GENERAL ARTICLE

One Never Knows

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ABSTRACT

Understanding anticipatory action as undergirding the dynamics of life is the prerequisite for defining what art is. Its change over time reflects the fact that life is purposeful and escapes prediction. Explaining art from the perspective of means and methods involved in producing it, from a deterministic view, leads to circular reasoning: the conclusion (machine art is the future) is in the premise (machines can make art). This fallacy becomes evident in the context of the current infatuation with automation of artmaking (especially through AI), and even art evaluation. The role art plays in defining the human condition is no less significant than that of science, itself indebted to aesthetics in its expression.

The Editor was clear: "I can't imagine *ArtForum* ever doing a special issue on electronics or computer art, but one never knows" (Phil Leider, 30 October 1967). Almost 60 years later, many books and journal issues have been dedicated to the subject. Of course, artists need articles or books about their work, or, for that matter, history or theory of art, aesthetics, and all other writing about what they do, as much as birds need ornithology in order to survive. (This is a paraphrase of Nobel laureate Richard Feynman's opinion about theory of science.) Words might tickle their egos or increase the price people pay for their works. But their art—if it is art—does not depend on opinions (competent or otherwise). Related to this: In times such as ours, when the production of artifacts claiming the status of art by far exceeds our ability to even keep a record of them, a simple question cannot be avoided: "What is art?" Artists and many others have produced rushed answers (now available on ChatGPT or Bard). Those on record have never settled the subject once and for all. And they never will. Art continuously redefines itself. The various activities through which it comes to life leave behind a lot of waste that claims recognition. When egos are involved, even refuse can become explosive.

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After all, "But I like it" serves as a sui generis certificate—behind which hides, "*De gustibus et coloribus non es disputandum*" (In matters of taste and color, there can be no disputes). It is a bit confusing—some like it, some don't—since the phrase covers as well liking a stone, a flower, a dress, some dish of food. Or some person. To identify the role art plays in humankind's self-making is the only way to free the answer from the deadly, but unavoidable, embrace of subjectivity. According to solid geological findings, empirical evidence regarding aesthetic characteristics of human activity goes back some 500,000 years. At some moment in time, the making of art became a distinctive activity with a particular role in the self-making of *Homo sapiens*. It was yet another moment in the human becoming different from anything else alive, an evolutionary marker rarely highlighted.

Everything humans do—from seeking sources of energy, to sexuality, to making tools, to describing reality—questions the future. Art is one among the many forms of inquiry through which life unfolds. It is a record of awareness ultimately expressed in the question: "What is the meaning of life?" Change drives art, as it drives everything else. In a world absent of change, there would be no art, not to say that there would be no life. The human being as an embodiment of change would not exist. This ontological premise leads to an inescapable inference: Art is consubstantial with human life. It is the record of our awareness. To ascribe the qualifier of art to the output of some grotesque conditioning of animals—elephants, horses, monkeys, birds, reptiles, and so on—is at best an example of legitimized cruelty, if not a practical joke. Nevertheless, examples of "animal art" have even been successfully auctioned—the silly implication being that if something is auctioned (and people pay for it because they like it), it must be art.

The hour of machine-based automated making of all kinds of products supposed to be recognized as art is only a confirmation of probably well-intentioned attempts at ascribing to animals intentions that are not part of their condition. Neither animals nor machines understand what

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they are "programmed" to do. Animals were tamed to provide power (pulling plows, driving treadmills, for example) or to become food (i.e. an additional source of energy). Machines were supposed to replace them (tractors are more efficient than oxen) in executing tasks that surpassed the physical abilities of human beings. Artists used them as well—think about what it took to build the pyramids—not as a substitute for their creativity, but rather as a means of production.

For the human being, awareness of change—on which survival and well-being depend—translates into the ability, moreover, the necessity, to inquire, to ask questions. There is no material record of Ur-Art (the origin of art): rhythmic movements, modulated sounds, synchronized activities. The interrogation implicit in rhythms, in sounds, in the use of odors, in sequences of motoric activity (such as in synchronized effort), is fully confirmed by the role they play in nature. The migration of birds, fish, butterflies, and algae are, evidently, different in purpose from how hominids express themselves. Survival is the lowest shared limit. Culture is the outcome of higher targets, transcending reproduction. The discovery that aesthetic expression augments human activity—better shelter, better food, more successful hunting and fishing—makes it part of the dynamics of evolution.

For this phase of human evolution, anthropologists produced reconstructions—conveniently defined as rituals, ceremonies, myths—illustrated through a variety of geological findings. The earliest material testimony comes in the form of questions regarding the sky (moon, stars, clouds, etc.), lightning and thunder, rivers, and animals, or in acknowledging disease. The Venus of Tan-Tan (dated rather indecisively to 500,000–200,000 BCE) in quartzite rock, and the Venus of Berekhat Ram (ca. 200,000 BCE) in red tuff pebble are as impressive as the three little pigs (ca. 45,000 years ago) leaping across the limestone walls of Leang Tedongnge on Sulawesi (an Indonesian island). They have in common not how they were made, but rather the specific inquiries into what the future holds. Art as inquiry is always for some purpose. There is a pragmatic dimension to early aesthetic *arte-facts*. They are "navigation systems," shared views of the threatening or the protective (eventually defined as the good and the bad shared concerns).

Whether the art is telling stories, singing, poetry, theater, dancing, drawing, object-making, painting, sculpting, photography, film, video, multimedia, or shelter and architecture, it by necessity consists of shared questions—more precisely, of inherited interrogations transmitted from one generation to the next. In making such art, humans made themselves. This is why making art is not different from interacting with it, making it yours in the act of perceiving it. The *awe moment* of making the Venus (at Tan-Tan or at Berekhat Ram), or of drawing the pigs, marks the path to the *awe moment* of their being perceived as question marks. The inquiry condition of art is like the waves on the surface of waters disturbed by the "stone" (i.e. the artist's ability to trigger questions that spread over time). Some of them disturb more, become even more relevant in new contexts than they initially were. Scientific explanations of natural phenomena are closed. Aesthetic expression is open-ended. Eco's *Opera aperta* [1] is a book title that offers a good description of the nature of art.

"Summer's lease hath all too short a date" (Recognize Shakespeare's 18th sonnet?) and T.S. Eliot's "I have measured out my life with coffee spoons," not to mention Frost's "Two roads diverged in a wood and I— / I took the road less traveled by," are part of the same testimony to the inquiry that drives every form of art. Interactions with such poetry are much different in our time than when it was originally entrusted to pen and paper. Examples from all the arts, and from every corner of the world, make the argument even stronger. But they also exemplify how creativity is expressed: anonymously in the ritual, and increasingly as a personal expression, eventually consecrating art-making as a profession. Engineers answer questions ("how to?"); artists interrogate ("why?"). Each interpretation, from casual perception of artworks to specialized analysis, is an answer (or several) to the question(s) posed by the creators of art.

FROM ANONYMITY TO AUTHORSHIP

The ongoing process in which making art is making a new human condition eventually led to the identifier "artist" and to the expectation of talent. Regardless, shared efforts, shared means of expression, anonymity or extreme individualism, the interrogation—including questions about the "Why?" of the art itself—remain the defining aspects of art. The cycle of life and all that it takes to overcome danger and succeed are part of an incessant questioning process. The meaning of change is what art expression is about. Aesthetics, always a step behind the making of art, is its language. From the art of the beginning to the many forms of expression through which it evolved—theater, architecture, photography, filmmaking—the focus is on what it means, not on how it is made. The fingerprints on clay or on the surfaces of cave paintings reflect the experience of immediateness. Over time, the act of making becomes mediated by tools of trade and materials conceived for particular aesthetic purposes. The physical is effectively substituted by the meta-physical: no longer presentation—lamenting or joyous voices, painted bodies dancing—but re-presentation: drawings, carved bones, narrations.

Against this background, the current challenges of new science and technology acquire a particular understanding. When the maker (e.g. the person at the pottery wheel, the weaver at the loom, the man or woman chiseling in marble the head of an imaginary character) is identifiable, authorship is easy to assign. In movie-making, hundreds, if not thousands, are involved. The dynamics of art reflect the nature of the art process. The newest machine, newest until the next hour, is part of everything humans do, or no longer do. Machines perform a great deal, including the making of what looks like art, or the making of copies, which sometimes look better than the original. In this respect, one preliminary observation: Since the earliest attempts at replacing numbers, as an output of computation, with images (started by Ivan Sutherland, in

1961 [2]), a path was opened toward using computer graphics—image generation—for artistic purposes [3].

Unavoidably, the focus became the "How?" of the process while the "Why?" of art was abandoned. There is nothing to object to the interest in the means used. After all, the abstract lines and dots on eggshell engravings (e.g. the Diepklook Rock shelter on the Western Cape of South Africa) or the cupules (of Les Eyzies in the Dordogne, France, all around 60,000 years old) are examined more as technical achievements than as meaningful expressions. Are they human-made or only accidents due to the laws of physics and chemistry? The same holds true for the beginnings of what is called computer art: "How did they make it?" instead of "What does it mean?" became the focus.

Let's stay focused on the art perspective. Desmond Paul Henry, whom Rawsthorn [4] celebrated as an early researcher in computation-supported graphics, started his adventure using an analog device deployed on airplanes in World War II. His geometric forms were displayed at the *Cybernetic Serendipity* show (Institute of Contemporary Arts, London, 1968). As impressive as this was at the time, one cannot forget Albrecht Dürer [5–6] and his analog computers: the compass—an analog computer for drawing circles—and the ruler—the embodied algorithm for the line—just as one cannot ignore Leonardo da Vinci—the master of inquiry, examining how leaves fold, how motoric expression is anticipatory, how facial expression gives away intentions in advance, and how individuals evolve over time.

"The noblest pleasure is the joy of understanding" expresses Leonardo's awareness of the questioning nature of art. It is embodied in drawings such as "View of a fetus in womb" (1511), "Study of Brain Physiology" (1508) and "Sprays of oak-leaves with a cluster of acorns" (1506–1508). It led him to a description (in *Trattato della Pittura*) of anticipatory processes at work when we raise our arms [7]. Aware of technology as a means for a variety of purposes, and aware of what mathematics can do in support of artistic inquiry, Leonardo realized that no work of authentic art is ever finished—much like the making of a table or of a brush—since those interacting with art continue the inquiry.

Does it really matter that Jackson Pollock did not use a brush but projected paint onto the canvas? The work is trivial from the perspective of "How?" it was made, but quite challenging in terms of the inquiry effort—human energy expressed in almost pure form. Many would-be artists have tried to throw paint against canvases, but the art refused to emerge. In the absence of authentic inquiry, the result remains incoherent, empty of life. Is this the case with computer art or the artificial intelligence (AI)/machine learning–based production of images, video sequences, games, stories, and poems? As Aaron Hertzmann has asked, "Could a piece of computer software ever be widely credited as the author of an artwork?" [8].

Sine Curve Man, a celebrated piece of "computer art," was present at the show where Henry was invited to display his inquiry into what the analog machine could do. It bore the signature "Charles Csuri/James Shaffer." In the age of integrated efforts, such as those expected in producing computer images or sounds, in making movies and videos, games, and multimedia installations, authorship changes. There was a J.G. Raudseps who worked at Ohio State University on interpolation of raster data (1963) in a piece called *Profile of a Woman's Face*. Additionally, there was Lester Miller, professor of mathematics (conformal mapping), originator of the idea; Jack Mitten, professor of engineering; and James Shaffer, programmer (the last two "wrote special functions for me," said Csuri [9]).

This is but part of the background behind the celebrated work eventually attributed solely to Csuri. I bring up this example, which I am familiar with, because at one time I worked in Ohio State University's Computer Graphics Research Group, not because Csuri would have taken credit from others, but rather because almost all those who courageously attempt to adopt computation in their art are in a similar situation.

My endowed chair in art and design technology funded the efforts of graduate students contributing not only to the flying logos of the ABC television network that originated in Csuri's company but also to attempts to integrate AI as a means of creating art. (Of course, the temptation to commercialize success was present: In the same building, Cranston Csuri Productions was a startup before every university pushed for new businesses based on the discoveries of their alumni.) Not unlike Frieder Nake and Georg Nees, who programmed, my own attempts were based on finding out whether the inquiry characteristic of art could be translated into programs. Was this a new aesthetic space? And if it was, what were its characteristics? More precisely, could the anticipation expression characteristic of art be generated by a deterministic machine? Although his focus was not on making art, it bears repeating that Sutherland remains the scientist behind everything done in the mathematical universe of computer graphics (including artistic endeavors, wars, and the World Wide Web).

Against this background of understanding, it becomes crucial to place the newest developments in some perspective. Before images were generated by a machine that turned numbers into lines and curves, there was music. Sound was heard before 1950 in Australia: by Trevor Pearcey and Maston Beard with CSIRAC, the country's first digital computer [10].

About 10 years later (1956–1959), Lejaren Hiller and Leonard Isaacson synthesized sound [11].

And again, before text-to-image, there was text (lyrics) to music—on TikTok, of all places. Indeed, music is the canary in the coal mine of machine-making of art. The relation between mathematics and music is probably more intuitive than the relation between geometry and space representation. George Legrady, credited for his digital media work, started his explorations of computer-based image generation in the studio of Harold Cohen (the artist who made AI his tool of inquiry) [12]. Legrady invited his students at the experimental Visualization Lab at the University of California, Santa Barbara (Fig. 1) to explore with him the aesthetic relevance of those more recent technologies that were making

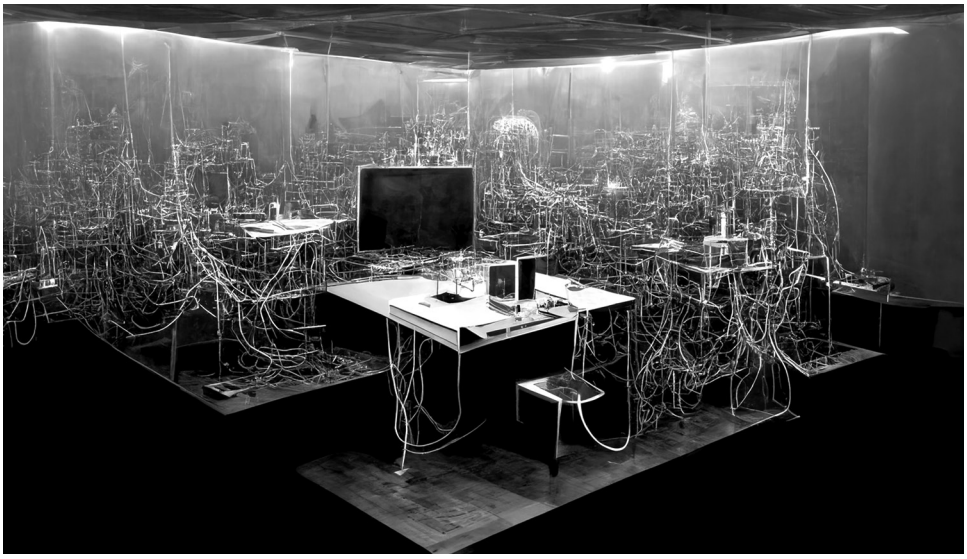

Fig. 1. George Legrady, image generated within text-to-image and image-to-image synthesis. (© George Legrady)

the headlines. Here is an example meant to debunk some of the latest myths of machine-generated art:

> I began with the phrase "imaginary workspace electrostatic," which produced an image. I then used that image to produce another one and continued in this manner. Each new image is dependent on its predecessor. Each is different and seems to occasionally reach back to an earlier version of course deviations [13].

The experiment shows how the echo chamber of neural networks training operates. Billions of images were labeled (often by hand) in order to make all kinds of associations possible. It is encouraging that students are actively engaged in discovering hidden rules, different in AI programs such as Midjourney, Stable Diffusion, DALL.E 2, and subsequent versions. Computation provides access to sources of inspiration, not unlike the paper clippings that students used to find in the foundation class collections of images provided by art schools to students in their junior year, before there was the Internet. The questioning comes from the artist and pertains mainly to how cognitive processes take place. Plus: never to be downplayed, the intellectual property aspect. Artists have egos! According to a lawyer (behind a new class-action suit), every image that a generative tool produces "is an infringing, derivative work" [14].

UNIQUENESS AND MEANING

It is encouraging that artists are exploring this new space of permutations, in which it is impossible to establish authorship even through the courts. But more important is the realization that expecting art to be automatically generated by machines is illusory. Machines do not inquire; they are the outcome of inquiries pertinent to technological development. What happens here goes back to Francis Bacon and his views. If Leonardo, Dürer, or others such as Michelangelo, Masaccio, and Fra Angelico, qualify as the originators of the infatuation with machine-generated *arte-facts*, Francis Bacon is the originator of the obsession with data and reproducible experiments. Reducing art to his ideal is to get rid of the artistic inquiry of meaning.

Csuri and Shaffer coauthored not only *Sine Curve Man* but also an article, "Art, Computers and Mathematics": "Suppose we have a machine which has stored in it all knowledge of art history theories of philosophy and aesthetics, in fact, the intellectual history of man" [15]. We are, with the monstrously large databases of texts, images, music, films, and so on, almost there, as well as to the question they posed (not knowing that it might apply to their own shared effort): "Who is the artist?" It is impossible not to agree with them. It is a terrifying and exciting question.

Imagine: A young Csuri or Shaffer (or both) could open shop in Carmel, California, the world capital of kitsch. Suddenly, all those galleries ceaselessly offering pseudo-art to people would be out of business. Machines are unbeatable at mass-producing customized insignificance—to each their own! In this context, nonfungible tokens (NFTs) as a distribution channel for the merchandising of art cannot be ignored. Short of a more engaging discussion about aesthetic aspects, a brief analogy is suggested: Buying NFTs is like purchasing space in a digital safety deposit box—the blockchain—not for jewelry you wish you owned but for an image of what you do not have but might access on a monitor.

Artists have always explored new means of expression and production. And they have explored ways to sell their art. This is an almost trivial statement. Not trivial is the understanding that Bacon's positivism—the doctrine of validation through experiment—applies to science, not to art. In the famous *Novum Organum* (1620), he ascertained, "The discovery of sciences . . . leaves little to the acuteness and strength of wits" [16]. Science requires precision, obtained from using a ruler or a compass. It "leaves but little to individual excellence" [17]. In art, to the contrary, individual excellence, the identity of the artist, his or her talent, is the source of

expressiveness. The computer "contains" all the perfect circles a scientist might need in order to describe how the nonliving—stones, shorelines, deserts, the universe with its stars and planets—change over time. The change described is of position only. The change of human beings is of their condition, not of their position in space. Art is about generating change related to life, which is never subject to law. Machines are built to provide sameness. Art is, by its nature, as unique as every aspect of life is unique, and not repeatable. Art is about the meaning of life.

References and Notes

1 U. Eco, *Opera aperta* (Milan: Bompiani, 1962).

2 I. Sutherland, *Sketchpad: A Man-Machine Graphical Communication System,* PhD thesis (Cambridge, MA: MIT Press, 1963). The arguments for why "computer art," as associated with algorithmic computation, is an oxymoron are presented in "The Age of the Fake," which *Leonardo* makes available online (https://direct.mit.edu/leon/issue/56/6). The text discusses in detail examples of images generated through the use of computers. It also explains why Ivan Sutherland is de facto the scientist whose work on the Sketchpad facilitated attempts at artistic expression in the medium of computation.

3 M. Nadin, "Art, Artists, and Computers," *Art & Artists* **17**, No. 5 (1988) p. 18.

4 A. Rawsthorn, "When Desmond Paul Henry Traded His Pen for a Machine," *New York Times* (27 February 2011).

5 A. Dürer, *The Four Books of Measurement with Compass and Ruler* (Underweysung der Messung mit dem Zirckel und Richtscheyt) (Nuremberg, 1525).

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9 Kerry J. Freedman, interview with Charles A. Csuri, Columbus, OH (23 October 1989). Charles Babbage Institute Center for the History of Information Processing, University of Minnesota, Minneapolis.

10 See "CSIRAC: Our first computer," University of Melbourne, School of Computing and Information Systems: https://cis.unimelb.edu.au/about/csirac. The CSIRAC pages were originally authored by Steven Pass, then substantially revised and maintained by David Hornsby. Further extracts are taken from Doug McCann and Peter Thorne, *The Last of the First: CSIRAC: Australia's First Computer* (Victoria: University of Melbourne, 2000).

11 Ayal Zipris, "ILLIAC Suite," Illinois Distributed Museum: https://distributedmuseum.illinois.edu/exhibit/illiac-suite/.

12 Private communication with George Legrady (10 October 2022).

13 Legrady [12].

14 Kyle Chayka, "Is A.I. Art Stealing from Artists?" *The New Yorker* (10 February 2023).

15 C. Csuri and J. Shaffer, "Art, computers and mathematics," *Proceedings of the December 9–11, 1968 Fall Joint Computer Conference*, Part II (New York: ACM. 1968) pp. 1293–1298.

16 Francis Bacon, *Novum Organum* (1620) Author's Preface.

17 Bacon [16] CXXII.

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Involvement in art and technology since 1958; researched the aesthetic space opened by computation since 1964 (images produced in 1968; digital sound sequences since 1964). Artificial intelligence involvement as the Eminent Scholar in Design and Technology at Ohio State University (1985–1989), continued within the Chair in Computational Design at the University of Wuppertal, Germany (1993–2004). 2004–2023—anticipatory processes pertinent to creative activities (art in particular)—University of Texas at Dallas.

The Age of the Fake—The New Normal

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ABSTRACT

The making of art, usually defined as creative act, cannot be reduced to data processing even when data processing is at work (such as in what is called computer art or AI rendered art). Neither can the interpretation of art (including history of art), regardless of how it was created, be made into a matter of data. Understanding art in its open-ended variety means understanding life, as expression of meaning.

The poet (Hölderlin) had it right: "There was never so much beginning!" The *Théâtre d'Opéra Spatial* –the fully identified AI program behind it—got a prize (August 2022) at the Colorado State Fair. "Garden in the Machine"—painted in cahoots with adversarial neural networks—opened in New York (September 2022). The Kate Vass Galerie in Zurich announced a show, "Dear Machine, paint for me" (a take on Martin Kippenberger's 1981 work in New York), displaying works by Frieder Nake, Alex Mordvintsev, Manfred P. Cage, Ganbrood, Espen Kluge, and the late Herbert Franke. Behind these examples is the large language model (LLM)—machine learning that handles natural language processing and links it to extremely large databases (in the range of 1.4 trillion tokens) of landscapes, portraits, and figurative and non-figurative art from many collections (the Met, among others). "Recite sentences that AI turns into images and you feel like an artist," so wrote on Twitter some of those who have tried the text-to-image technology. There is so much taking place that sites dedicated to what is cavalierly called "computer art" or "AI art" are literally choking.

The broader context is definitely more telling of what is actually happening than any set of examples (soon bound to be "old" stuff). Reputable publishers of scientific journals are faced with fake submissions. In some cases, visuals used as proof of experimental evidence turn out to originate in the machine-learning procedures similar to those coming from the newest images vying to be recognized as art.

Remember the "Hitler Diary" euphoria of 1983? Konrad Kujau, a forger, set a trap into which *Stern* magazine in Germany, as well as *Newsweek* and the *Sunday Times* of London rushed into with the same naivete as TV and radio stations that feed fake news to those no longer capable of or wishing to distinguish between the fake and the real. A movie—*F is for Fake*—documents forgeries since the time when they were morally unacceptable. Michelangelo, the great artist, presumably produced fake antiquities. Elmir de Horry (50 million "old" dollars from cone art), Eric Hebborn (who painted copies of Breughel, van Dyck, and Rubens)—rebellion against those in power was his excuse—van Meegren, Wolfgang Beltracchi, and Ken Pereny—each outperformed the others. They chose anonymity—although their skills would have easily bought them celebrity status if applied through original works. China is folding the operation in the Shenzhen village of Declan that used to make, by hand, almost 80% of all copies of famous works sold in the USA and in Western Europe. The Chinese now prefer to invest in AI research instead of competing in the fake art market. One curious detail: they request that AI-generated media (text, image, voice, video synthesis) be earmarked in order to avoid the spreading of fake messages and to protect legitimate rights.

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TECHNOLOGICAL PERFORMANCE VS. ARTISTIC RELEVANCE

Creation—giving birth—is a seductive endeavor. Uniqueness is definitory of everything that is alive. There are no two identical cells among the hundreds of billions in the human body. This is not a caprice of Nature, but rather an existential necessity. Life is, by its nature, never-ending creation. Art, as one among the many forms through which the need to know (oneself, others, the world) is expressed, can result in making artifacts (e.g., paintings, sculptures, photographs, movies), in texts and music, in performances (e.g., songs, movements, theater, games). In an ever-faster changing world of unprecedented technological innovation, art changes, too, not by some decree or aesthetic whim, but by *necessity*.

Survival explains the existential need to know. Art is one among many forms of inquiry. The outcome of artistic activity is an aesthetic expression of shared awareness. The ritual, the mythical, the religious are question marks of social relevance. Art is no less questioning of how the universe functions than the descriptions called *science* and *philosophy*. But instead of seeking the commonality of change in nature or in human nature, and expressing it through laws, art reveals uniqueness.

It is against this background of what makes art expression necessary that any new form of art can be analyzed. Passionate pioneers of computer graphics (from the early 1960s), attempting to properly frame their creativity, deserve respect for researching aesthetic possibilities connected to computation.

When, in 1971, Nake screamed, "There should be no more computer art!" (the title of his essay in the *Computer Arts Society Bulletin* [1]), his experience with the computer morphed into an ideological point. A lot was at stake. To make computer art, as he believed he was doing, implied enlisting in the defense of capitalism and supporting wars. Years before, in 1965, a student publication at the University of Stuttgart reproduced one of his early computer-generated images (as well as one by Georg Nees, Fig. 1) calling it "stochastic art."

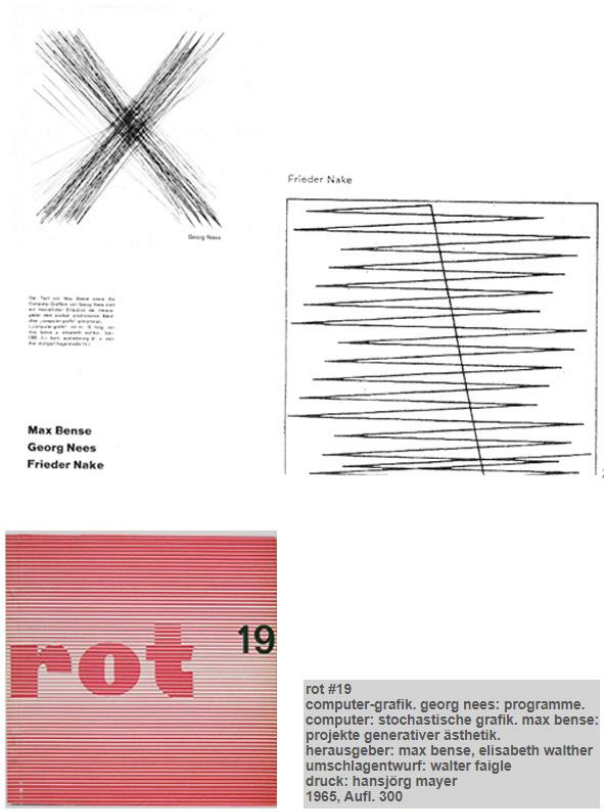

Fig. 1. In 1965, in a series called *rot* (red), published by Max Bense and Elisabeth Walther, issue 19, was entitled "computer graphik." The *Studenten Zeitung* (Students Newspaper) reproduced images from this issue of *rot*.

Max Bense (Nake's professor) was, like his friend Abraham Moles (professor in Strasbourg), against speculative aesthetics. They offered the conceptual background of generative aesthetics, combining Birkhoff's mathematics and Peirce's semiotics. The alternative advanced: "Measure" the artwork in order to understand it. Use the data from measurement and generate new art. The detailed quantitative description of the form—usually defined in semiotics and computer science as the *syntax*— together with operational rules for generating alternatives, was, in their view, sufficient for rendering the outcome aesthetically relevant. That the same data could be derived from a work of art as well as from its copy was of no interest. They cavalierly ignored Walter Benjamin's warning about "art in the age of its mechanical reproduction." The age of the fake originates at the meeting point of computation—i.e., the data-processing machine—and generative aesthetics. With Bense and Moles (and their followers) the aura of art was replaced by the aura of data processing. It was the next step in the idolatry of the machines that originated within Descartes' reductionist determinism.

THE IDOLATRY OF THE MACHINE

What became known as "computer art" is, for all practical purposes, nothing other than applications of computer graphics. This goes back to the 1950s: the SAGE system for air defense used visual representations of space. Ivan Sutherland [2] conceived the *Sketchpad*. Visual primitives (e.g., lines, polygons, arches), defined in the Bauhaus tradition, were made available for applications such as design drafting, but also for military applications. Vector graphics (supported by the 1965 IBM 2250), and eventually raster graphics (inspired by none others than the post-impressionists), enabled the modeling of objects. The focus on military applications was never made explicit. Sutherland, as well as Andries van Dam (who, at Brown University taught almost everyone involved in computer graphics) are the pioneers of translating knowledge pertinent to perception of reality (in particular space) into images. Neither ever claimed recognition as artists.

The visual, as opposed to other forms of representation (e.g., the formalism of logic, the language of mathematical formulae, among others) facilitates different forms of describing reality than natural language does (using words, sentences, etc.). Visual language serves well in activities as different as medicine, design, chemistry, engineering, and, not surprisingly, military efforts. In this respect, it is quite telling that *Computers and Automation* (published by Edmund C. Berkeley since 1950), after discovering a "New Handmaiden of Aesthetics," launched an Annual Computer Art Contest. The winners in 1963 and 1964 are the US Army Ballistic Research Laboratory (Aberdeen, Maryland). The images awarded recognition (e.g., ricocheting bullets) correspond to its mission. Eventually, Frieder Nake himself would get a prize. This was before his awareness of how computers, computer graphics in particular, became the underlying science and technology of all recent wars caught up with his revolutionary enthusiasm.

The ideological position that Nake takes—no more computer art—reflects his political profile. His aesthetic choices correspond to a view anchored in an aesthetics devoid of its core: meaning abandoned in favor of measurement. One of Nake's favorite modern artists is Sol LeWitt. For him, Conceptualism (with which LeWitt identified) meant "all the planning and decisions are made before hand and the execution is a perfunctory affair," [3]. The sentence: "The idea becomes the machine that makes art" defines algorithmic art by an artist who did not use computers.

Artists, always eager to expand their investigation of reality—as they did when photography, for example, and, later, filmmaking emerged—did not hesitate to experiment with Sutherland's Sketchpad, or, like Nees, Nake, Noll, and many others, to take up the challenge of "talking" to the machine. Harold Cohen was one of such artists (investigating the AI of his time), as Manfred Mohr still is (dedicated to algorithms but also aware of semiotics, [4]). Regardless of whether they used programs written by others (such as Shaffer for Csuri) or attempted to program themselves, somehow one question in particular regarding the results gained from interacting with the new machine could not escape their mind: *Who* is the artist? In Harold Cohen's home, he and I debated whether, after his life ended, whatever "Aaron" (the machine) were to output would be his art. Selection from among the many variations of an image was, in his view, part of the creative process.

Of course, Nake, like many others, asked whether there was any accomplishment in the "computer art" domain that qualified as exceptional (commercial success or not): "How far away are we from the first masterpiece of computer art?" [5]. Jasia Reichardt [6] noted that the effort "produced nothing so far that can be called a great work of art." Again Nake [7]: *Und wann nun endlich "Kunst"-oder doch Lieber nicht?* (And when, finally, art—or better yet not?). In other words: Is it art, or better let us stop kidding ourselves? Those passionate about experimenting with the newest technologies often question their own efforts.

Questions from individuals sincere in their efforts to become artists populate discussions on social media. Suddenly, they are able to generate images using machines that "translate" their words into paintings—actually matching language patterns to images in vast databases. But they have no idea whether what they do qualifies as art. They expect others to make this call, or to qualify them as artists. There are already machine-generated short films posted on the world wide web. And there are games, many games. "Pretty crapola" said an art critic (*New York Magazine's* Senior Art Critic Jerry Saltz talking to "Nightcap's" Jon Sarlin) known to be open to experiment and innovation. Aesthetic junk, maybe not at the scale at which it can be generated using computers, is nothing new within culture. It is inevitable, as much as scientific and technological junk is inevitable. But is the hope for good art automatically generated through faster and more sophisticated machines also inevitable? The aesthetic cost associated with exploring automated artmaking has yet to be acknowledged. Bad taste is contagious.

Within the no longer extant ATEC School (at the University of Texas at Dallas), I carried on, for almost eighteen years, an experiment involving more than 1000 graduate students. The assignment: *Is an aesthetic machine possible?* To the best of their abilities, they produced prototypes and posted their presentations on YouTube. If anything, the realization that, so far, such machines did not produce art was pretty much unanimous. It's good to know what does not seem possible. Not in order to limit investigation, but rather to define its purpose.

To acquire knowledge—which is the ultimate purpose of artistic endeavors—no matter in which form (scientific theories describing laws of nature or works of art as an expression of uniqueness, not subject to law) is a noble task, but not necessarily always successful. Many Nobel prizes inadvertently recognized junk (remember the award given for the science that led to lobotomy?). Peer reviewed articles are retracted in large numbers; reputations are often questioned. Throughout history, the Masters, i.e., the successful artists, often produced junk—and disposed of it with the same fervor they used in promoting what was successful, or in winning more patrons. Therefore, to evaluate the outcome of the computation behind the increasing number of attempts to automate the making of art by comparing it to what is acknowledged as art is a futile exercise. Given the particular nature of art, the question is whether the dominant form of computation today—i.e., the algorithmic—can result in art, exceptional or not. Processed food replaces the art and common sense of cooking (never mind how nutrition affects health). As "food" for the soul and mind, art is justified by the interactions it triggers. Its meaning is the outcome of such interactions, changing over time as the human itself is continuously changing.

THE IMPOSSIBLE—IS IT ONLY A MATTER OF TIME?

As a preliminary, a short comparison: The mechanical contraption we call a photographic camera and its digital implementations have in common "Painting with light." Today, everyone "takes pictures" without automatically becoming artists. Albeit, everyone can now have access to a program that a text command ("Make me a landscape with flowers") turns into AI images. Before that, TikTok, with its machine-learning-based algorithm turned lyrics into songs. The *machine illusionist* is not hiding its secrets—it is not the art that wants to be celebrated, but the computer. As artists, photographers capture knowledge of the uniqueness of a person, of a landscape, of a thought, of shapes, etc. They do not merely record impressions of a vacation or a graduation. Photography expanded the aesthetic space: the invisible, the remote, the intimate. It made new creative experiences possible.

Change itself can be investigated, with the benefit of shedding light on meaning. Computer-generated images (and for that matter sounds or 3D-printed objects, games, animations, etc.) exemplify new production means. At the beginning there was the raster image. It was inspired by TV images: point-to-point lines were drawn, and curves were attempted. It was a one-dimensional geometry. Soon afterwards came surfaces and volumes. But they were not scalable. The mathematics of vector processing assumed a library of shapes and colors, easy to use as desired. Then arrived the time to use the huge library of images accumulated by millions and millions of users of computer images. The mathematics of tensors, making possible operations within immense databases, supports the illusion of "painting" a new world, of conceiving buildings, of making new gadgets or even of producing answers, in articulate language) to whatever a user wants to ask. No

guarantee of accuracy. But it all sounds and looks like it is real. Albeit the aesthetic space made available to those who use computation (including AI) is that of the past: data is always a description of what was, including the art of the past or various texts stored over many years. The past is the "recipe." Comparing the impact of photography and of computation-supported artistic endeavors prompts one clear-cut question: Is creativity possible in algorithmic computation?

"Squaring the circle" is the classic example of an impossible task: *In a few steps, construct a square with the surface of a circle, using only a compass and straightedge*. The mathematical proof boils down to π being a transcendental number. The numbers 3.14159265… after the decimal point go on and on. Therefore, it is impossible to draw a line of this length. The area of a circle depends on π, but the area of a square does not. Consequently, it is impossible to draw a square with the same area as a given circle using a compass and a straightedge. There are other impossible tasks, such as doubling the cube or trisecting an angle. It is not a matter of time or of resources (such as more computing), but rather an intrinsic characteristic. As Sam Altman (of fame through Open Ai and GPT-4) put it: "The speed of light is such an annoying thing," meaning that there is no higher speed possible within relativity theory.

It turns out that the Turing machine—the mother of all algorithmic machines—is the result of yet another impossible task. In a simple formulation: making a machine that, for every statement, would tell whether it is true or false. It was formulated by Hilbert and Ackerman [9]: Is there an effective procedure which, given a set of axioms and a mathematical proposition, decides whether it is or not provable from the axioms? No one interested in whether computer art is possible would read this challenge—how to decide upon a mathematical proof—as having anything to do with whether "computer art" is possible. But the provenance—the origin, the record of ownership—of the question of whether computer art is possible, or even whether the automated making of images qualifies as art, begins with a mathematical challenge. Although the type of knowledge acquired mathematically and the type of knowledge acquired in artistic endeavors are different, there is art and uniqueness in both. Questioning defines both, and so does their artistry—they are human made. Indeed, mathematics—the language used in describing quantitative aspects of reality, and art—the language describing the meaning of our interactions with reality—have in common their aesthetic identity. Jacques Hadamard [8] identified elegance as a criterion for his mathematical expressions:

> "It may be surprising to see emotional sensibility invoked *à propos* of mathematical demonstrations which, it would seem, can interest only the intellect. This would be to forget the feeling of mathematical beauty, of the harmony of numbers and forms, of geometric elegance. This is a true esthetic feeling that all real mathematicians know, and surely it belongs to emotional sensibility."

With all this in mind, it should by now be clear that the *Entscheidungsproblem*—the decision problem—is relevant to art as much as it is to mathematics. Turing (in the footsteps of others) demonstrated that the *Entscheidungsproblem* cannot be solved. His paper, "On Computable Numbers, with an application to the *Entscheidungsproblem"* [9], describes a way to deal with anything that can be described through a recipe (*algorithm* is the fancier word). The *Yes* or *No* of a mathematical proof cannot be derived from a recipe, i.e., it is not an algorithmic procedure. The Turing machine contains every machine that works on recipes: all the typewriters (reduced to word processing programs), all calculators, all pencils and brushes can be reduced to algorithmic computations. All imitations—TikTok or Stable Diffusion, not to mention DALL-E-2 (or whatever comes next).

For everything of a deterministic nature, for which we can identify a cause and an effect (the "recipe"), the machine delivers a testable description of its functioning. It cannot determine—the impossible aspect—whether a proof is right or wrong in a limited time and in a limited number of steps. This is not a provisional limitation, but the necessary consequence of the premise upon which it was conceived. Mathematics and, for that matter, the arts are by their nature non-deterministic activities; that is, the same cause can have unpredictable outcomes. There is Euclidean geometry—in which parallels do not meet—and non-Euclidean geometry—in which they do meet. Thus, it is unsurprising that algorithmic computation would not suffice for deciding to what extent something is mathematically right, or, for that matter, artistically meaningful. The art of the Impressionists was physically attacked (in exhibitions between 1874 and 1886) by those who would not accept it. ("The critics are eating us alive" Pissarro complained in a1874 letter to a friend.) The art of Jackson Pollock, of Mondrian, of Picasso, and of Jasper Johns are examples of reactions to new forms of aesthetic expression. They are discoveries for which no description, no matter how detailed, can substitute. Their *raison d'être* is their ever-changing meaning—the interactions with viewers of our time are different than those of times past. They derive their living nature from such interactions. Let us translate these considerations of logic and mathematics into the specific subject of "algorithmic art" (yet another name for "computer art").

Of course, art is not a mathematical proof. (And mathematical proofs, despite their artistry, are not works of art.) Moreover, art is not the translation of reality in the broadest sense of the word, i.e., including the reality of thought, of emotions, and of art itself. Art is rather the unique interpretation of reality. In a succinct formulation: Art conjures meaning where science seeks and demonstrates truth. The Turing machine has only a syntactic dimension: there is no meaning in the sequence of the two letters of its alphabet (zero and one). There is no pragmatic in computation: it can process the trajectory of a falling stone, of a bullet in the air, of the flight of drones, regardless of the *WHY?* of their movement in time and space. The *WHY?* of art is driven by the pragmatic. Its formal aspect, i.e., the aesthetics—its "language"—as it is sometimes called, becomes essential in reaching its goal. To know in terms of

art is to engage its public—ordinary individuals or specialists (art historians, critics, etc.) in the questioning. To interact with a work of art is unavoidably *to make it again*, with the purpose of understanding it, in the context of its perception. Picasso's *Guernica* in the context of World War II, made possible by the industrial age, and in the context of the wars made possible by computation, triggers different questions. Searching for what the artist meant (the artwork as a riddle) is as illusory as explaining who we are by examining the genome of our mother and father, or our own genome. *We are what we do*, not what we are made of—although what we do is in many ways conditioned by our make-up. Art is what it means, not the data describing the matter in which it is embodied and transmitted. When the Chinese copied masterpieces, they even faked the proper amounts of lead in the white pigment used by the artists (for instance, back in the Renaissance). Of course, it did not give aesthetic life to the fraudulent copies. It did not make them authentic To be clear: There is no authority—critic, theoretician, politician, investment advisor, etc.—who can decide what is art and what is not. Art is what artists have made it to be over time, regardless of how their work was described in books on theory, or what technology assisted them.

"COMPUTER ART" IS CAMPBELL SOUP, BUT NOT WARHOL'S "CAMPBELL'S SOUP CANS."

Let us unpack this subtitle: Computer-generated artifacts—music, images, objects, multimedia, games, etc.—are as much art as Campbell Soup (or that of Heinz, Kraft, Nestle, or Maggi) is soup. Of course, the immediate reference here is to the art of cooking: the soup our mothers, grandmothers, and sometimes fathers and grandfathers prepared; liquid food, reminiscent of bread soaked in some sauce, as the etymology of the word suggests. Never the same, even though the recipe that everyone wanted promised a repeat. But it was not: the water used is different, the pots are not the same (some carry the taste of previous cooking experiences in their material), a pinch of salt added after tasting, some spices, another boil. Homemade soup is *Repetition without repetition* (a formula that N.A. Bernstein [10] used to describe how the human motoric system works). To be clear: the subject of Andy Warhol's famous 32 synthetic polymer paintings—corresponding to the 32 processed soup flavors produced by Campbell—is not the soup, but consumer culture. His aesthetic focus: "I don't think art should be only for the selected few." Mass art (processed as printmaking) would be the equivalent of mass-made food in factories. This rather innocent observation inspired the provocative label "canned art" in a discussion disclosing my enthusiasm for the possibilities opened through computer graphics (SIGGRAPH 1985) [10], [11]. I chaired "On the Aesthetics of Computer Graphics." Hiroshi Kawano, Frank Dietrich, Charles Csuri, and his assistant Tom Linehan (an Irish genius of art administration) joined me in a conversation that upset Silicon Valley entrepreneurs present. They were more interested in monetizing computer graphics (the military was active in funding it) than in promoting a new aesthetics for which they were not prepared. For the record: established artists at the time considered computer graphics with interest, but were rather reluctant to change their art, or their view of what it is. It was not worth the effort of learning how to use a computer program—never mind how to express, in the miserable programming languages of the time, what they would expect a machine to do for them.

Barbara Nessim was attracted by computer graphics (Fig. 2), as was Nam June Paik and, later, David Hockney, not so much because they could accomplish aesthetic goals otherwise not attainable, rather because they searched for new means of expression.

Fig. 2. *Rainbow Shower* © Barbara Nessim, 1982-1984 (reproduced with permission).

As artist in residence at Time Video Information Services (TVIS, 1982-1984), Nessim learned how to use the Norpak machine, to which she had access. The interface: keyboard, stylis, tablet. Available shapes: arc, circle, rectangle, line, polygon, dot. You had to build the image in layers, from the background to foreground. At that level of technology, the machine was "using" the talent of the artist. It was a rather poor palette; instead of pigments, it offered a limited number of light colors and a rather crude resolution. Everything accomplished using the program could have been done by hand faster and better. Ultimately, Nessim's art won over: it benefited from the discovery that "Less is more."

But nothing concerning the pioneering stage compares to what takes place today. At the main Zurich train station, anyone (and their dog) can come up with phrases (the more ridiculous the better) that are made into images by some online AI shop. What is produced is fake art. It looks like whatever is imitated, but it is empty of meaning. And thus, by necessity, obsolete from its inception. A game of chasing after novelty, devoid of aesthetic ambitions. Addiction to the disposable, which originates in the economy of consumption—Warhol was right in highlighting it—is replacing the ideal of permanence, not to say the ideal of uniqueness. The knowledge acquired through automated

digital processing becomes obsolete as each new artifact is disposed of, just as pictures taken with digital cameras are forgotten before anybody would care to see them.

Almost all the machines of the past—the hydraulic (set in motion by falling water), the pneumatic (moved by air pressure), and the electric—were of interest to artists. Mostly, they could (and indeed did) help in the making—"production," as it is called—but not in replacing the creative effort. They did not originate questions about reality, but merely served as tools. The tools themselves were expressions of knowledge (mainly physics), but not of the kind that the artist discovers while adding new realities to the reality to which they belonged.

FREEDOM OF EXPRESSION IS DEFINED IN CONTEXT

There is yet another aspect of the beginnings of what eventually was labelled "Computer art:" freedom of expression. Machines utilized in the process of artmaking afford freedom, but mostly in relation to the physical effort involved: the *techné*, the making. Not unimportant, if you think of what it took to build the pyramids. Or what it took to assemble the Terrace Army at the Emperor Qinshihuang's mausoleum. To paint the frescoes decorating many church ceilings (Michelangelo's painting the Sistine chapel). Or, more recently, to make Richard Serra's large metal sculptures possible. These are artistic and engineering endeavors. However, freedom of expression goes beyond the making, the production of art. It pertains to the knowledge it makes accessible, more precisely to the *meaning* it conjures. Art, more than science, and in ways different from science, disclosed meanings provocative in nature. It became a form of resistance to all kinds of oppression, including that of established art and of conformist aesthetics.

Evidently, 1965—the year the first shows of computer-generated images—counts as a time reference for a provocation. In Stuttgart, the first shows on record took place at the Studiogalerie of the Technische Hochschule and the Galerie Niedlisch; also in 1965, the Howard Wise Gallery, in New York, held a show focusing on the machine's performance. Even the simplest visual computation (intersecting lines, circles, polygons, etc.) was celebrated as an alternative to hand drawing: "You can't draw a circle? No problem, the machine will do it for you." Skill, quite different from talent, was to be substituted by technical performance. This would, as was claimed, democratize art. No more just a few—artist, i.e., privileged white individuals, mainly males, according to today's jargon—but everyone could make it. As is known, some masters of the past—among them Michelangelo and Rembrandt—had their "production" facilities—students eager to learn from them while working on large compositions. In recent times, Vasarely (of op-art, famous after WWII) comes to mind. He ran a *factory*-like studio employing many assistants who executed, by hand, programs of "paintings." It was a system of numbering grids, like a color code on a pattern, with numbers at the location of the square backgrounds. Jeff Koons does this, so does Damien Hirst (to name the better-known employers of art fabricators). The algorithmic machine could be programmed to mimic artwork. This kind of "freedom of expression," prophetically captured in Walter Benjamin's *The Work of Art in the Age of Mechanical Reproduction* [12], is echoed today in the text-to-image frenzy of AI-generated "art"—mechanical indeed. Unfortunately, Benjamin's thoughts, often celebrated, are ignored. The visionary (exiled in Paris during Nazism) warned about the dangers of submitting to technology. It is not the lost aura that the art community or society should be concerned about, but rather the abandonment of values in favor of commercialism.

While in the advanced West of the post-WWII years you could experiment (within the limitations of art economy), in the Soviet empire, things were somewhat complicated. In Eastern Europe, where official art was encoded in the rules of socialist realism (anchored in the dominant ideology), making images with machines was a way to shake loose from the handcuffs. For those seeking freedom of expression, it meant the opportunity to express what was officially not acceptable. The knowledge that art reveals is not always comfortable, neither to the public nor to those in power. The use of computation opened a way to get around censorship. You could not attribute intentionality to machines. Of course, only those few who had access to computers—the state owned them—could experiment. Those wishing to use them needed to be certified by the secret service as posing no danger to the system: the privilege of being vetted as trustworthy. In the works of Vuk Cosič, Vladimir Bonačić, and Edward Zajec (more names, and not only from Serbia and Croatia, deserve to be remembered), what counted was way more than the formalism of computer graphics. They were "researching" the visual before the visual became the dominant means of communication. Being subversive in a society in which to be subversive—as art always is—was a crime became an act of resistance to indoctrination.

This is not the place to rehash or rewrite the history of computer graphics, or that part of it that claims the identifier "computer art." But it is the place to contrast innovation as a new aesthetic formalism, and innovation as a new way to convey aesthetic meaning. The focus was on searching for means of expression free of political and ideological pressures. Seeking aesthetic freedom by adopting the new machine was more than number processing and translating it into plots on paper. It was in opposition to what the regime (in the Soviet Union, Romania, East Germany, the former Yugoslavia) promoted. It was dissidence—a qualifier usually associated with writing: Solzhenitsyn comes to mind, but many others—the *Samizdat*— circulated their works of opposition to dictatorship.

In general, attempts at generating computer images connect to the revolutionary art of Malevich, El Lissitzky, Moholy-Nagy, Tatlin, and so many others in the so-called socialist countries. The New Tendencies (NT4 and NT5) and Visual Research (1968-1969) were driven by issues of creativity. Generative processes, associated with those

movements, were deployed in pursuit of creativity. An example: against the domination of technology, Boris Kelemen, in the Catalogue "tendencies 4" (Zagreb 1970), was seeking "an alliance with the most advanced research in natural and artificial intelligence." Such goals testify to awareness of possibilities, but also of dangers. In the hands of artists—Sherban Epuré is one example I am familiar with [13]—computers were supposed to become part of their creative process. It was not the algorithmic output (recipe-based art and automated production) that made a difference. The goal was freedom, the artist's liberty to integrate a new way of thinking, outside the prescribed ideology, in the creative process.

BOILING THE OCEANS: THE OBSOLETE IS EXPENSIVE

To make "computer art" feel like human art, the false prophets of those days—Max Bense, in particular—theorized that they need some aleatory component. Therefore, another machine (random number generator) was supposed to make the art-making machine seem more human. In the absence of understanding what art is, and why creative individuals identify themselves through the specific knowledge that their art shares with others, theories were advanced regarding the description of art through data. They were based on what was called Shannon's "information theory." His genius at work solved a military task: how to get data safely from one point (command) to another (executor). It became known as "information theory"—a misnomer as confusing (and dangerous) as "computer art." In reality, Shannon's "information science" was "data science," devoid of meaning, as Shannon himself pointed out. It states that the thermodynamics of data transmission (electrons traveling through wires, or electromagnetic waves propagated in the atmosphere) affects the process. In other words, it describes the physics of the process, including the role of "noise," which is independent of what the transmitted data stand for.

The core of what in our days became the new obsession is the following: Describe in language what you wish to make into an image. AI will do it for you based on data that describes images, used to train neural networks. This is the semiotics underlying the process. The larger the collection—amazingly large databases supposed to be the living visual memory of humankind—the better. Brute force at work—regardless how much energy is consumed. A first reaction to what it takes to accomplish the task came as a tweet to my account: "For me, the question of AI is not 'Can this make good art?' but 'Can this make art so good that it's worth boiling the oceans for?'"

Many, artists among them, are concerned that the breaking of an iceberg off Antarctica might lead to ocean levels rising two feet over current levels. But they seem less concerned about the breaking of aesthetic dumpsites: all the libraries of images recycled by ever-faster machines. Nvidia, maker of high-performance machines (high-end graphics processing units/GPU), profits from the computational orgy associated with large neural networks, more than the AI-focused companies. Burning computer cycles regardless of what makes sense, and what is an exercise in futility, is not indicative of intelligence. Sustainability, in terms of using huge amounts of energy—an image generated in the text-to-image sequence has a large footprint—can easily be quantified. But the danger of mediocrity, generated at a rapid pace, is more insidious. Instead of innovation, the automated production of meaningless images generates more landfill waste and affects the cognitive and emotional profile of those who are subjected to the invasive outcomes. Let us try to understand what is expressed here. Assuming that authentic sustainability is of concern to society, and not just a slogan, it should become clear that we are making more and more holes in the boat carrying us to the future.

Reporting on a painter (the qualifier was left ambiguous—was it someone who paints homes [or someone who is an artist?) the *New Yorker* [14] took note that he generates interpretations of other images ("usually culled from cheap art books") at a pace of 60 and over per day. The public can order (ten bucks a piece) from his website. No way to choose—the client gets one work from among those available. Of course, it takes energy to produce over 300,000 such items in a life-long dedication to making them. There is no reason to compare this production to what various versions of DALL-E, MidJourney, Stable Diffusion, etc. output. In the train station in Zurich (who knows what other "terminals" at airports and in shopping malls offer the same), passengers can "make art" by requesting, in natural language, whatever they describe. Walter Kirn [15] gave one example: "a tarantula wearing a green scarf." You can tell the AI to render the tarantula in the style of a cubist drawing or a vintage photograph, or even a Soviet propaganda poster. (In China, the image would carry an earmark—AI made—in order to prevent misunderstandings!)

By 2016, *AlphaGo* had beaten everyone playing chess. For this it used up the energy of more than 3000 human beings [16]. The fact that in the process of playing all games possible (Shannon calculated that there are not more than 10^{120} possibilities), the AI chess program practically did away with chess—while burning a huge amount of energy—was never brought up. Check out the saga of the recent chess game in which a young opponent (Hans Niemann) of the world chess champion (Magnus Carlsen) is accused of playing like a machine (and his body searched for possible micro-transmitters). Playing like a machine is the equivalent of painting like a machine.

Chess as we know it within culture is finished, whether we like it or not. Is art, exposed to brute force methods for making images from other images, also finished? In the same context, the courts examined whether Andy Warhol's "Purple Prince"—an interpretation of a photograph by Lynn Goldsmith (license for use dutifully paid)—fits in the "Fair Doctrine Use." There is an "Orange Prince," and there are more interpretations signed by Warhol, not unlike what AI does, as it chomps on huge image databases that translate texts into images without any authorship attribution. Lawsuits of copyright infringement are symptomatic in the evolution of artistic expression: aren't we all trained on data

sets that make up the books we read, the shows we attended, the museums we visited, the recordings we used? Legal actions will never settle issues of creativity.

Remember Nake's ideological call, "There should be no more computer art!" that led to a pretty passionate discussion about computers and art? Of course, the answer to the many questions associated with change—in science, technology, in the human condition, in economic activity, in wars, in sexuality, in our understanding of "gender," race, ethnicity, privilege, etc.—is not to stop, or to forbid something. Or to earmark! Hilbert, whose challenge (the decision problem) led Turing to discover the seeds for the algorithmic machine, believed that every mathematical problem has a solution. "We must know, we will know." (These words are chiseled on his gravestone.) Artists act in the same spirit. Machines or not, what counts is the meaning unveiled through interactions between art and those whom artists are trying to reach. In the spirit of optimism, let us advance, through a rather tight argument, the idea that in order to know what all these changes are bringing about—so much more lies ahead—we will unavoidably readjust our perspective. In the new system of values associated with the automated production of art, or with the substitution by NFT (nonfungible tokens) of art itself, obsolescence replaces permanence. Is this also the end of intellectual property? An address on the chainlink as proof of authenticity? The end of commoditized art? Don't wish for a revolution if you are not prepared to live with its consequences. Many heads fell in the American, the French, and the Russian revolutions.

ART IS CONSUBSTANTIAL WITH LIFE

There are two distinct conditions of planet Earth: before life, and after life emerges. Not a clear-cut moment, rather a long-term process. Everything taking place before life—such as the making of the elements, or the functioning of the universe—constitutes the knowledge domain of physics. In retrospect, i.e., looking back from the perspective of what we know so far about change in the non-living—the physical universe—such phenomena are decidable. This means that they can be described fully and consistently. The laws of physics are an example of such descriptions. Based on them positions of planets are defined precisely, and space exploration became possible. But once life emerges, change in the world is no longer only a matter of coordinates in space (describing their movement), but also reproduction, i.e., survival. The offspring is never the same as the progenitor. The physical is defined by its sameness: gravity, for example, does not multiply, it has no offspring. Neither do stones. The living is defined by change that ensures its continuity: it reproduces, but never in sameness, rather in uniqueness. There are no two living entities, from Aristotle's blades of grass to human beings, that are identical. Therefore, as John von Neumann—the visionary of the age of reproducing machines—observed, the living continuously becomes more abundant than the non-living. This in itself suggests that a complete description is, if not impossible, at least not within the ability of an observer, whose own life is limited. Moreover, the living is "undecidable": it cannot be completely and consistently described [17]. The dynamics of life, how it changes, is contradictory. Think only about *archaea* surviving in the most noxious environments (extremely hot, i.e. more than 100° Celsius, extremely cold, acidic, alkaline, salty, deep in the ocean, even bombarded by gamma or UV radiation, etc.). Not to mention human behavior: from cooperation and solidarity to aggression and war. Unpredictable. Art is one of the records of this dynamics. Probably the most faithful, since it reflects what it means to be subject to change, and to be aware of it. In this sense, art is knowledge about the meaning of emotions, feelings, thoughts. Awareness itself is entrenched in what artists do and, more important, in why they commit themselves to creation.

The fact that everything not alive can be described as decidable, and everything living escapes decidability is not sufficient for explaining the fundamental difference between the living and the non-living. Life is by necessity creative: it gives birth to more life. The nature of the process through which this takes place is more important than the outcome. The change of the physical can be described in terms of a form of causality defined as determinism. Let's say "How does a stone turn into sand?" For this we need to describe all forces at work in grinding the stone. The dynamics originates in its past. The living, bearing the past as its history (or biography) is driven by survival, which means *possible future*. For the deterministic view of change of what has no life, a description of how it changed position or shape suffices. Based on deterministic science, human beings were able to land on the moon, not to mention that they conceived and constructed all kinds of machines for the sake of prompting more change. For the non-deterministic condition of life, descriptions of change as non-decidable imply that together with the physics of action-reaction, we need to consider the biology of anticipatory processes (Fig. 3). This is not only the origin of life, but also the origin of art, and of all other forms of inquiry based on which survival takes place.

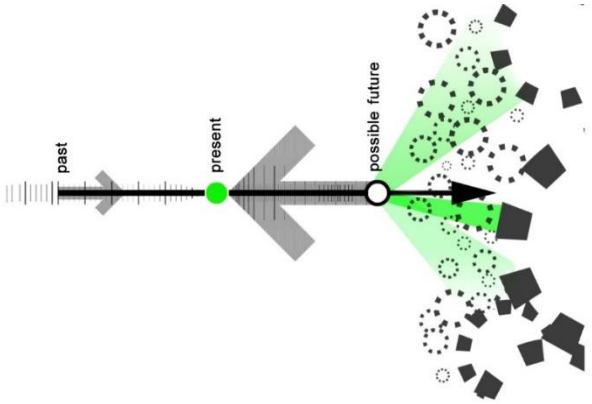

Fig. 3. *The current state of an anticipatory process depends on past states (which cannot be changed) and possible future states (an ever-changing multitude).*

The living is aware of its own life and of the environment in which it unfolds. Anticipatory processes, at all levels of existence (from the cell to organisms to societies), are at work in order to make survival and reproduction possible. To know, in various forms, is the pre-requisite of survival. In reference only to the human being—but with the understanding that all forms of life are defined by anticipation—all activities carried out (hunting, foraging, tool-making, settling, etc.) are forms of knowledge acquisition. Art is a particular way through which to know becomes embodied in means of expression that correspond to the continuum of sensorial perception. Sounds, rhythms, shapes, colors, textures, taste—the synergy of everything perceived—nurture a variety of expressions of knowledge. They range from elementary interactions (such as sexual preferences and behaviors, to cave paintings, as they are called), to whatever else shapes humankind's evolution. Art is not a cause-effect phenomenon, but the outcome of a multitude of ever-evolving anticipatory actions.

ART ENRICHES REALITY

One more thing: phenomena of physics can be explained following the reductionist scheme of segmenting the whole into parts that are easier to understand. Life phenomena are holistic: they can be understood only in their wholeness, kept together not by the material make-up, but by their evolving meaning. Indeed, art is alive; it evolves as humans do. The life of art comes from interactions between art works and those willing to remake them in the experience of art perception. The fact is that most of what is produced as art is doomed, i.e., ends up as waste in landfills, corresponds to the nature of artistic activity. Inquiry can be inspiring, or it can lead to all kinds of dead ends.

What does all of this have to do with Nake's call, or with the fact that we are experiencing an orgy of AI art that is anything but? What does it have to do with the fact that the aura of the fake surpasses awareness of the unique, the original? Remember, squaring the circle is an example of what by its nature is an impossibility. The impossibility of speeds higher than that of light is yet another illustration of the thought. No matter how much faster computers might get, and even how much their energy consumption can be reduced (to avoid boiling the oceans), algorithmic computation will never result in art. The fake is not replacing art, but it constitutes a by-product of machine-supported human activity. Even the replacement of the human being—the robot called *artist*—by machines is part of the same process. Deterministic processes can, at best, reproduce or mimic what was—the past—but never result in anticipatory processes. Art is not the reflection of the past—even when its subject is history—but the making of the future. In the absence of anticipatory expression, life is reduced to its physical substratum. The reduction of the human being to a machine (and the practice of treating people like machines) corresponds to the same tendency. The idolatry of the machine leads to lost freedom, less and less choice, submissiveness as part of the new human condition, and obsolescence [18]. Sustainability is abandoned for the sake of immediate satisfaction. Mediocrity undermines authentic value.

Would all this mean that museums and private collectors of early computer graphics images are wasting their money? Or that they are not important for understanding our own change? Of course not. They should be celebrated. One of my own pieces (*Free-form Constructions by Iteration*, Nadin 1966) made it into the Victoria and Albert Museum via the collection of the American Friends of the V&A through Patric Prince. Anne and Michael Spalter are courageous collectors (who, when they started to collect computer graphics, were ridiculed by speculators in established art). The ZKM (the Center for Art and Media in Karlsruhe) is a serious repository of many types of digital artifacts. But the reification of the past should not lead to exacerbating the idolatry of the machine to the extent of doing away with ourselves.

TESTIMONY FROM A THEORETICIAN (NOT SHY TO IDENTIFY AS SUCH)

In my record of accomplishments (I don't report on my own computer graphics here), there is the Frieder Nake exhibit (*Die präzisen Vergnügen*) at the Kunsthalle Bremen (2005). It took place after I convinced Wolf Herzogenrath, the Museum's director at that time, that Nake's early prints of computer images deserved public attention. And again, a Nake retrospective at the ZKM. (Peter Weibel gave in to my pressure; Nake was generous in acknowledging my help.) But there are also failures: I could not convince MIT Press to publish an English translation of Nake's book, *Ästhetik als Informationsverarbeitung* (Aesthetics as Information Processing, Fig. 4). It still is, with its charming quotes from Mao's Red Book, and with its Bense/Moles cult blind spot, the most serious publication on the many aspects of the aesthetics of images generated using algorithmic methods. It should be published in English—probably with annotations from its author.

Fig. 4. *Aesthetics as Information Processing. Foundations and Applications of Informatics in the field of aesthetic production and criticism. Springer-Verlag, Vienna/New York, 1974.*

Another miserable failure: I could not convince the Dallas Art Museum (i.e., Bonnie Pitman, the director at that time) to host Harold Cohen's *Aaron*—the very first attempt by an artist to integrate AI methods in making art. Even Manfred Mohr's art was not good enough for the Museum. Today, Cohen's works and those of Mohr appear in the international auction market. I failed when trying to organize an exhibit of Sherban Epuré's works (*Leonardo* was as helpful as possible). And I failed again, this time with Nake as co-host, in convincing the NSF and the NEA to fund a meeting of all those still alive who generated early images working with computers. My own university, with a program in art and technology—folded due to the incompetence of administrators exactly at a time when the program is more necessary than ever—was not interested. Worse yet: 158 million dollars will be spent to build an "Atheneum" (already nicknamed "Mausoleum"—Lamster [19]) dedicated to mediocre collections of oriental and Mexican art, and someone's private library, while the idea of a repository of early digital music, images, and multimedia could not warm the heart of anyone among those running a capital campaign of $750 million. Imagine: instead of unsustainable museum space (the old obsession with brick and mortar), instead of useless collections dumped as gifts for tax purposes, a digital repository, open, via the Internet, to researchers around the world and to the public. And if a building must be (it does not!). let it be a space of interactions and experiments. Indeed, regardless of whether there is such a thing as computer art, the early investigations of computer graphics, of music, of interactive installations are testimony to humankind's dedication to the paths towards our shared future. And it should be available in its native digital reality, not as a collection of prints. The fact that some of these investigations ended up in extremely useful visualization technology—think of medicine, from the pre-computer Roentgen (X-ray machine) to the digital "X" rays and MRI—and others extremely harmful—the technology of brute-force wars—is only one aspect. These investigations affected our ways of thinking, and they affect the human condition in the age of networking. Consider: without computer graphics, the Web would not exist.

Is being tethered to one's cell phone (yet another offspring of computer graphics!) progress is as much an open question as whether art changed, and whether chess playing or of playing *Go* irreversibly changed. Of course, I was, and still am, hoping for more of the good, even during a time when evil seems to have the upper hand. Therefore, I cannot second my friend's call: "…no more computer art." Rather: understanding the need for a new perspective might help in making our own choices, which art exemplifies as a meaningful living process that cannot be reduced to data processing. Regretably, we continue to look at life through the "eyeglasses" of physics. It is time to reverse this. Understanding life and art, in particular, as expression of meaning, might be the key to understanding the broader reality.

I wish I could express this idea in a work of art. But I am only (and happily) a mere theoretician who was lucky enough to live through the most exciting time ever.

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