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Georg Nees & Harold Cohen: Re:tracing the origins of digital media

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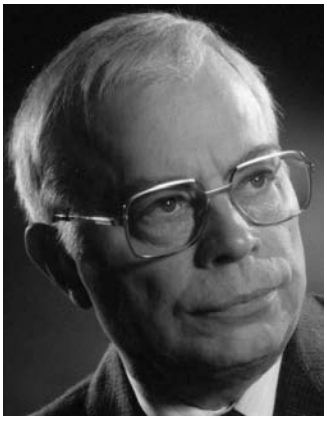


Figure 1. Georg Nees (1926-2016) (first algorithmic art show 1965 in Stuttgart)

Figure 2. Harold Cohen (1928-2016) (first algorithmic art show 1972 in Los Angeles)

One day in 1964, Georg Nees, son of the city of Nuremberg, and as a mathematician working for the Siemens Company in Erlangen (Germany), watched the new Zuse Graphomat Z64 automatic drawing machine as it generated a first short straight line segment and, after a change of direction, continued to do the next, and again, and more of them. Though somewhat fast in its movements, the machine was still slow enough so that Nees could closely observe how it switched direction and continued it for some distance, before it again altered direction for another seemingly straight line segment. And so it went, repeating the same simple operation eight times before closing the funny little figure that meanwhile had emerged. The line segments appeared on paper in black ink as graphic entities, building groups and neighbourhoods forming shapes. An entire array of such creatures (Fig. 5).

Decades later, recalling for the visitor from his memory the scene with the Graphomat, Nees says: “I was standing in awe, overwhelmed by what the machine made me become a witness of. Here was something,” he added, “that would not disappear again.”

Some other day four years later, in 1968, Harold Cohen, young and already a successful British artist, just arrived as a visiting professor to the Fine Arts Department at the University of California at San Diego (UCSD), felt a bit frustrated by Jef Raskin's attempts to teach him programming. Raskin (1943-2005), then a graduate student of music at UCSD, holding several previous degrees, and up to later becoming an important figure in the design of the Apple Macintosh, was concentrating on the fundamentals of programming as he was introducing the forty-year-old artist into the art of computer programming.[1]

Raskin was fifteen years younger than the British artist, but obviously understood very well what his job should be: He required from Cohen some degree of patience when he chose flow-charts as the basic objects to make his student become familiar with. In flow-charts, we may describe a program independent of the intricacies of a concrete programming language. This helps the novice to better understand principles of programming. But Cohen, after a while of growing impatience, said, enough of this, I finally want to get my hands on code. In reaction, Raskin left him and, after a while, returned with a fat handbook for the FORTRAN programming language, dumped it on the table, “here it is”, and left Cohen

1 It is a beautiful co-incidence that the first volume of Donald Knuth's century-project, "The Art of Computer Programming" (Knuth 1968), appeared in the same year.

behind, now alone with the handbook. The artist started reading and exercising, and did not stop doing this before the middle of the night.

Decades later, recalling the scene with Raskin for his visitor, he says: “I was baffled but overwhelmed by the code elements that opened up in front of my eyes.”

Nobody will ever know precisely how the two situations happened in actual fact. But who would care to know them better, perhaps from cameras installed at the Erlangen and San Diego locations, including microphones to record what the two actors did, what happened to them and how they reacted. Both stories are nice stories that Nees and Cohen tried to remember when they told them to the author. He did not change much of what he was told, or even nothing. But who knows, and several media transmissions are responsible for what you, dear reader, are now reading about two incidents that have happened in 1964 and 1968, in Germany and in the USA.

So much for a first meeting of our two heroes. Before I am going to say more about each one of the two, I want to inject a short note about digital media. It is intended as a kind of bracket for what the mathematician and the artist are doing in their very different manners at the two poles of a contradictory spectrum, far apart geographically as well as intellectually. The two men are contributing to, and pushing forward, a field in the history of fine art that is often, unfortunately, called "computer art." Much better, and more precisely, it should be called by names like "algorithmic art" or "generative art."[2]

Both these terms reveal the important fact that the artist in generative or algorithmic art is working from a radically novel perspective. He or she are *thinking their work*, they build it in their head before they describe, in an appropriate way, to the machine what they want it to do. “Think the work, don't make it!” is their revolutionary approach. It entails a dramatic consequence: When you think the work, you never think a single work. You immediately realize that the thinking of works is a thinking of possible realizations, of schemata, methods and techniques to generate works, much more than a thinking of generating an individual work. The creation of an individual work is materials to be combined, melted, attached,

2 When on the 5th of February, 1965, philosopher Max Bense opened Georg Nees' first exhibtion in Stuttgart, he read a short text of his (in German) under the title "Projekte generativer Aesthetik" (Bense 1965). Bense took the term "generative" from Noam Chomsky's "generative grammar" (Chomsky 1956). Much later, it became an attribute of many artistic approaches using self-constructed software to distiguish this from the use of application software.

mixed, piled up, connected, applied, etc. The generation of an entire family of works, however, amounts to transforming signs into materials that the signs stand for. Therefore, it is a thinking of infinities, of literally infinite sets of works. The individual work becomes an instance only of an infinite class of works. The class is described by certain (visual) features that are parameterized. The set of parameters and their ranges of variation determine the variation and changes from one instance to the next.

As a corollary to this, the work of algorithmic art is constituted as a class of works. Each single realization is an indicator only of the class it belongs to. The work of algorithmic art, when viewed in a more traditional way, is reduced to a state of "standing-for." The masterpiece disappears. The permanently changing appearance of the works transforms them into dynamic processes more than into fixed, static works.

Such statements in their style of factuality may not yet convince the reader, or they may appear trivial to her or him. Both reactions are okay. For they depend on how much or how little we have accepted that our time's fabric is determined more by the dynamics of change than the statics of permanence. Peter Lunenfeld has written about similar observations as the *aesthetics of unfinish*[3].

Georg Nees is the mathematician who moves into fine art; Harold Cohen is the artist who moves into computing. Both gain their exceptional creative capacities and their historic positions by emigration into unknown lands. They gain by giving up, and they re-gain what they give up. As individuals, they stand for new sorts of media. They stand for media that require two capacities melting into one in the same person: algorithmics and aesthetics.

Media, digital

Both our stories are about computers. But computers appear in opposing roles. Nees is an expert in program development; Cohen is an expert in painting. When Nees approaches the computer, he knows perfectly well how to do this; but he may be hesitant about what he should ask from the computer. When Cohen approaches the computer, he knows perfectly well what he wants it to do; but he may still be uncertain about how to get it to do just that.

3 "In fact, »unfinish« defines the aesthetic of digital media." (Lunenfeld 2001: 7).

Figure 3.
View of Cybernetic Serendipity,
ICA London, 1968.

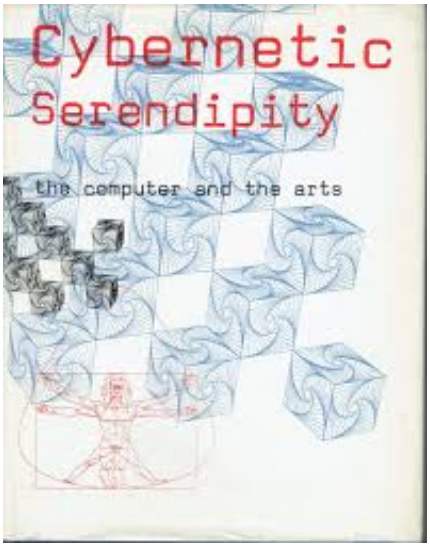


Figure 4.
Catalogue Cybernetic Serendipity,
special issue *studio international*, 1968.

Nees is observing a drawing automaton. He has before instructed a computer to output a punched paper tape such that the automaton, when controlled by the paper tape's codes, generates a drawing of ink on paper that is the result of Nees' thinking. This last sentence, I assume, may read a bit complex. It means that Nees has developed a program that, in the end, draws. He is concerned with computer output that he is going to evaluate from an aesthetic perspective.

Cohen, on the other hand, is eager to learn how to write a program, using a particular programming language for a particular computer. His teacher, however, with the best of intentions, introduces him to general principles. That makes him, the artist, become nervous. For, as an artist, he is accustomed to the particular and single specimen, as opposed to the general and all members of a specification. Cohen's concern is: when do I finally get down to writing code so that I can force that machine, the computer, to do precisely what I want it to do?
Computer input is what his thinking is focussed on and he feels intuitively that it may still take quite a while before he gets to where four years earlier Georg Nees already was.[4]

4 As an aside, to the best of my knowledge, Nees and Cohen have never met. They knew of each other, nothing more.

Georg Nees knows well what one can do with a computer. He plays with it, forcing it to do what he wants it to do and nothing else. He does not know much about how to do art. Harold Cohen knows well what one can do with brushes and paints. He plays with them, forcing them to generate forms and colourings that look the way he wants them to look. He doesn't know much about how to deal with computers.

The first exhibition of drawings claimed to be of artistic interest was displaying works by Georg Nees (in February, 1965, in Stuttgart[5]). A few weeks only, before Cohen left London for San Diego, the large and comprehensive international exhibition *Cybernetic Serendipity. The computer and the arts*[6] had opened at London's Institute of Contemporary Arts (ICA; the opening on 2 August, 1968, Figs. 3 and 4). Of course, Cohen had visited the show. He was impressed, and when he, shortly after, arrived in California, his mind was full of fresh new possibilities opening up to his artistic thinking. At the ICA, he may have seen Nees' work but it may well be that the kinetic creatures of the show attracted his attention more than the computer-generated drawings on the walls.[7] The spectacle[8] of a flower bending over towards the visitor as he or she makes certain noises does not only attract kids much more than a static drawing—adults do not react very differently.

The computer during the 1960s and well into the early 1980s is considered to be a machine and this interpretation can hardly be different. It is a machine of the automaton type of machinery. Like the telephone or the conveyor belt, and many more: machinery that functions automatically. To a large extent, the automaton can operate without much of explicit control by humans. Only in the early 1980s, with the appearance of the Apple Macintosh in 1984, the tool metaphor takes on prominent status. The machine computer is transformed from an investment good into a consumer good. Without tremendous changes in the way of using the machine, the transformation would not have been possible. The computer now becomes a good to be picked up from an ordinary store or supermar-

5 Putting Nees' show in the rank of an "exhibition" may be contested by the strict criteria of art history. The Studio-Galerie was not officially involved. They gave the rooms. However, people came for an opening; the works were on display for two weeks; Bense and Nees spoke; there was reaction in the press. For those who were there, it was an important event.

6 See Reichardt 1968

7 Cohen may also have come aware of Nake's work also on display, and chances are that the two almost met on their different ways from Europe to North America.

8 Should I mention the fact that Guy Debord's Society of the spectacle had appeared only recently? (Debord 1967)

ket. With the breakthrough of the Internet (1994), the "tool" computer, already widespread, but now—by taking on the function of an end-device to access an enormous and rapidly growing mega-machine, the Internet—the computer is gradually seen as a medium.[9] With the additional global storm of the smartphone, the people of the world are now almost slavishly and in permanence engaged in trivial forms of communication that pretend to be greatly liberating and providing access to the knowledge of the world. Part of this is, of course, not really wrong. But the medium's impact is of the kind that air plays for land-based, and water plays for sea-based animals: The medium to sustain their lives.

Georg Nees

As he told us his story, when he first observed the machine drawing lines he had thought before and described algorithmically, Georg Nees stood in awe, overwhelmed by what he saw happening. Was he observing how his own thoughts were taking on material form? A short while before, he had picked up from the computer a punched tape that his own program had generated as output. He had taken the tape to the automatic drawing machine, had inserted its front end into the paper tape reader, had pressed the start button and was now watching the machine doing its jerky job. A cold vibration was running down his spine: "This will never disappear again."

At around the same time, late in 1963, I had been in the same situation of observing the machine as it was materializing my own thinking. Excitement shook me. But the moment I saw the calculating machine mutate into a drawing machine, did not affect me as deeply, as I now feel, my friend experienced it. Independent of each other we saw moments of history when a new medium was born.

9 Heidi Schelhowe's doctoral thesis (Schelhowe 1997) is about the inherent metamorphoses of the computer from machine and automaton to medium.

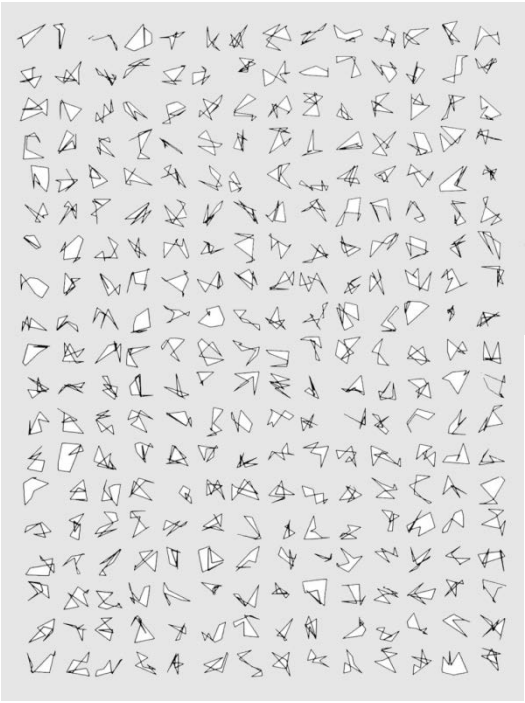


Figure 5. Georg Nees, *Achtecke*, 1965. ©Georg Nees

Closed polygons of 8 vertices placed into a regular grid. The random variation of placing the vertices inside a small drawing area demonstrates a wild variety of simple shapes. The white areas are a later additional effect in this rendition. The original drawing only shows the black lines of the polygons on white ground.

Of course, history does not happen in the form of isolated moments. History is much more floating than jumping from one state to the next. Separate moments may make great memories for individuals involved in the happening. But we can safely assume that there have always been other persons who have lived through similar kinds of awesome events, a moment or two before, somewhere in the world. Their action, their reaction, all of them collected together as a joint experience, make up the historic moment, collapsing into the very date that may one later day be identified as the beginning of something new.

There were others in the United States who were lucky enough to do their work in environments where the first drawing machines were put to use (in the USA, they are called "plotters").[10] In Germany, the author started developing a basic graphics package for the Graphomat Z64 in 1963.

10 The idea of graphic output devices originates in the mid-1950s. In Germany, Konrad Zuse is reported to have begun such work in 1956. In the USA, such devices or usually called plotters or flatbed plotters, resp. (Hewlett Packard, CalComp, Texas Instruments, and others were manufacturers.) Flatbed plotters can use any kind of (high-quality) paper. Plotters were always slow because of their mechanical operation. They could use professional drawing pens and inks. Plotter drawing is based on vectors. They almost disappeared when large-size raster printers (and, thus, the digital principle) became available.

Our point here is the subtle shift from routine engineering work to artistic creation. None of the early drawing devices was intended and constructed with anything else in mind but outputting results of engineering, or business-type, calculations not only in numerical form, but also (and more appealingly) as drawings of statistical analyses or constructions of machine parts, electric circuits, architectural plans or other engineering designs. The visual-iconic output (instead of the numeric-symbolic output) was almost a side-product only of common engineering work than a drawing whose purpose was the visual appearance of drawing itself and nothing else. To some degree in contrast to engineering, the visual appearance is to the heart of artistic thinking.

Georg Nees' fantastic *ur*-experience must be understood against such a background. The early existence of computer-aided drawings does not devaluate the shiver and foresight caused in Georg Nees' mind by the appearance of a first artistic drawing here, in the Computing Centre of the Siemens Company, some day in 1964. What he, the mathematician, had been experiencing would soon shake the world of art. To be more modest: a small part of that world. But eventually, it came to deeply influence culture, to revolutionize the world of image production and much of our daily perception and, thus, of aesthetics.

In order to make all that happen, Nees had to write software that generates punched paper-tapes that were to control the movements of the Graphomat's ink pens mounted into a container controlled by the xy-movements of the drawing machine. In a way, Nees was watching his "ideas becoming a machine that makes the art." Nees' action was three years before conceptual artist Sol LeWitt (in 1967) would formulate as one of his famous *Paragraphs on Conceptual Art* exactly this insight about the relation between idea, machine and work: "The idea becomes a machine that makes the art." (LeWitt 1967). But here, at the Siemens Computing Centre in 1964, exactly this happened: the drawing machine generated an image that had before existed in form of a human idea. A mathematician had done in his actual practice what an artist would describe in form of words three years hence. The two persons, Georg Nees and Sol LeWitt, did not know anything of each other.

Harold Cohen

Las Vegas was famous, and perhaps still is, for gambling, nudity and other ways of getting rid of your money. Oddly enough, such places also attract scientific conferences. There may be hidden relations and similarities be-

tween such diverse activities of culture. Why not think of science and erotics as two kinds of exhibitionism? In either case, you must be willing to freely present something of yourself: your body, your money, your work.

The 1965 Fall Joint Computer Conference (FJCC, 30 November – 1 December) took place in Las Vegas. As was frequent practice at that time, industry displayed their most recent developments and relevant books were announced. But this year, an extra show presented earliest works of computer art by A. Michael Noll from Bell Laboratories (drawings of digital origin) and Maughan S. Mason (analog origin). In April of the same year, Noll's drawings had been exhibited at the avant-garde Howard Wise Gallery in New York City[11].

The New York and Las Vegas events built a remarkable manifestation of newly emerging experiments in using computers and programs for generating aesthetic objects (to avoid the term "art"). At Howard Wise in New York: the art scene gets a chance to take notice. At the FJCC in Las Vegas: technology and science are becoming aware of this. Two different sites, two different audiences, but the same kind of objects: drawings of artistic quality but constructed by technological processes. The bridge between art and science takes on real form, when just one person is applying mathematical and engineering skills intending to generate aesthetic sensation (cf. Schmidgen 2017: 7).

Hardly anybody was taking much notice of the seemingly sudden break by high technology into the world of art. But the fact that Noll presented his works to an art-oriented audience of high rank at the avant-garde gallery, and a bit later again to the international audience of a large scientific and engineering conference, may be interpreted as a new kind of double event. Do those works constitute a new kind of aesthetic reality? In all likelihood, such questions were probably not discussed at the two events. However, the fact that engineers and mathematicians were making public artistic statements was discussed (at times with arrogant undertones by artists or art critics).

We will see later that, in fact, the works on display in New York City and Las Vegas constituted a new kind of aesthetic reality, a reality that is meanwhile dominating large parts of artistic manifestations.[12] At the

11 Howard Wise ran his New York Gallery from 1960 to 1971. He mainly specialized in kinetic, light, and video art. His gallery was considered leading avant-garde. Noll's works appeared together with studies on perception by Bela Julesz.

12 Another double presentation was happening in West Germany. Frieder Nake and Nees exhibited their algorithmic art from 5 to 26 November 1965 at Galerie Wendelin Niedlich in Stuttgart; shortly after, Nake was responsible for the visual works of a show at the

times of the actual events, they were puzzling, creating a weird kind of discussion and attention, but no real understanding of what was actually happening. Some time had to go by before the public was ready to realize the enormous impact that algorithmic techniques could bring to image generation.

Six years later, the 1971 FJCC returned to Las Vegas. With it came a show entitled "A computer-controlled drawing machine". That's what you may find on records of some of the galleries that have later exhibited Harold Cohen's work. At least one of them claimed, Cohen had a solo show in Las Vegas. Others may have copied this.

Experience has told us that what a commercial gallery writes is not often altogether trustworthy. It is true that the FJCC in 1971 took place in Las Vegas from 16 to 18 November. It is also a fact that the industry there showed their products (AFIPS 1971). The name "Harold Cohen" is not mentioned in the proceedings. However, the computer company Tektronix is listed among the exhibitors. Cohen's first drawing machine was controlled by a Tektronix computer. He presented the hardware as part of his 1972 exhibition at the Los Angeles County Museum of Art (LACMA). In a lecture given on 23 September 1980 (Cohen 1980), he shows slides of the 1972 event. There we see the arrangement of the Tektronix plus drawing machine and he explicitly refers to it. It is not impossible that Cohen had been given a chance, at the 1971 FJCC already, to show and, perhaps, even demonstrate his drawing machine.[13]

In fact, it would be marvellous if this were the case. For, if it were, we would have a second case of one person turning himself into the bridge between science/technology and art. This case would be different, more advanced and more convincing than the first experiments in the mid-1960s.

For now it would be an established artist of international renown, who built the drawing machine himself and who would soon start into a long-lasting process of software development that is unparalleled up to this day. I am referring to Cohen's system AARON that he started to construct in 1973 and continued in ever new steps until the end of his life (2016). A unique career of an artist who occasionally turned himself into an engineer without ever lowering his artistic goals and intentions.

Deutsches Rechenzentrum in Darmstadt from 15 Jan to 15 Feb 1966, also presenting computer-generated poems and music, the first of its kind, and again, an explicit approach to the two cultures, the artistic-literary and the scientific-engineering cultures (Snow 1959).

13 Tom Machnik suspects a Data General NOVA 1200 drove Cohen's first drawing machine and a PDP-8 drove the Tektronix Graphic Terminal.

Figure 6. Harold Cohen, *Early work by AARON*, 1974, hand coloured by H. Cohen . © Harold Cohen

In Fig. 6, we see a very early drawing done by the system AARON. AARON is based on rules of the type if <condition> then <action>. Here, <condition> stands for a logical expression that can be "true" or "false". If it is true, then the <action> is executed. Otherwise, nothing is done. The early version of AARON contained rules that would allow finding some empty area on the "canvas", and would put the outline of some closed form into such a space. As we can see, such closed forms may be connected to another one, even several of them. Cohen did the colouring himself, after the plotter had done its job in drawing the shapes. Cohen's interest has always been colour. He took the liberty of adding this decisive component to the image (Fig. 6), which then owes its appearance to a collaboration of human and machine.

Harold Cohen had moved to San Diego, CA, from London, UK, in 1968. Under the Californian sun, first hesitatingly, he became interested in computing. As for anybody else in the early times of algorithmic art, this meant to him to learn how to program. Nobody—and certainly not Harold Cohen—wanted to pass on to some programmer the activity of describing to the machine what it was supposed to do. If there are exceptions to this unwritten rule or mode of conduct, the resulting images would most likely suffer in aesthetic quality or some other feature.

Why would this be so? The answer is quite simple. The act of creation was transformed and the final steps of materialization were moved away from the acting artist in quite a dramatic manner. He or she found herself in the programming lab rather than the painting studio. In the programming lab, the emerging work was first to be transformed into its own description. Before any visual aspect of the work became visible, it was necessary to describe in symbolic terms how the machine should generate the work. In a way, we may accept the description as a different form of the work itself. The "program" is, of course, the instrument to generate the work. But in some (perhaps twisted) way it is the work itself.

The program without which nothing was going to happen was to be the precise description of the work. However, it was not the description of the *one and only* work. The artist was not thinking of the single and unique work she had been sketching and painting and constructing and designing and correcting and changing or, finally, throwing away in half-despair—all those struggles with the canvas and the paints and the lines and the other materials had vanished. These struggles were fights of the artist against the canvas and all the other materials that played a role in expressing whatever the artist wanted to show and, thereby, tell. The canvas disappeared almost, stepping back behind the description of the generative procedure. A transition took place away from focussing on material to concentrating on semiotic processes.

Canvas and other materials, as material, always have the power of resistance. Material does not want to be forced into certain forms pleasing the artist's will. Materials have their own strong will, a will of resistance, of keeping the form they had before the artist starts playing god in following her or his incessant formative will.

With the advent of the computer—i.e. with the program that is needed to force the computer into doing what the human wants it to do—the individual painting or graphic work started to disappear. The individual image can no longer claim the focus of all interest. To write a program or to design an algorithm, in other words: to accurately describe in unforgiving rigor to the machine what it is supposed to do under all circumstances—such a task makes sense only if, what you describe, is an entire class (or set) of images.

As an artist, who decides to develop software to control the operations of a computer, you *think* the image, you *don't make* it. For, the making has now become the computer's task in this relation. Such thinking almost immediately takes you to not think *one* image only, but many. Your

thinking leads you to think infinitely many images. Step by step, you put into abstract form more of the concrete individual decisions you would have to take when you force your materials into the form you want to achieve. In other words, everything that can be different in the resulting image becomes a *parameter*. Parameters are allowed to vary and take on concrete values from their associated and given sets of permitted values. The list of parameters defines the degree of arbitrariness, the potentialities the program allows for. This parameter list represents the cardinality of the new type of work. The individual work takes on the status of an instance only of the class it belongs to.

Always already infinities! That's the new ontology of the work of art in times of the generative principle. Only series of works, no individual pieces anymore![14] In particular, no more masterpieces! These are the horizons against which the algorithmic artist develops his or her skills and capabilities: Precision of utmost degree in order to allow the machine to freely fill in the gaps. Accidental surprise within great precision, this seems to be the new aesthetics. It's a jazzy aesthetics: Improvisation framed by computability! Imaging finally reaches the level where music has been for, perhaps, a century already. Thinking the image corresponds to improvising the jazz tune. The latter happens as performance in the dimension of time. Thinking the image aims at the dimension of space. But the image now wants to move. Therefore, thinking the image amounts to thinking the dynamic image. Describing it (the creative act) becomes an act of choreography.

These considerations have taken us far away from Harold Cohen in Las Vegas at the 1971 FJCC. So let us return!

Nees, Cohen, media

The subtitle of this essay promised I would “re:trace the origins of digital media.” However, I have given my versions of a few stories and developments of the early history of algorithmic art, by the time mainly called "computer art." Between the lines, the reader may have discovered indications of what would, at some later time, be called “digital media.” It seems

14 Even though, we still want to have and see the individual piece. We can *perceive* only the concrete piece, the representative of its class. The class, we can never perceive. Art in algorithmic times seems to lose its major attraction. It gets reduced to concept, away from percept. This observation may be irritating to some of us. But we don't lose the joy of sensual perception; we gain the joy of algorithmic thinking. It is about abstract concept where perception is about concrete percept.

about time that we get to the announced topic. What are origins of “digital media?”

Computers are machines. They are in line with, and continue, the development of machines that govern the era of industrialization: machines of great variety that transform matter and energy into new forms of matter. The societal purpose of the industrial machine is essentially to enhance and expand productivity of manual labour. During the epoch of big industry, *mental labour* still remains with the workers. But by the end of the 19th century, Taylor's *Scientific Management* starts to rigorously investigate the organization of work itself (Taylor 1911). Mental components of work are gradually identified and treated in separation in order to further increase productivity of human labour and of machinic[15] production under the regime of capital.

From this process, mental labour emerged as a special occupation of industrialized labour, and even if the actual action of an individual worker appeared mainly to be of manual character, he could—seen from the purpose of his work—be an element of the totality of mental labour in a given industrial enterprise. It is obvious that a separation of manual from mental labour does not exist in practice. But the organization of labour can, under certain conditions, enforce such separation. Historically, it is an aspect of the alienation of the worker from his work under capitalist economy.

From then on (and this state is reached early in the 20th century with the conveyor belt and the organization of labour that it stands for), mental work itself becomes subject matter of rationalization. The *machinization*[16] of all labour does not stop before mental labour. A bit before the middle of the 20th century, the computer appears as the fantastic machinery to rationalize mental labour, and control all aspects of society that can be described by use of data. The computer's original and fundamental *raison d'être* is, very simply, the machinization of mental labour.

But then the most peculiar character of the computer not just as a machine in general (that it is and remains) but as the *semiotic* machine in particular, leads to unexpected qualifications and determinations of that

15 The term "machinic" – even though not very common – stands for "done by a machine" or "like a machine".

16 We here use the unusual expression "machinization" (and not, e.g., "mechanization") because the computer (as the instrument of the transformation of mental labor into machinic operation), is not a mechanic machine. It is correctly to be called the "semiotic machine". (Nadin 2007)

machine. The machine computer turns out to be viewed as if it were a *tool*, first, and soon later also as if it were a *medium*.[17] How come?

The view of the computer as a tool becomes necessary when it takes the gigantic jump from being an investment good to becoming a commodity for everybody. This happens around 1980 and a bit before. The PC appears, the "Personal Computer." Its name already announces that it is owned and used by individual persons. In this transition, the appearance of the Apple Macintosh in 1984 plays an important role in many ways. It was prepared by Alan Kay and his Learning Research Group at Xerox Palo Alto Research Center (PARC) during the 1970s.

This tremendously innovative group invented all the technological components and the metaphorical rhetoric that have led to the ubiquitous human-computer interface and to interaction design that we all became familiar with in daily practice. We all like it, use it and have inhaled it so that, with certain modifications, everyone can now use any computer for a lot of everyday operations. The surface of a computer has become a graphical interface which is a rich and growing collection of small images ("icons" as they are often wrongly called) that grant access to enormously powerful software. It, in turn, uses icons to get at the plethora of operations ("tools," again) made available by the software.

As with all other (hardware) tools there is a bit of expertise that must be acquired if we want to use the tools. But in relation to the horrendously complex functions available for us, the learning effort is modest.

Only ten years after the first Macintosh, the World Wide Web and, with it, the Internet, had its breakthrough (in 1994). It occurred when the first graphical browsers appeared (Mosaic was one of them and the most successful). Now it became possible that the growing number of users of PCs could easily access all the greatly heralded goodies of the Internet. The powerful machine on everybody's desk at home and, often, also at work, now was to be used as if it were a tool and as the access device to the mega-machine of the Internet. It gained media-character in many ways.

Air is the natural medium that makes possible life of those animals and plants occupying the crust of the earth and the space above it; water is the

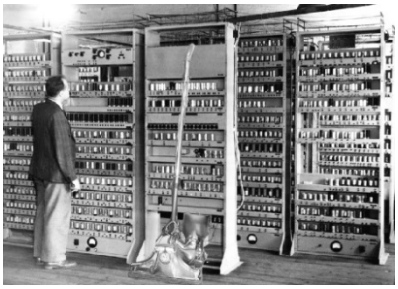
17 It is an interesting coincidence that A. Michael Noll, one of the earliest pioneers of "computer art", in an article of 1967, calls the computer at the same time a "medium" and a "tool" (Noll 1967). Here are two quotes from the beginning of his paper: "This article explores the possibilities of the computer as an artistic *medium* ...". And: "In the computer, man has created not just an inanimate *tool* but also an intellectual and active creative partner ..." (my emphasis). Even the "partner" appears here that has since been dropped but seems to be re-emerging just now as Artificial Intelligence is tooted again.

natural medium of those living in it. Natural media are ubiquitous, and noticed only when missing. Technical media are never unnoticed to the same degree. But they may get close to it. Current digital media are approaching such a state of supporting life. The digital medium was born as an offspring of the semiotic *machine* when humans as individual beings discovered its *tool*-like character, and, as social beings, they also discovered its *media* qualities.

I needed this summarizing view of the semiotic machine as tool and medium in order to now get back to our two heroes, Georg Nees and Harold Cohen. Our visual perception and visual senses (and, to a lesser degree, the auditory senses also) played a decisive role in the creation of the tool-perspective of the computer. Visual perception (combined with symbolic understanding) also played the decisive role when the computer as a calculating machine was transformed into the access device to a ubiquitous medium. Because that medium is based on algorithmic operation and digital storage, it has become the medium of all media. All the media we know keep their specific aesthetic qualities. But transposed into digital code they seem to become accessible without break of medium. We pay for this with a loss of sensuality. But we seem to accept this loss for the sake of a homogenizing convenience in availability, accessibility and perceivability.

All that was in the most innocent way prepared when specialists like Georg Nees and Harold Cohen started to program the computer to generate images that they put up on the walls of galleries, thereby claiming, it was art. The innocent experiments by the mathematician turning to aesthetics, and by the artist turning to algorithmics turned out to prepare for a cultural revolution of such enormous impact that we even nowadays struggle to fathom the floods that were created.

It is purely a coincidence, but it is true that, in hindsight, these two sorts of experts had to move at almost the same time: the mathematician and the artist. Both had to leave their professional homelands and intrude the other's land: It is between, and in, both algorithmics and aesthetics that digital media appear.



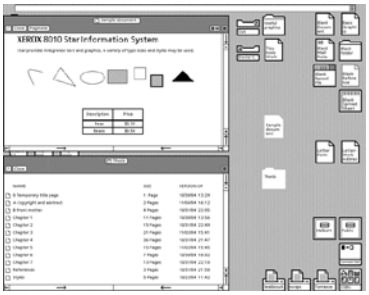


Figure 7. Three levels of computer development.

Mainframe computer: machine (late 1940s); Personal computer: tool(mid 1980s); Hidden computer: media device.

The medium was the message

Marshall McLuhan's famous, then forgotten and only recently revived publication *Understanding media* (1964) may be read as a book to propagate one short slogan: "The medium is the message." The book's main title announces that reading it may help the reader understand what media are. If we additionally observe the subtitle, we learn what media are: "Extensions of man." And the heading of chapter one then offers the slogan, "The medium is the message." More you don't need to read.

Even though the work thus appears as a hard to top masterpiece in brevity of its content, let us still read the first sentence!

> In a culture like ours, long accustomed to splitting and dividing all things as a means of control, it is sometimes a bit of a shock to be

> reminded that, in operational and practical fact, the medium is the message. (McLuhan 1964: 23)

Each extension of ourselves—which amounts to "any new technology"—results in a "new scale that is introduced into our affairs" (ibid.: 23). Other authors (e.g. German anthropologist and sociologist Arnold Gehlen) derive from their observations that the human being lacks many preconditions necessary for survival and, therefore, the necessity for technology exists.

But McLuhan's interest is simpler. He studies technology as medium at a time in human history when the media of radio and television and the light bulb exist, among many more. The light bulb is the first example of a medium he studies: "The electric light is pure information. It is a medium without a message ..." (ibid.). So the example serves him well for the slogan that the medium is itself the message. More traditional authors might claim that a medium is used to transport a message from one location or actor to another location or actor. McLuhan's claim, however, is that "the 'content' of any medium is always another medium." As if media where a never ending self-perpetuating medium.

An old medium as content of a new one, according to McLuhan, is so for any medium irrespective of time and space: The content of the medium of writing is the older medium of speech, and the written word becomes the content of a new medium, print. The development of media follows a path from the naturally given to more and more refined technical media. But as this happens (and in our times, it happens at an accelerating pace), the new medium itself takes on the role of the content. The content gradually seems to evaporate, lose interest, become unimportant. Communication for the sake of communication. That's our time, isn't it?

Where ever you go, you must hold in your hand a smartphone in order to be ready immediately to answer any incoming signal. But more: You hold the physical gadget in your hand to signal that there is that gadget and it is yours. You are, perhaps, on your way to meet some friends of yours, and when you meet, you all stand in a circle or row demonstrating to the others that you are online. Is this then the message, the one and only message, permanently sent around?

Georg Nees and Harold Cohen had to describe in algorithmic form the schema that would be capable of generating a drawing. They then had to trigger a computer that was supposed to execute the algorithmic description. The execution resulted in a drawing that before did not exist. How-

ever, it was in some way contained in the space of possibilities the algorithmic description stood for.

That very description, as a description, was a medium. A medium of a high level of technological existence. It had to be sent to the computer which, thereby, was used as a simple storage medium. The act of "starting" the computer (triggering it) was interesting: The storage medium was turned into an operating machine. The machine was taking the stored description (insofar as an object), read it and interpret it. The act of interpreting the description meant that the computer (under the control of its operating system) would turn itself into a special-purpose computer generating a drawing which was, of course, another medium whose content were lines and marks on paper.

The human looking at the lines and marks that were generated in this intricate way by a process of several levels of media becoming their own content which again became a medium etc., this human visitor would save her disturbed mind from insanity by saying: Okay, an abstract drawing, geometric at best; I see squares and circles and also fancy lines.

Harold Cohen, however, developed AARON to a point where it could generate foliage and human figures stepping out of the jungle. Having reached this level of expertise, AARON was made to draw men and women in their homes with flowers on the table. They did not look photorealistic, as did the images by some other artists at the same time in the 1990s. But Cohen's images were clearly representing something we all would immediately recognize as woman and man and vase with flowers. So now, under Cohen's mind and hands, the medium re-gained content. Georg Nees did not follow this line.[18] What happened?

Harold Cohen had manoeuvred himself into a dead end. He wanted visitors to recognize what the black lines and coloured marks stood for. This had been his goal when he started his fantastic tour of developing AARON. His goal was to answer the question: What does it take as minimal conditions for an arrangement of graphic marks to be recognized as a figure? This was his problem of representation.

In the forty years of his unique journey, he had solved the problem. He had solved it in a fantastic way with many extra results along the tour.[19] But now he realized that the audience was more interested in watching the machine paint then in the image it painted. The medium had become

18 A bit later, Nees did turn to the figurative, islands, and landscapes, and persons. He was then doing image processing.

19 As his constructions of drawing and painting machines, solutions to algorithmic issues of shape and, to some extent, also of color.

the message even though the audience had no problem recognizing the contents of the images.

We might be inclined to judge as tragedy this recognition of Harold Cohen's at the end of the 2000s. But Cohen would not be Cohen if this would be his conclusion. He pushed to the side the large set of rules he had come up with and started anew all over! He quite easily found an algorithmic solution to the problem of lines he wanted to see and continue to work with. He also recognized that the colouring problem was algorithmically hard, if not untraceable because of its subjective implications. He now let the computer generate arrangements of lines in fantastic forms. They were projected onto a huge touch-screen. He himself interactively selected colours from a smaller display unit which then almost miraculously became the paint at his finger's tip to do finger-painting digitally, in the 21st century! The black lines became his inspiration for the choice of colours and the way of placing them onto the "canvas". *Conversations with my other self*, Cohen called his last exhibition. The medium no longer was the message.

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References

AFIPS. 1971. “Proceedings of the 1971 Fall Joint Computer Conference”. In *AFIPS Conference Proc.*, Las Vegas, Nov 1971. Vol. 39, pp.16-18.

Bense, Max. 1965. “Projekte generativer Aesthetik.” In *rot 19*, Stuttgart: Elisabeth Walther private publication, pp. 184-199.

Chomsky, Noam. 1956. “Three models for the description of language.” In *Information Theory* 2/3, pp. 113-124.

Cohen, Harold. 1980. *The program and art behind the museum's murals*. Lecture Sept. 23, 1980. www.youtube.com/watch?v=U1DbaUATNtY&index=1&list=PLAl91JHaOGs3766Kx8R58G7h4NIbp4MFh .

Debord, Guy. 1970[1967]. *The society of the spectacle*. London: Black&Red.

Knuth, Donald E. 1968. *The art of computer programming*. Vol. 1: Fundamental algorithms. Reading, MA: Addison-Wesley.

LeWitt, Sol. 1967. “Paragraphs on concepual art.” In *Artforum* International, Vol. 10, pp. 79-83.

Lunenfeld, Peter. 2001. *The digital dialectic*. Cambridge, MA: MIT Press

McLuhan, Marshall. 1964. *Understanding media. The extensions of man*. New York: McGraw-Hill.

Nadin, Mihai. 2007. “Semiotic machine.” In *The Public Journal of Semiotics* 1/1, pp. 85-114.

Nake, Frieder. 1992. “Informatik und die Maschinisierung von Kopfarbeit.” In Wolfgang Coy et al. (eds.): *Sichtweisen der Informatik*. Braunschweig: Vieweg, pp. 181-201.

Noll, A. Michael. 1967. “The digital computer as a creative medium.” In *IEEE Spectrum* 4/10, pp. 89-95.

Noll, A. Michael. 2014. *First hand. Early digital art at Bell Telephone Laboratories*, Inc. ethw.org/First-Hand:Early Digital Art At Bell Telephone Laboratories, Inc .

Reichardt, Jasia (ed.). 1968. *Cybernetic Serendipity. The computer and the arts*. Special issue of studio international, London. Reprinted in 2018.

Schelhowe, Heidi. 1997. *Das Medium aus der Maschine. Zur Metamorphose des Computers*. Frankfurt: Campus.

Schmidgen, Henning. 2017. *Forschungsmaschinen. Experimente zwischen Wissenschaft und Kunst*. Berlin: Matthes & Seitz.

Snow, Charles P. 1959. *The two cultures and the scientific revolution*. London: Cambridge University Press. Reprinted in 2001.

Taylor, Frederick W. 1911. *The principles of scientific management*. New York: Harper and Brothers.