture of what we take for history is by Walter Benjamin, the same Benjamin whose essay about the work of art in the age of mechanical reproduction defines one of the starting points for any attempt to understand art activities now, in the age of semiotic production. Using less poetic words, but expressing similar ideas, Marshall McLuhan pointed out that we observe history through a rear-view mirror.²

In this essay, I will apply my rear-view mirror to look at the early history of computer art, or, as I prefer to say, algorithmic images accepted as art.³ I will start by way of a story before offering a series of notes.

To Start: A Story

It is the afternoon of February 5, 1965. Artists, students, some scientists, and a few of those who go to art show openings are gathering in the seminar room on the eighth floor of Hahn-Hochhaus in Stuttgart, West Germany. This floor houses the Institute of Philosophy of the University of Stuttgart (then still the Stuttgart Institute of Technology). The institute's director, Professor Max Bense (1910–1990), is known for his critical rationalism and his great interest in art and literature. He regularly uses the seminar room for exhibitions of concrete and constructivist art and poetry, typography, and generally experimental works.

This afternoon a small collection of graphic works is shown. They are computer-generated, the announcement said—whatever that might mean: thin black lines, matrices of little figures in variation, overlapping arrangements of rectangles, geometry in a playfully random appearance. A new issue in the *rot* (Red) series on experimental theory and poetry is for sale, *rot 19*. Bense speaks. The author of the images, the mathematician Georg Nees from the Siemens company at Erlangen, explains how he has gotten his computer to draw those images. Many of the artists at the opening are baffled. They are a bit hostile. One of them gets up: "Tell me, Mr. Nees, can you make your machine draw like an artist's flow?" Nees ponders for a moment. He is a calm, patient, friendly mathematician of about thirty-five years of age. Then he says, "Yes, I can. If you can tell me precisely how to define your way of drawing." That is too much for the professors from the Academy of Fine Art. They leave, some slamming doors: "Who does he think we are?" Bense tries to calm tempers: "Please, dear friends, what you see here is only *artificial art*," he declares.⁴

1. Walter Benjamin, "Theses on the Philosophy of History, IX" (1940), in Benjamin, *Illuminations*, ed. Hannah Arendt, trans. Harry Zohn (New York: Schocken, 1969).

2. Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illuminations*, 217–52; Marshall McLuhan and Quentin Fiore, *The Medium Is the Massage* (New York: Bantam, 1967), 74–75.

3. I will use the terms "computer art," "algorithmic art," and "digital art" interchangeably.

4. This account of the situation and the words spoken are based on my memories as an eye-witness.

The Zuse Graphomat Z64 drawing machine, at the Computing Center, University of Stuttgart, 1965. The drawing area was about 4 feet square (1.2 x 1.2 m). (Photograph © the author)



What kind of art caused the philosopher Bense to suddenly propagate a split of art into natural and artificial art? What was displayed along the walls of the Studiengalerie? Why did the flock of renowned local artists react so disruptively? After all, they were known as modernist, constructivist, or Art Informel painters and graphic artists. They knew that Bense, with Abraham A. Moles, one of the founders of information aesthetics, had a preference for experimental, concrete art, which always had to fight for its acceptance and never became very popular.

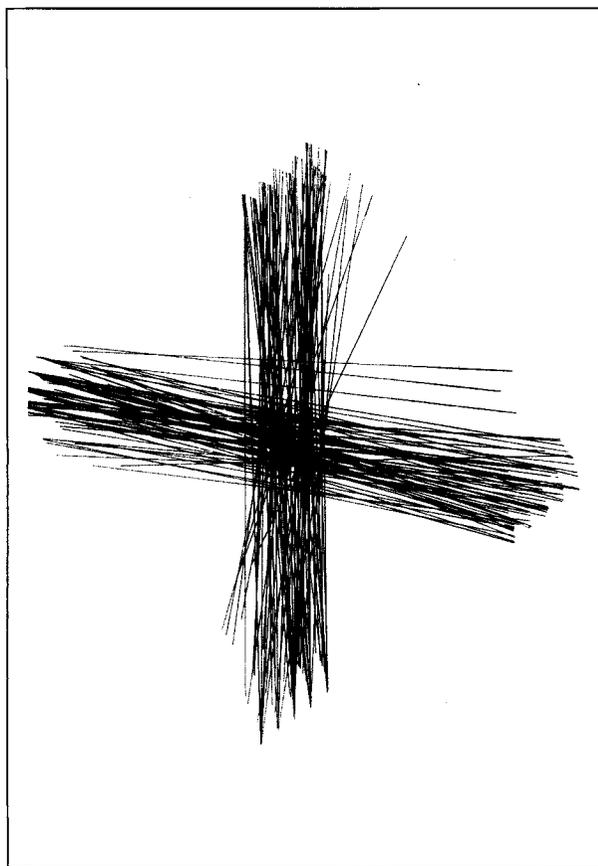
The dozen or so drawings themselves could hardly have caused the almost furious reaction. The visitors assembled for the occasion were established artists who often came to the eighth-floor seminar room; some of them had themselves exhibited their works there. They were on good terms with Bense and other members of the Stuttgart School of artists, writers, and theoreticians.

The opening would have gone as smoothly and amicably as any previous opening had it not been for a single but most sensitive detail of the situation—the questioning of one aspect of the artist's existence. It was one of the last and much-cherished redoubts: the artist's intuition and creativity. With his rescue operation, the quick invention of artificial art, Bense tried to save the situation. The term was clever and sharp, typical for this master of the unusual term. But it came too late for the occasion.

Not many scientists in the Germany of the mid-1960s held a developed understanding of research in artificial intelligence. The government supported research into this field, and there was also a controversial discourse on the possibility, or desirability, of an electronic brain. Bense may have intended to refer to this approach to computing when he used the term *artificial art*. At least implicitly, he did so. But without hesitation, he called art a set of drawings that had been produced by an automatic drawing machine controlled by a program running on a digital computer. More precisely, a flat-bed drawing machine had been controlled by a sequence of instructions stored on a paper tape, whose data had before been calculated by a computer. It was, in turn, controlled by a program that Nees had written using the programming language Algol 60.

Georg Nees, *Andreaskreuz*, 1965, ink on paper, 11¼ x 8¼ in. (29.7 x 21 cm) (artwork © Georg Nees).

The work was first published in *rot 19* on the occasion of the Generative Computergrafik, Stuttgart, February 1965.



Nees (born 1926 in Nuremberg) was working as an engineer for the Siemens Corporation at Erlangen, where he had access to a Graphomat Z64. The Graphomat was a flat-bed drawing machine of high precision, but it was rather slow. It had originally been intended for use by cartographers and others needing high-precision etchings. The Graphomat could drive a chisel or up to four pens. They could be of any variety and were filled with inks. The German inventor of the electronic computer under program control, Konrad Zuse, had constructed the device in 1963 as his last commercial product.

From the time of his youth, Nees had been interested in drawing, optical instruments, and art; looking back, he sees himself as an art lover who was never afraid of abstract art and who had an inclination to philosophy.⁵ Through lucky circumstances, he came into possession of the first seven issues of an extremely interesting scientific journal, *Grundlagenstudien aus Kybernetik und Geisteswissenschaft* (Fundamental Studies in Cybernetics and the Humanities). If there was anything like a scientific avant-garde journal, GrStKG, as it was abbreviated, was it. It had been founded in 1960 by Bense and some of his colleagues and friends, among them Gotthard Günther (1900–1984), the logician and philosopher of aspects of cybernetics. At the University of Illinois, Günther, who was living in exile, had come into contact with Heinz von Foerster (1911–2002), a physicist from Austria who had been secretary to the 1946–53 Macy Conferences on cybernetics and later became a leading mind in radical constructivism. A third founding editor of the journal was Abraham A. Moles (1920–1992), the physicist and philosopher,

5. Nees presented the story of his aesthetic life at a symposium, "Stuttgart 1960: Computer in Theorie und Kunst," on September 30, 2004, in Stuttgart. With his permission, I refer to the German text of his contribution. My thanks go to him as an exceptional engineer who became my friend. From the symposium came the remarkable volume (mostly in German) *Ästhetik als Programm: Max Bense/Daten und Streuungen*, ed. Barbara Büscher, Hans Christian von Herrmann, and Christoph Hoffmann, published as number 5 in the series *Kaleidoskopien* (Berlin, 2004).

and the other originator of information aesthetics, a bold theory that had some influence on early European computer art.⁶

Though the journal gained only a small group of readers, we should be aware of what GrStKG proclaimed, for it approached the common foundations, as its title said, of both cybernetics and the humanities. This conjunction was a remarkable sign of the prevailing intellectual atmosphere, although general comprehension of some of the more formal publications may have been severely limited. By 1959, when Charles P. Snow delivered his famous “Two Cultures” lecture and essay, the people in Stuttgart had already begun to tackle problems of aesthetics by using Norbert Wiener’s theory of control in animals and machines and Claude E. Shannon’s 1937 reduced theory of information.⁷ Wiener had proposed that feedback loops were enough to model and control the behavior of technical systems. The output of the system was compared to a control variable and fed back to the input to influence further operation.

Shannon’s theory, which became popular immediately after World War II, is a formal theory of a quantitative entity he called information, where information content was a measure of the degree of unpredictability of a statistical message: in any sequence of signals, the less predictable the next signal in the sequence, the higher the message’s information content.

The first axiom of information aesthetics, then, was that the work of art is a complex sign in time or space. As such, its information content could become the basic ingredient for other measures. The intention was to establish an objective aesthetics of measure, as opposed to a subjective aesthetics of value.

In 1963 or 1964, Nees came in touch with a newly acquired Graphomat, which was used at Siemens to test-draw the movements of tools on numerically controlled machines. Given his broader interest, it became clear to Nees that he could use (or misuse) the machine for aesthetic purposes. In the fall of 1964 he generated his first three abstract drawings and submitted them to GrStKG. He called them *Statistische Graphik* (probabilistic graphics), a title by which he aimed to protect his engineering reputation.⁸ When he observed the machine generate the first drawings he had programmed, Nees told himself, “Here something is emerging that will not again disappear.”⁹

Note 1: On Manifestos

Issue 19 of the now-legendary publication *rot* contained six of Nees’s computer drawings. *rot* was a series of small, square booklets on semiotics, concrete poetry, information aesthetics, text analysis, and typography. In it the editors, Bense and Elisabeth Walther, published almost exclusively authors of the Stuttgart School, a loose and informal set of artists, writers, theoreticians, architects, and composers whose only common bond was the theory of information aesthetics. For *rot* 19, Bense contributed a text of three pages, “Projekte generativer Ästhetik” (Projects of Generative Aesthetics), which, in retrospect, must be considered the first manifesto of computer art.

The style is not manifesto-like at all. The crisp and sharp language is between writing about mathematics and philosophy. Its statements are declarative. It does not argue, nor does it condemn. It is not easy to understand. It introduces a terminology as a possible way to distinguish generative aesthetics from

6. It may not be a pure coincidence that Moles’s seminal book, *Information Theory and Esthetic Perception*, was translated from the French into English and published by University of Illinois Press (in 1968). It remained essentially the only source of information aesthetics in the United States. Let me add, however, that through great support by Leslie Mezei, a seminar on information aesthetics was staged at University of Toronto in 1969 (under the title “Cybernetic Serendipity”).

7. Charles P. Snow, *The Two Cultures and the Scientific Revolution* (New York: Cambridge University Press, 1959). A first article by Snow on the same subject, “The Two Cultures,” had appeared before in the *New Statesman* (October 6, 1956). But it was the lecture and book publication that led to a worldwide explosion of intellectual uproar. A new German edition of the debate was published in Stuttgart (!) in 1967 and 1969, and in paperback in 1987. Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana, IL: University of Illinois Press, 1949).

8. It is interesting to observe that A. Michael Noll at Bell Labs occasionally spoke of similar hesitation. Industry people, even when working in research labs, at times had to take precautions of a kind that academia would consider odd and unacceptable. Two short notes by Georg Nees appeared in *Grundlagenstudien aus Kybernetik und Geisteswissenschaft* 5 (December 1964): 67–68 and 121–25. They are in terse, technical language, describing only the programming. Anything that could come close to the idea of art is carefully avoided.

9. Georg Nees, talk at the symposium “Stuttgart 1960,” my translation from the manuscript.

analytic aesthetics. Many art movements of the twentieth century have had manifestos as their points of departure. It would be surprising, therefore, if computer art did not. Looking back, it appears essential to observe that what computer art introduced into the world of art is the algorithmic principle.¹⁰ This principle lies at the heart of Bense's 1965 declaration in rot 19.

Note 2: On Engineers and Artists

It is generally argued that the first people who had access to computers in the mid-1960s and used this privilege to generate images (drawings, sculptures, and animations) were not professional artists. They were *only* engineers or mathematicians. An accurate observation—but why does it get repeated so often, with a slightly derogatory tone? The way authors identify the early pioneers of algorithmic art as mathematicians and engineers seems to imply that their productions can hardly be accepted by the art world, and that this is so *because* of the pioneers' professional backgrounds.

Whereas the first implication may or may not be so, depending on personal taste and art history background, the second implication is ridiculous. Quite the opposite should be the case: although these adventurers did not have a formal background in the arts, they were daring enough to leave behind their everyday occupation, perhaps in a subversive way, to try out something nobody else was trying.

The Bauhaus had called for artists to closely collaborate with craftspeople, though soon enough, practice separated famous names (of artists) from unknown helpers in the workshops. We can observe similar attitudes and behaviors in later instances. The names of artists who thought up devices and processes for the *Nine Evenings: Theatre and Engineering* event of Experiments in Art and Technology (E.A.T.) in New York in 1966 are still known—but not necessarily those of the engineers who helped those ideas materialize. Some names of programmers who assisted artists in realizing their design ideas got mentioned for a while and later dropped. I myself have experienced difficulties with friendly museum people when I told them that an exhibition installation must be identified as the result of cooperation by several of us, artist and programmers. The world of art is only reluctantly accepting the fact that innovative design is *not* a one-artist affair.

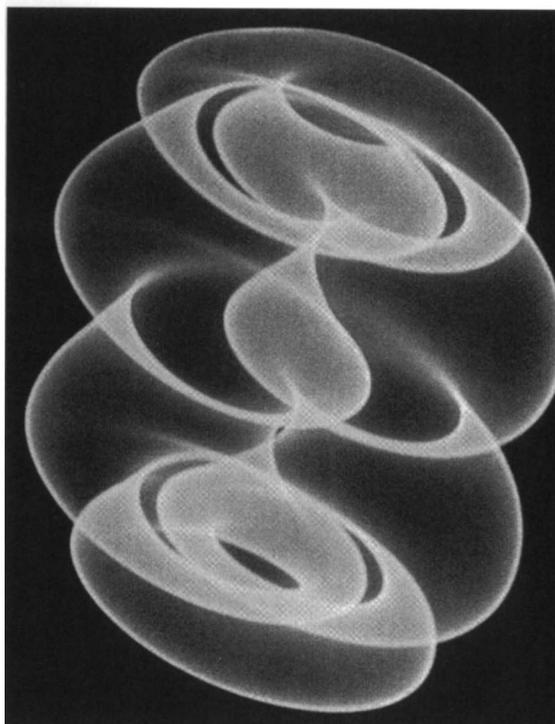
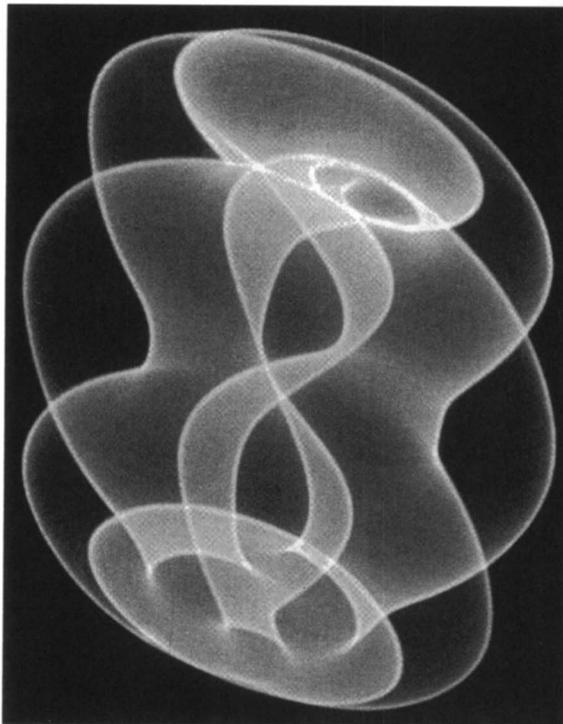
Note 3: Four Principles

It is tempting to identify a phenomenon by unique principles to emphasize its new and original character. I do not share the obsession for novelty. In science you become modest when you think of your own small contribution.

Nevertheless, historical continuity is one aspect of our way of dealing with the world; systematic differentiation is another. If we characterize computer art by a set of four principles, the claim is not that these appear in computer art and nowhere else—such a statement would be preposterous. But the following four principles and their combined importance do not bear equal weight in all cases. We may—today more decidedly than forty years ago—characterize digital art by these four principles: algorithmics, randomness, semiotics, and interactivity.

The principles of algorithmics and randomness are closely related.

10. A most successful exhibition at the Zentrum für Kunst und Medientechnologie (ZKM, Center for Art and Media) in Karlsruhe, Germany, opened in 2004: *The Algorithmic Revolution: On the History of Interactive Art* (October 30, 2004–January 31, 2008) connected computers, constructivist art, Op art, algorithmic art, the work of Marcel Duchamp, and contemporary interactive art.



Herbert W. Franke, two works from the series *Elektronische Grafik*, 1962, black-and-white photographs from analogue monitor screen, $13\frac{3}{4} \times 10\frac{3}{4}$ in. (34×27 cm), and $22\frac{1}{2} \times 17$ in. (57×43 cm). Kunsthalle Bremen (artwork © Herbert W. Franke)

Algorithmics is beyond any doubt: Nothing can happen on a computer if no algorithm is involved. Even when so-called end users are far from thinking in algorithms, they must use pieces of programs, each of which is in the peculiar form an algorithm must take to run on a computer. Software is used like a mosaic from which we choose little precious stones. But each one derives its identity from its performance of one particular, minuscule, algorithmic step.

The algorithmic principle requires and allows us to sit at a distance and think of an entire class of works. We are not so much occupied with a particular and unique work that we see in front of us as a material substrate as we are interested in the abstract description of all possible members of a class of objects. So digital art is art from a distance. It is painting with your brain. If photography liberated art from representing visible aspects of reality, algorithmics liberates art from carrying out the work. It is now enough to describe it. Once described, entire series can be generated.

The principle of randomness says that the artist is free to introduce into the algorithmic description of a class of works any number of random decisions. Within a class of works, each individual work is identified by a set of parameters. If such a parameter is fixed, it does not really function as a parameter. If it is not fixed, it may vary in a systematic but also probabilistic way. The randomness principle prefers the random parameter: its feasible values are determined within the limits of a probability distribution.

The most general principle is that of semiotics. Briefly, it considers the work as a sign. To be a sign, it must be corporeal in the first place. But a work taken as material alone would never become a work of art; only its functioning in semi-oses—sign processes—opens up the possibility of its becoming a work of art (by acts of interpretation). This condition leaves the materiality of the work behind

without denying it. Such statements are, of course, true for all of art, but in the case of digital art, the sign turns out to be of a special kind—a point to which I will return.

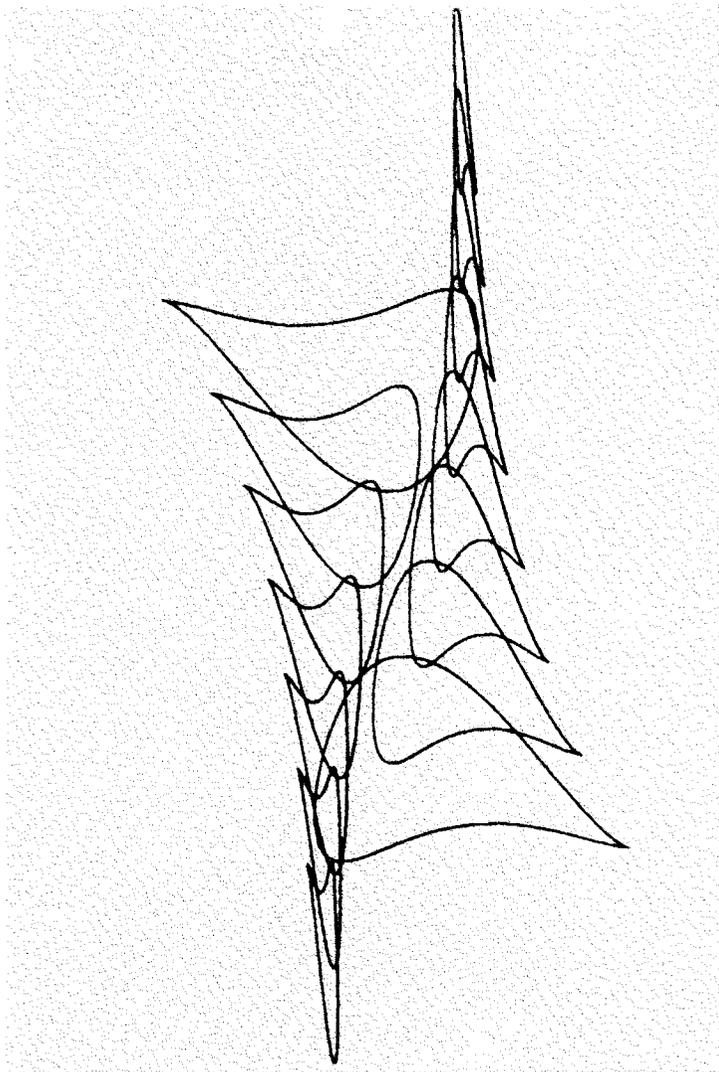
Finally, digital art is experimental by nature. The experiment here appears as more than a method to derive a result (the work). The experiment has a tendency to become part of the work. This shows in the participatory nature of many of the artifacts, which, in our context, is better called interaction. The principle of interactivity is so important that I reserve an extra note for it below.

Note 4: On Some Persons and Events

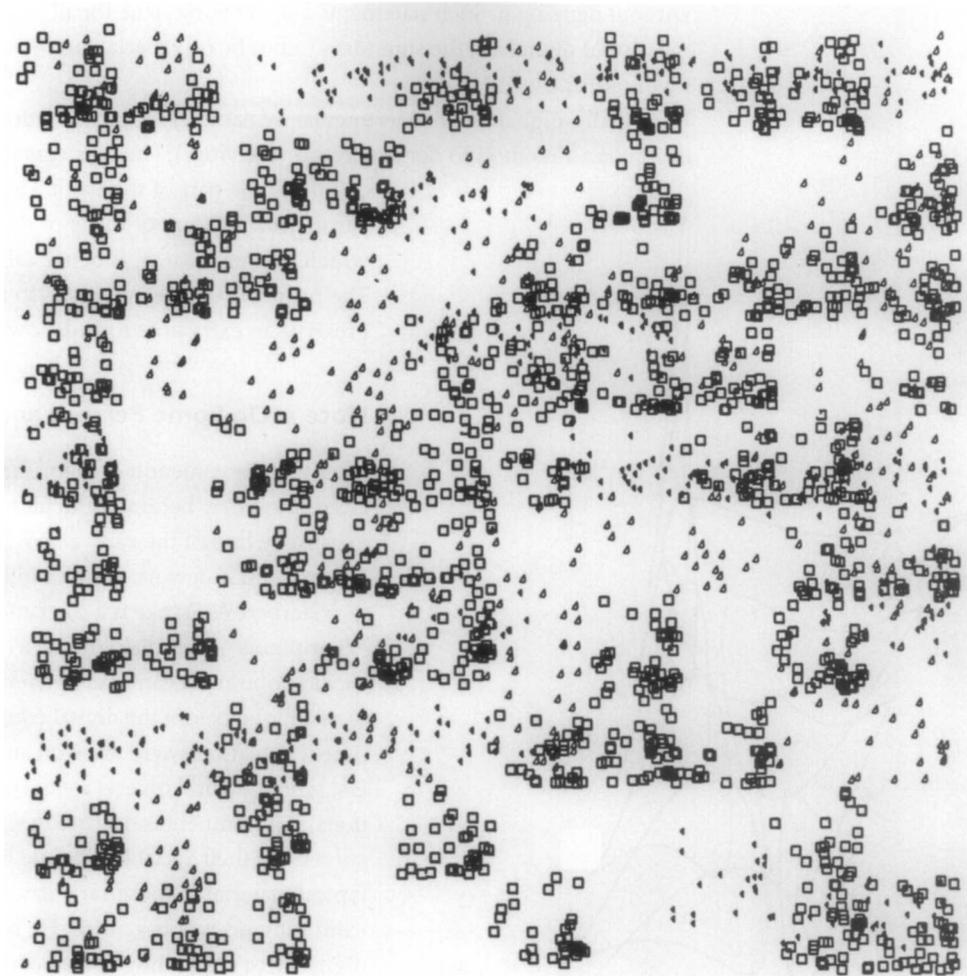
After the phenomenon of algorithmic art surfaced, it quickly became difficult to compile exhaustive lists of the early activists in Europe. Nevertheless, a few names should be mentioned.

Herbert W. Franke is a forerunner with his experiments of the analogue variety, using an oscilloscope and a camera to generate patterns that were unique before the digital computer. At the time, calculations were done on analogue computers, whose natural objects are curves and oscillations, not numbers and structures. Parametric curves and their variation in time became the typical material in those early days. Franke started exhibiting his works in 1956. He later became a digital artist with a huge production, and also worked as an author, theorist, and exhibition organizer. His large collections of early works (several hundred pieces) are now in the possession of the Kunsthalle Bremen. Kurd Alsleben, with the help of Cord Passow, generated a small number of curves on an analogue computer in 1960. He published them in a book and later exhibited them when (digital) computer art started. Georg Nees and I are usually considered the first to exhibit algorithmic art in Europe (Nees at Studiengalerie Universität Stuttgart, February 5–19, 1965; Nees and I at Galerie Wendelin Niedlich, Stuttgart, November 5–26, 1965). A multiperson exhibition mounted at the Deutsches Rechenzentrum Darmstadt the following year (January 15–February 15, 1966) became noteworthy in two ways. It united three kinds of works: computer-generated texts (by Gerhard Stickel), music (by Max V. Matthews and Ben Deutschman), and graphics (by Frieder Nake). It also was the first such show to generate considerable coverage in the public media (television, national newspapers, and art magazines).

The former Bauhaus teacher Georg Muche visited the Darmstadt show and sent messages to some of his artist friends. Among them was Otto Beckmann in



Herbert W. Franke and Peter Henne,
***Algebraische Kurven (Algebraic Curves)*,**
1969, silkscreen print after plotter drawing,
25½ x 11½ in. (64.5 x 29 cm). Kunsthalle Bremen
(artwork © Herbert W. Franke and Peter Henne)



Frieder Nake, *Zeichenverteilung* (Distribution of Signs), 1965, colored algorithmic drawing, ink on paper, ca. 19% x 19% in. (50 x 50 cm). Museum Abteiberg Mönchengladbach (artwork © Frieder Nake).

11. Molnar was the first and Mohr the second recipient of the new *d.velop digital art award* (ddaa) in 2005 and 2006, respectively. This award was initiated by Wolf Lieser, the owner of Digital Art Museum (DAM) in Berlin, and was made possible by the German software company *d.velop*. It honors seminal contributions to early digital art or an artist's life achievement.

12. See *Manfred Mohr*, ed. Marion Keiner, Thomas Kurtz, and Mihai Nadin (Weiningen-Zurich: Waser, 1994), and *Vera Molnar: Inventar 1946–2003*, ed. Linde Hollinger (Ladenburg: Preysing, 2004).

Vienna, who started a correspondence and cooperation with me. For about ten years, Beckmann concentrated on computers, and with his son Oskar and two other engineers he founded the group *Ars Intermedia*. The members were quite active and constructed a special-purpose hybrid studio computer (now at a museum in St. Pölten, Austria). The first version was operational in 1970; *Ars Intermedia* probably can be considered the art-technology collaboration of earliest and longest standing besides E.A.T.

Two names that appear early in Paris became two of the great and successful artists in the digital domain: Manfred Mohr (of German origin, now based in New York) and Vera Molnar (of Hungarian origin). Both were artists to start with, both began using computers around 1969, and both make a living from their art.¹¹ Mohr transformed himself from a saxophone jazz musician and hard-edge painter to a programmer-artist. Molnar keeps doing art by hand, whenever she likes, and relies to some extent on the programming expertise of Erwin Steller, who also generates and exhibits his own algorithmic art. Two large volumes deal with Mohr's and Molnar's lives and art.¹² Mohr was the first artist to exhibit algorithmic art in a solo show at a museum (*Musée d'art modern* in Paris, 1971).

Early contributors to algorithmic art in Spain are Manuel Barbadillo and



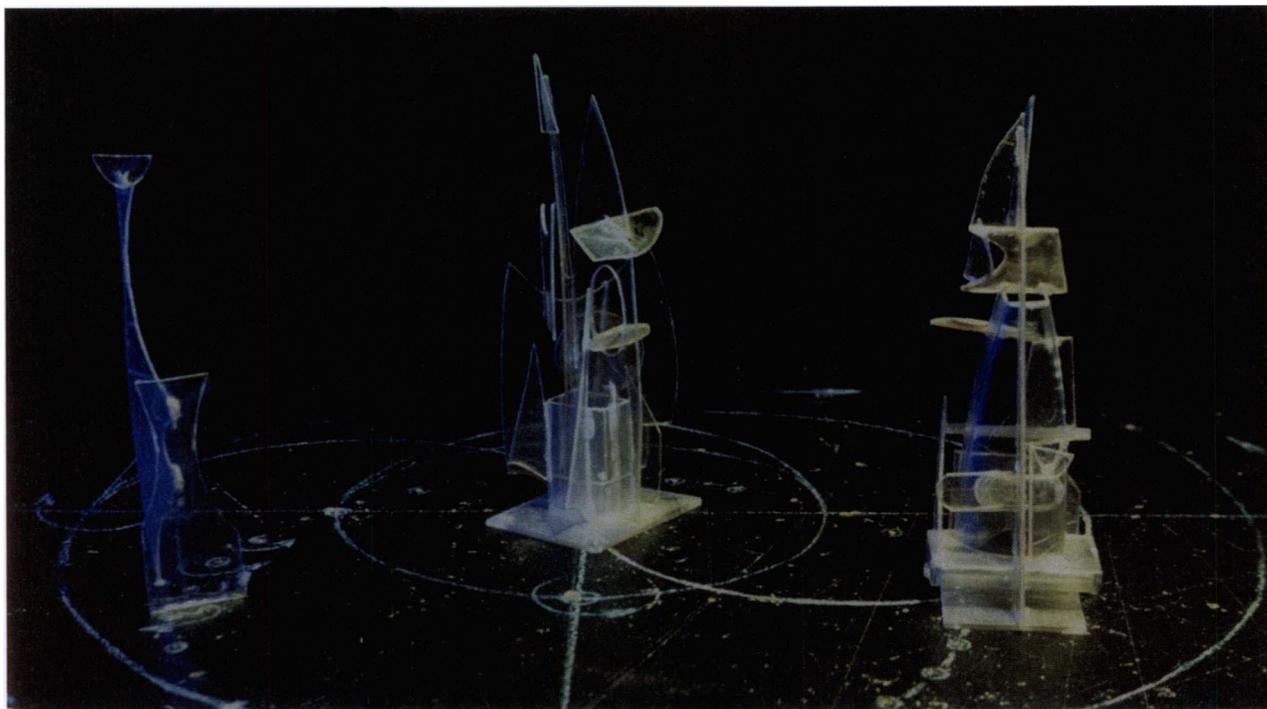
Frieder Nake, *Geradenscharen (Bundles of Straight Lines)*, 1965, colored algorithmic drawing, ink on paper, 27½ x 19¾ in. (70 x 50 cm). Collection of the artist (artwork © Frieder Nake).

Both works were exhibited in November 1965 in Stuttgart. *Zeichenverteilung* won first prize in 1966 Computer Art Contest of the magazine *Computers and Automation*.

Ernesto Camarero. The computing center of the University of Madrid was an early place of interdisciplinary cooperation. Barbadillo made use of formal grammars and painted the printouts on canvas. He contributed a piece to a remarkable portfolio of six screen prints that Gilles Gheerbrant produced in Montreal in 1972 (also represented were Hiroshi Kawano, Ken Knowlton, Mohr, Nees, and myself).

Almost forgotten are three exhibitions Jiri Valoch arranged in the former Czechoslovak Socialist Republic (now split into two states) between February and April of 1968—during the time of the Prague Spring and before the London and Zagreb events the same year. The show traveled to galleries in Brno, Jihlava, and Gottwaldov with works by the already well-known Americans, Canadians, and Germans, but also by Valoch himself and Lubomir Sochor. Sometime later Zdeněk Sykora became the best-known Czech computer artist. Sykora developed a very personal style of lively, colored curves that he painted by hand according to the computer output.

In the United Kingdom, John Lansdown, Gustav Metzger, George Mallen, Alan Sutcliffe, Michael Thompson, and others appeared in a show in Edinburgh in connection with an artificial-intelligence conference in 1968. A year later,



Otto Beckmann with Ars Intermedia, frame from an untitled animated film, 1966 (artwork © Otto Beckmann and Ars Intermedia).

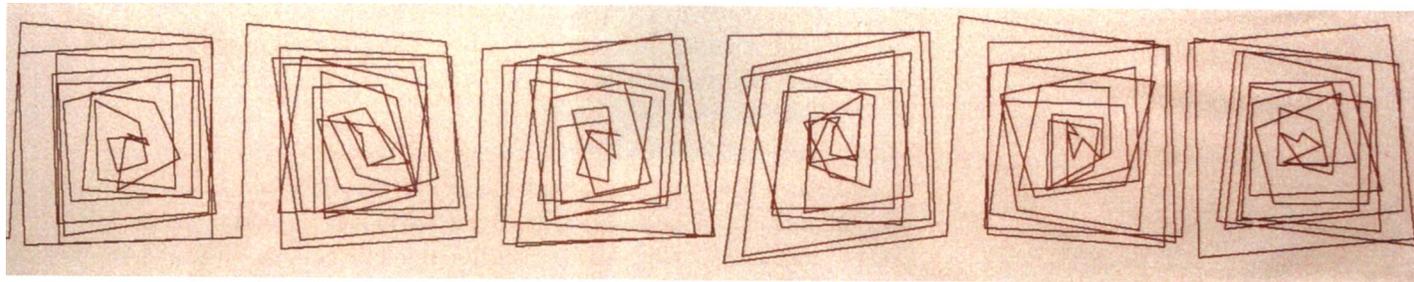
Plexiglass figures in laser light are moved stepwise along computer-generated circular arcs, each position creating a frame of the film.

the Computer Arts Society was founded in London in affiliation with the British Computer Society. After being active for a long time, it went dormant but was revitalized a few years ago and is now more active than ever.

Marc Adrian in Austria, Peter Struycken and R. D. E. Oxenaar in the Netherlands, Auro Lecci in Italy, the Groupe de Recherche d'Art Visuel (GRAV) and Groupe Art et Informatique in Paris all stand for a clearly algorithmic orientation.

Two international events happening just one day apart in August 1968 represent two features of digital art that could hardly be more different: the exhibition *Cybernetic Serendipity* (opened at the Institute of Contemporary Arts in London on August 2, 1968) became an early case of art as an event, whereas *Computers and Visual Research* (opened at the Galerije Grada Zagreba in Zagreb with a symposium on August 3–4, 1968) was art as research.

For the London show, the curator Jasia Reichardt brought together a wide spectrum of genres and works; Londoners and an international audience had great fun, and the publications preparing for and coming out of *Cybernetic Serendipity* gained a certain standing. Three years after its first exhibition, digital art had gained some minimal acceptance. Farther south, in Croatia (then part of Yugoslavia), concrete and constructivist artists from the West and East, who had shown their work biennially since 1961 under the title *New Tendencies*, experienced a critical situation in 1967 and decided to postpone that year's show by one year, changing its title to *Tendencies*. A year of symposia, an art competition, exhibitions, and publications ensued. Interaction and algorithmics were central to many of the works, most by artists of international renown. The computer played a prominent role as tool and medium, but exhibits were not restricted to the digital domain. Gradually conceptual works started to appear. An international and bilingual journal, *bit international*, came out of Zagreb between 1968 and



Vera Molnar, *Une ligne, grecques, après tremblement de terre (One Line, Meander, after an Earthquake)*, detail, 1996, plotter drawing on paper, 24¼ in. x 39 ft. 4½ in. (63 x 1200 cm) (artwork © Vera Molnar)

1973. In its nine issues, it attempted to demonstrate some of the media fields that needed research. In Zagreb one could see the meeting of important strands of contemporary art, and though this lasted for a short time only, it was of future importance.¹³

The range between fun event and visual research demonstrates what early computer art meant in Europe: an oscillation between playful leisure and entertainment on the one hand, and serious analysis and research on the other. Looking back, the spectrum between the London and Zagreb shows may be considered as an early demonstration of what would later become “digital media.” Based on the virtues of algorithms, presentations of digital media very often are great events for mass audiences, often in public space. At the same time, digital media require for their continued existence research of a detailed nature. As with the events of E.A.T. in the United States, artists then considered avant-garde took part or were represented. Parts of the art world accepted algorithmic and interactive principles and were applying them in their own works.

Note 5: On Conceptual and Coded Art

Paul Hertz has asked what the relation could be between code and work of art on one hand, and concept and work of art on the other. It is striking that computer art and Conceptual art first appeared at the same time, but it doesn’t necessarily mean much. More generally, the work materializes between a mental concept, an inspiration, or act of imagination, and its gradual appearance as a form—in fact, the work exists as the tension and dialectics between those two states. In Conceptual art, the concept alone is taken most seriously, to the point where the concept itself is displayed—an act that heavily questions the formal aspect of the work. The final form that the work must attain in traditional art becomes less and less relevant. What counts is the concept as such.

A simple observation tells us that the algorithm underlying an algorithmic work is clearly a concept. Thus algorithmic art is a kind of Conceptual art by nature. But an important distinction is to be made. The algorithmic description of a concept—other than a traditional description on the back of an envelope or in some design sketch—may itself be executed. The algorithmic description turns out to be two, a twin pair, or a Janus being. It is well known in computing that algorithms (and, a fortiori, programs) must be viewed as texts and machines at the same time.

The algorithm is a text since as we write and read it, we interpret it and generally treat it like any other text, from poem to drama. At the same time, the

13. The exhibition *The Algorithmic Revolution* continues some of the Zagreb spirit. A retrospective was staged under the title *Die Neuen Tendenzen: Eine europäische Künstlerbewegung 1961–73* (The New Tendencies: A European Artist Movement 1961–73), at Museum für Konkrete Kunst Ingolstadt (2006–7) and Leopold-Hoesch-Museum Düren (2007); it included a remarkable catalogue. In February 2008, again at ZKM, another retrospective appeared, under the title *bit international: [Nove] Tendencije—Computer und visuelle Forschung Zagreb 1961–73*.

algorithm is a machine, since the computer can read it, too. It determines the sequence of operations that make up the algorithm and executes them. We summarize these observations in the double statement that algorithms are texts to be executed and machines to be read.

The only technical requirement necessary to let this observation become true goes almost unnoticed: a compiler or interpreter must translate the given program into a machine program. Since translation is mostly an automatic process, we may feel safe in saying that algorithmic art is Conceptual art whose concepts are executable. The algorithmic artist creates a (description of a) concept. But she creates a form as well. This form appears when the algorithm is actually executed. So the executable concept combines the description of a whole set of feasible objects with individual realizations of the set.

Note 6: On Interactive Art

In the early days of computer art, the question of why there were no masterpieces or at least outstanding works was often raised. There were, perhaps, a few. But they did not rank highly enough to be accepted by the art market, they did not appear at auctions, and they had a hard time entering museums.¹⁴

Early computer art explored the algorithmic principle that became the technological backbone of the changeover from modernism to postmodernism. The work generated signs and made heavy use of random numbers. But it was realized in still images on paper or on canvas to be hung from a wall like any other traditional work. The radical production process was contradicted by the visual results. Drawing with the brain was far-out and conservative at the same time. The denial of its own revolutionary implications made it easy for critics to state that computer art was boring, worse than mediocre traditional drawing or painting, and that it would never lead anywhere.

The situation changes a bit when you realize that the question of the masterpiece is not well defined. In fact, the question itself is proof of the old-fashioned mind. The fact is that in computer art the individual piece is no longer important. Only the class property is important. The individual piece dissolves into being a member or an instance of a class. The art of the work of art, in the case of computer art, is the class of works the algorithm stands for. Looking for the masterpiece becomes looking for the master algorithm.

But still, what computers are good at are long chains of commands that must be carried out repeatedly with only minor changes from step to step. The incremental algorithm is really the favorite realm of algorithms. This will lead us to the last note.

Interaction between members of the audience and the code is what the transformation of the work into its class is calling for. In interactive use of algorithms we exploit the peculiar features of computer programs. As long as the feature of interactivity does not become central, the computer is used more as a tool, or as an automaton, than as a medium. When use itself becomes the issue, interactivity enters into its algorithmically based form. Only then are the capacities of the digital really tapped. Only then does the computer truly become a medium. Only then may masterpieces show up. Even though remarkable results were achieved in the early days, interactivity was still lurking behind the scenes

14. It should be clear, however, that at least today there are substantial collections of digital art in museums. To mention just a few, Kunsthalle Bremen has around one thousand works (including the collections of H. W. Franke and other artists' donations); the Victoria and Albert Museum in London owns the prominent collections of Patric Prince and the Computer Arts Society; Museum Abteiberg in Mönchengladbach has had about fifty works since 1974 (Sammlung Etzold, advised by Karl Otto Götz); and the Leigh and Mary Block Museum of Art in Evanston, Illinois, has begun to build a collection.

and had not yet gained an important status. It took the separate movement of interactive art to show that.¹⁵

Note 7: On the Algorithmic Sign and the Semiotic Engine

A new and special kind of sign characterizes the work of algorithmic art: the algorithmic sign. A new and special type of engine is the breeding ground for all algorithmic or digital art: the semiotic engine.¹⁶ The statements belong together and are two sides of the same coin.

An algorithmic sign is like any other sign but with the hidden property of being interpreted twice. The material, perceptible side of the sign is what makes it noticeable to us. On the computer this is the visual appearance on the screen. This appearance relies for its existence on a coded form that we do not and can not usually perceive. It is, fortunately, accessible to the computer, which, in turn, has no clue of the visible form we observe. The computer manipulates the coded form and presents to us a slightly changed appearance. We immediately and permanently interpret the sign through its changing, perceptible presentation. At the same time, the computer software is algorithmically interpreting the sign. This permanent cycle of two parallel interpretations turns the sign into an algorithmic sign.

The computer, as the carrier of all software, sets the software in brutally storming motion. Economically speaking, it is a machine like any other machine. Ontologically, however, the stuff it manipulates is of a different kind than the stuff of ordinary machines, which deal with matter as material and energy. The computer requires matter as well (how could it be different?), but the semiotic nature of that matter is most important here. Things undergo a semiotic transformation when they enter the computer. They grow a skin of signs, and those signs are what the computer manipulates. Mind you, it is manipulating only the syntactics of those signs. It strips the sign of its precious character and deals with the signal only. It must do so, since it is the semiotic engine.

Computer art is dealing with processes of this kind and planning for the generation of such processes. The computer artist must learn, when she wants to become a master, how the machine would interpret the sign, although that machine lacks the capability of genuine interpretation. All the semiotic engine can produce is a determination. Determination is interpretation as the extreme case, where free interpretation is not allowed. The revolution in aesthetic thinking that algorithmic art started around 1965 is the attempt to think like that engine that cannot think: the semiotic engine.

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15. This genre starts with the work of Myron Krueger. See Myron Krueger, *Artificial Reality* (Reading, MA: Addison-Wesley, 1983).

16. Mihai Nadin was the first to use this term in lectures at Rochester Institute of Technology in 1983–84. He published his views in *Semiotic Engine: The Public Journal of Semiotics* 1, no. 1 (January 2007): 85–114. See also Winfried Nöth, *Cybernetics and Human Knowing* 9, no. 1 (2002): 5–21.