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Artificial Intelligence in art:
a contingency of contingencies

Abstract
Artificial Intelligence (AI), especially in its current incarnation of Machine Learning (ML), is an endeavor that is characterized by contingencies of two kinds. Intrinsic contingencies stem from the use of specific computational techniques that seem to decrease the control that human users exert on this technology. Relational contingencies emerge from the interaction of AI with other disciplines and contexts. I conduct an analysis of these contingencies on the backdrop of the visual arts with the aim to shed light on the complex relations between technology and creativity.

Keywords
Artificial Intelligence, *Computer art*, *Contingency*

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1. *Introduction*

Artificial Intelligence (AI), in its current incarnation of Machine Learning (ML) systems whose operation depends on the elaboration of enormous quantities of data, is an endeavor intrinsically based on contingency. Contingency is interpreted in this work as a series of possible circumstances that cannot be predicted with certainty. In this sense, contingency emerges from an epistemic lack on behalf of all the individuals (both programmers and users) that exploit an ML system without having a complete understanding on how each component works and contributes to the results, nor a comprehensive view on the data used to train the system itself. I will call this an "intrinsic" contingency of AI, as opposed to a "relational" contingency of AI that arises from relationships and interactions that AI as a discipline entertains with other fields.

Indeed, the success in terms of media hype and financial investments that AI is currently enjoying is one of many periods in recent history in which the discipline was viewed as a technological endeavor destined to revolutionize a significant portion of human activities: automated reasoning was supposed to do so with logical reasoning in the decade following the official foundation of AI in 1956 (McCarthy, Hayes 1969); expert systems were to change diagnosis and problem solving for good in the 1970s and the 1980s (Waterman 1985); then, it was the turn of software agents with autonomous decision making and trading throughout the Internet in the 1990s and the 2000s (Mele 1995).

These periods of enthusiasm are called "AI summers", and they have been regularly interleaved with "AI winters", when the discipline experienced a stagnation in research and development, due to a pessimism that is generally thought to be induced by the contrast between overly ambitious promises and far humbler actual results (Umbrello 2021). The current AI summer started with the notable results obtained by Google's AlphaGo, an ML system that learned how to play the game of Go and beat human masters several times (Mozur 2017), including one match in which the machine made a move that left all the experts perplexed at first but, after further analysis of the game, was eventually considered a stroke of genius and has now set a new standard that is studied and used by many human players. Such move has been deemed as creative and unique, and has reignited enthusiasm in AI as a creative endeavor in a variety of fields, including urban planning (Leach 2022) and the military (Simpson 2024).

This AI summer is particularly interesting because, for the first time, there is an overlap between the relational contingency of AI, in terms of all the factors that are external to the discipline but that have nevertheless contributed to its resurgence from the last AI winter, and its intrinsic contingency, given by the fact that such success is based on ML systems that are data-driven and, hence, less dependent on their designers' directives.

In what follows I will conduct an analysis of these contingencies and how they may affect each other on the backdrop of the visual arts. This is a cultural endeavor in which the use of computers has played a significant role since the early years of AI.

The use of artefacts with the aim of automatizing various kinds of endeavors, including creative ones, has been around far longer than AI: the early attempts can be traced back to Ancient Greece (Dijksterhuis 1961). Moreover, arithmetic combinations of measures of geometrical parameters (Birkhoff 1933) and models imported from telecommunications engineering (Moles 1966) were proposed as a computational model of aesthetic before AI was acknowledged as a force to be reckoned with in the arts and culture. These proposals were not met with universal acclaim: there were warnings against the danger in thinking that, because certain aesthetic problems have been redescribed and relabeled, they have been solved (Kraehenbuehl 1967). This critique is meaningful still today, because it points at a problem that is intrinsic to all things computational, including the latest AI systems, which run on computers, that is, machines that crunch numbers. Delegating the execution of any task to a computer requires a description of such task in numerical terms. Execution, thus, becomes computation in a machine. For something like an aesthetic endeavour to occur by means of a computer, then, we need a complete numerical description of such endeavour and a sequence of numerical operations that the computer must execute to bring the task to completion. Technological advancements may enable an ever-increasing speed in the execution of such elaboration, but the question on the validity of the models the elaboration is based upon still stands.

When the computational side of the infrastructure is framed as AI, the question becomes more critical because of the clout surrounding this discipline, especially during an AI summer like the current period. The tasks automatized with this technology are becoming more and more varied and complex, to the point that many users, especially those who do not have a working knowledge of the inner operations of an AI system, give in to the tendency of confounding a high level of automation with autonomy. These two concepts are distinct, and their relation is object of debate in the field of AI (Formosa 2021). In those contexts where AI technology is used for creative endeavours, however, the conceptual issue seems to be overlooked in favour of a looser idea of agency, where humans and sophisticated computers are viewed as collaborators. Even where great attention is paid to language, because "moving the focus from technical discussions to the field of language allows us to deepen the discussion on creativity and AI. This is because language […] goes beyond merely limiting discussions to the representation of things. More importantly, language allows artists to project new things" (Vear, Poltronieri 2022: xviii), statements like "it is important to note that (…) technological systems work creatively in partnership with humans" (Vear, Poltronieri 2022: xix) are made uncritically. Another slippery slope is the usage of the same word both for a typically human act and for a technological process, like "perception" (Zylinska 2023). On the one side "it has biological connotations, signifying the system of perception in human and nonhuman animals", but on the other, technological side "perception here is equivalent to image-making, a process of the temporary stabilization of the optical flow that involves apparatuses such as cameras, telescopes, and scanners." (Zylinska 2023: 9) The conceptual conflation is intended as a basis for a warning against being absorbed by a machinic cultural dictatorship, as an invitation "to experiment with, retune, or hack the perception machine. While we still can. While we can still see and feel its edges and limits" (Zylinska 2023: 199). However, anthropomorphizing an artefactual process seems to be a step in the opposite direction. One may argue for the efficacy of metaphorical discourse, but in a field that is foundationally based on a hotly debated metaphor (what is meant to be "intelligent" in AI? See Fetzer 1990), more caution is needed because if AI as a discipline is underpinned by a possibly misapplied concept of autonomy in terms of delegation of action to the machine, it intrinsically questions the very idea of authorship when such an artefact is involved in a creative process.

This work is organized as follows. In Section 2 I illustrate AI's intrinsic contingencies in terms of computational techniques that, because of particularly complex interactions, seem to be diminishing the control that artists exert on their creative process, in apparent accordance with the narratives mentioned above. I will focus on two artworks by two artists in particular, Frieder Nake and Mario Klingemann, for distinct but connected reasons: the former is a pioneer who first employed contingency in a computer with artistic aims, whereas the latter has recently risen to fame in the art world by using the latest, most advanced AI technology. Despite the temporal and technological distance between the two works, they seem to present commonalities that may point at some intrinsic characteristics of art made with AI. As guiding principles, I will adopt concepts from artist and critic Robert Morris, which will enable me to draw a comparison with works by traditional artists like Jackson Pollock and Francis Bacon.

In section 3, I tackle two relational contingencies of AI that are in connection with Nake and Klingemann. The first deals with the complex relation between AI and Computer Science itself, of which AI is a subfield: the analysis of Nake's work sheds light on the conceptual issues surrounding these disciplinary boundaries. The second relation is between AI and the art world, and it is explored under the light of the performance of Klingemann's work in the auction markets. Finally, in Section 4 I draw my conclusions.

2. *Intrinsic contingencies in AI and art*

2.1. *Can there even be contingencies in AI?*

Considering that AI is a subfield of Computer Science, there is a conundrum that needs to be tackled immediately: how can any sort of contingency emerge from a computing device? The founders of AI defined it as the endeavor of modelling learning and reasoning processes, traditionally carried out by human beings, by means of arithmetic operations in a computer (McCarthy et al. 2006). Such definition relies on the very strong assumption that such processes are amenable to numerical modelling and prescribes that the results of that modelling activity be run on a computing machine.

For the moment, I will set the arguable assumption aside and focus on the prescription. It works against the possibility of contingency in any Computer Science endeavor, including AI, since computers are comprised of electronic circuits that embody the most fundamental rules of logic and arithmetic in binary form: low-tension and high-tension signals inside the machinery are to be interpreted as instances of the values '0' and '1', respectively, which can be in turn sent through circuits that transform them in ways that yield results analogous to what we would obtain if we did logic (i.e. the negation of '0', which stands for 'false', is '1', which stands for 'true') and arithmetic (i.e. $0 + 1 = 1$ and $0 \times 1 = 0$). Unless there is a hardware failure, such operations are carried out in a deterministic way: a fixed input and a fixed set of operations will always give the same output, in accordance with the universal and invariable logic and arithmetic rules.

The first programmers to try and challenge these constraints were also responsible for the very first framing of the outputs of a computer in artistic terms: Frieder Nake and Georg Nees in Germany and Michael Noll in the United States were all active in the 1960s and used the combination of clever programming and a plotter to create prints with an abstract aesthetics. At the time Computer Art did not even exist as a concept, so these three individuals were exploring uncharted territories. Nake and Nees were bolder and organized the first ever exhibition of computer outputs in Stuttgart in 1965 (Bense 1965), whereas Noll limited himself, at that time, to writing a technical report in which he described the code that generated the drawings but neglected "any discussion of the 'artistic' merits of the results" (Noll 1962: 1). The challenge against the rigid constraints of a computer is best illustrated visually with a work by Nake, shown in figure 1. *Random polygons* is only one of many visual artworks produced by Nake but it is very useful to illustrate the fundamental principles that he and also the other pioneers in Computer Art followed in their explorations. The idea is to delegate the choice of the coordinates of the points in the composition to the computer. The artist had a rough idea of how the final output must look like (in this case, a geometric line broken at multiple points), so he programmed the computer to draw a finite sequence of segments, each of which starting where the previous one ends. Not everything, however, is fully set at the time of programming, because the x-y coordinates of the points where the line breaks, that is, where a segment ends and the next one starts are computed by means of a 'random' function.

This is the first and simplest case of contingency sneaking into the deterministic realm of computing. By design, real randomness does not exist inside a computer: the machine would have to be built with parts whose operation depends on quantum phenomena (e.g. neutrinos arriving from space and hitting a sensor) for random events to play a role in it, but this is not the case. What the pioneers of Computer Art were using was, to use a more precise terminology, 'pseudorandom' functions: a sequence of mathematical operations whose result was depending on the values of a number of parameters at the time of the execution of the program.

Since there is no way to escape the determinism of a computing machine, the trick here is to make computation contingent to some conditions that are not known, even to the very programmers. For instance, if the computation of the x-y coordinates of the first point in *Random polygons* depended on the second-to-last figure in the milliseconds counter of the computer clock and on the sequence of bits (0,1) contained in the 36th row of the main memory of the computer, then Nake would have had to have access to many more parts of the computer he programmed to be able to predict with precision what the final output would look like. Since this was not possible, the final composition appeared to be original in his eyes: the result of a collaboration between a human programmer with a rough initial idea and a machinic executor with the precision and efficiency of computation.

In recognition of this synergy, the artist put the model names of the computer and of the plotter next to his. When I had the chance to ask him whether he really believed that he had to share authorship with the machines he used, Nake explained that the main reason behind such choice was to make his work look even more cutting-edge by hinting at a new kind of artificial agency.

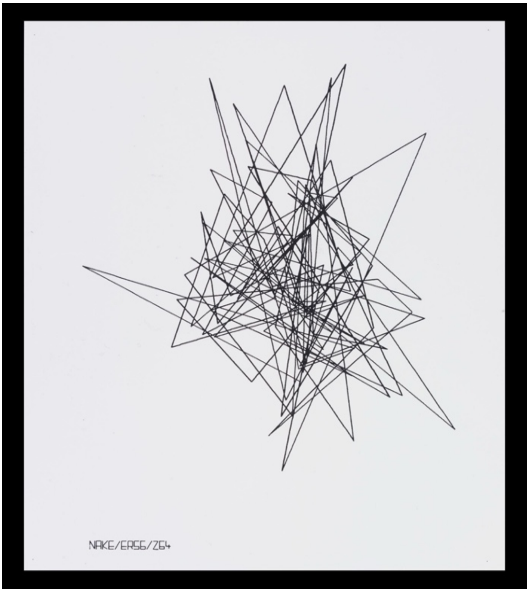

Figure 1: *Random polygons*(1965) by Frieder Nake (courtesy of the artist and the Victoria & Albert Museum)

2.2. *A comparison with contingency in art*

An abstract composition of black lines over a white background whose placement appears to be set by chance is reminiscent of some works by Jackson Pollock, who had risen to fame the decade before. There is obviously a notable difference in visual style, and there is no evidence that the pioneers of Computer Art were influenced in any way by Pollock's artistic explorations. However, an interpretative key provided by artist and writer Robert Morris allows for an interesting comparison. Morris was part of a group of artists in the 1960s who sought a synthesis between process-driven creative methods like Pollock's and Dada-like conceptualisms after Marcel Duchamp (Malone 2009). In this effort, Morris elaborated an aesthetic program in which the relation between the creative process and the created product, also in connection with the materials used, is to become apparent and visible and, moreover, the perception of such relation is supposed to alternate between the arbitrariness and the containment that have both contributed to the artwork (Morris 1970).

Pollock's drip paintings fully embody these criteria. His acts of flinging and dripping paint onto an unstretched canvas laid on the floor can be seen or, more precisely, induced by the viewer of the finished artwork. Moreover, the appearance of the artwork emerges from an interaction between the arbitrariness of the artist's gestures and the inescapable containment of the force of gravity governing all physical entities, including flying drops of paint. There is another important concept that is relevant here and that Morris took into consideration, perhaps more from a theoretical perspective in his role as a writer rather than actively engaging with it as an artist and practitioner: the concept of automation. "Automation serves to remove taste and the personal touch by co-opting forces, images, processes, to replace a step formerly taken in a directing or deciding way by the artist" wrote Morris (1970: 65), which also aligns with Pollock's action-based process, about which the artist himself said "When I am in my painting, I'm not aware of what I'm doing" (Pollock 1959).

These principles, process visibility, arbitrariness/containment dichotomy, and automation, offer interesting directions for a comparison between Nake's work and Pollock's. In particular, I will try here to verify whether the use of a computer and a plotter for art, a groundbreaking innovation at the times of Nake's first exhibition, contributes additional insights within the framework of the existing discourse on contingency in art. I will start with automation, the most evident facet of any endeavor based on computing machines.

If automation is to remove personal touch, computers realize this goal fully in a portion of the endeavor. Once a program is inserted in a computer memory in the form of instructions that are compatible with the operation of the central processing unit and is launched, the role of the person (or group of persons) who wrote the program comes to an end: the machine takes over the execution by fetching each instruction in order, decoding it and executing it until the final state, also specified in the program, is reached. The more technological character of Nake's venture obviously allows for a higher level of automation and, hence, a greater degree of removal of the artist's personal touch. If we focus on the very specific act of putting ink on paper, the artist is present and active in Pollock's case, and absent in Nake's case.

However, if we include intentionality in our analysis of the agency of these artists, we realize that there are nuances to such removal. It is true that at execution time Nake is not present nor has any active role in the process, but we must not neglect the fact that such execution is directed by a program that was written by him. Many proposals in the field of AI to frame acts by technological devices are based on the idea of delegation (Castelfranchi, Falcone 1998) and such concept provides a straightforward interpretation of what happened in Nake's process: he did not act directly on the paper in the plotter, but the program that directed the machine that did was comprised of operations written and hence intended by him.

This would be a case of automated (as in delegated and delayed) action for which the artist would be considered fully responsible, but the program includes the above-mentioned pseudorandom function that is used to determine the coordinates of the points in the composition. There are two characteristics of that function that put a distance between the artist's intentions and the execution of such function: I have already mentioned the fact that it is parametric, that is, its result depends on the value of some parameters that are outside the artist's knowledge and control; moreover, its code, i.e. the arithmetic operations it is comprised of, wasn't written by the artist, but by the software engineers that built and made the programming environment of the E56 computer available to him. All Nake knew about this function was the name that he had to write in his program to call for its execution. There is a choice here, but it is a choice not to choose, and to delegate the task of picking x-y coordinates to the machine, on the basis of its internal contingent state.

When it comes to artefacts, and the delegation of action that they enable, Nake's process obviously seems to exhibit a greater potential for a replacement of the artist as envisaged by Morris. Pollock, indeed, was not working with computers and plotters, but fully manually with the traditional tools of painting like brushes, paint and canvases. Pollock's claim about his lack of awareness during his creative process could be taken at face value, but there are at least two reasons for doubting that the removal of the artist's touch is complete.

One reason may sound obvious to the point of pedestrian: the control Pollock exerted on his paintbrush may have been minimal, especially if compared to traditional painting techniques, but it was definitely not non-existent, since the artist was indeed directing the paint towards the canvas on the floor instead of elsewhere in the studio, like on the walls or even outside a window. An analogous consideration can be made for the pseudorandom process in Nake's work: the coordinates were determined in a way that appeared to be random even to the artist's eyes, but those values were selected within a very precise range, established by the size of the paper in the plotter and set in the program by Nake himself. Indeed, all the segments in *Random polygons* lie completely within the frame of the print: not so 'random' after all. Also in this technological framework, the relinquishment of control must be controlled: there is an ultimate goal of creating a visual composition in a specific location, and precise enough operations must be carried out to pursue such goal.

The other reason for challenging Pollock's claim about the automaticity of his process is much less patent, and stems from an in-depth mathematical analysis of his signature moves. A team of mathematicians have analysed Pollock's paintings in terms of fractals, which are geometrical entities that exhibit self-similarity, that is, they are comprised of parts that are a reduced-size copy of the whole. The analysis was carried out taking into consideration the luminance patterns in Pollock's paintings, that is, how the coexistence of darker and lighter parts on the canvas creates a pattern in luminosity in each of its portions. The fractal perspective prescribes to look for a correspondence between patterns found in smaller parts and those detected in larger parts of a painting. The proponents of this research claim that a statistically significant criterion has been found to group 30 paintings made by Pollock between 1930 and 1955: indexes that are correlated with the fractal character of his works, that is, the likeliness of finding similarities between parts of a painting on different scales, increased around 1937, when Pollock met and was influenced by Mexican muralist Siqueiros and, instead, decreased in the 1945-1946 period, when he moved to the natural landscapes of Springs, Long Island (Alvarez-Ramirez *et al.* 2016). An analysis of this kind has its limitations: for instance, fractal indexes provide a quantitative method to distinguish Pollock's works from those of Van Gogh, but fail at the same task when works from Canadian surrealist group "Les Automatistes" are in the mix, because they are characterized by very similar fractal values (Taylor *et al.* 2007). Still, it is meaningful to know that mathematics can provide a way to shed light on patterns in an artist's opus that may stem from his life experiences and influence his painting style, perhaps on an unconscious level.

Interestingly, a mathematical analysis or, more precisely, a statistical analysis could be carried out also to investigate the characteristics of the function that generated the random-looking positioning of the points in Nake's work. Analyses of pseudorandom number generators have been conducted in the contexts of computer security: sequences of numbers characterized by an apparently random pattern can be employed as parameters for cryptographic algorithms and, in particular, they constitute a key ingredient in the construction of encryption keys, with which sensible data can be protected while being exchanged online (Soto 1999). Statistical tests can be employed to probe a number generator and check whether it really produces outputs that appear to be random or whether a certain mathematical pattern can be induced from them, which would reveal clues on the generator's inner workings that hackers may exploit to crack data protection systems. No test of this sort has ever been used to analyze computer artworks with claims to randomness but, again, mathematical tools have the potential to reveal the internal operations of an apparently unsystematic and arbitrary process. On the one hand, there is an artist like Pollock that sets his mind free, yields control, and lets paint fly, and on the other there is a mathematician like Nake who breaks into the Artworld with a computer, to which he delegates the oversight of the plotter.

This perspective crosses into the discourse around the arbitrariness/containment dichotomy. Pollock's process is amenable to a straightforward interpretation: he releases paint by means of arbitrary movements, and those gestures are contained by the force of gravity, and what is obtained on the canvas on the floor is the result of such interaction. Nake's employment of a computer introduces additional complexity for a number of reasons.

Firstly, the arbitrariness of a human painter's gestures is substituted by the random selection of the position of segments to be printed by a machine. Such replacement appears to be plain and unambiguous in a context where no distinction is made between the agency of a person who acts without thinking and that of an unconscious computing device: they are both put under the umbrella of a local contingency. However, is this compound indicative in any way of the true nature of agency, human and artificial, or is it a gross approximation, or even a conceptual mistake? I have already pointed out that there is no true arbitrariness inside a computer: what appears to be random to a human user is actually the result of very complex and parametric mathematical functions, and computation does not deviate from its rigorously defined rules. Is then the substitution of a human with a machine a transformation that eliminates the dichotomy completely in favor of a new process of pure computational containment?

The fractal analyses conducted by the mathematicians who challenge Pollock's claim to ignorance of his own actions could be extrapolated towards an even more radical conception. The possibility of unveiling a causal relation that maps his apparently arbitrary gestures onto the circumstances of his life would be one example of a much wider endeavor to experimentally prove that human agency exists but without uncaused intentions: every action would be a reaction caused by an agent's exposure to past and current events. This is a very unsettling thought because if it were true, there would be no space for our choices nor our free will, but it is a hypothesis that has been floating around for quite some time, even in the more recent theories in quantum physics (Chen 2023). In this sense, in Pollock's process there is indeed a removal of personal touch, but for the fundamental reason that personal touch does not exist. Substituting human gestures with a programmed computer, as in Nake's endeavor, means only that a biological, carbon-based causal entity is replaced by a silicon-based one.

Radical hypotheses aside, the introduction of a computer also changes the nature of the output in a way that deserves further investigation. I am not referring to the material aspects of having a plotter and paper instead of a paintbrush and canvas (although a change in materiality is an issue I will tackle later in paragraph 3.2), but to how results are generated by a computer, specifically when a parametric program like Nake's is executed. When computing technology is involved with purposes of automation, as illustrated before, the material act of painting (or printing, in this case) is delegated to a programmed machine, so that a new intermediate layer is added: if Pollock created an artwork, Nake wrote a program that, when run, created an artwork.

This new level of indirection, because it consists of a program in a computer, ensures the automation of the creative gestures, but since the program is parametric, those creative gestures will depend on the contingencies characterizing the computer at the time of execution and involved by the pseudorandom number generating function used in the program. Depending on these contingencies, the final output will be different: within the containment of the deterministic workings of the machine and the boundaries set by the program written by Nake, there is the arbitrariness of parameters that are chosen but not by the artist himself. What Nake created inside the computer, then, is not one artwork, but the potential for a myriad of different artworks: a “class” of artworks, to borrow a term from Computer Science that designates the whole set of entities that are grouped on the basis of some fundamental characteristics. This shift from instances to classes is intrinsic to the use of parametric programs: at the time of writing, the programmer is dealing only with placeholders (e.g. “place the first point at position x, y”) that are going to be assigned a concrete value established by the computer’s contingencies only when the program is executed, thus materializing one instance (“place the first point at position 1743, 3809”) out of the otherwise abstract class. Nake’s artistic endeavor cast the concept of containment in a new light: a parametric machine has the potential of generating a virtually infinite sequence of artworks within a class delineated by the relevant program, and the artist contains such otherwise humanly unmanageable multitude by actualizing one instance.

Under this light, Pollock’s gestures may be amenable to an alternative interpretation: they are acts of selection, in that they embody one possible interaction between the artist’s body and his tools among all possible events allowed in the gravitational space of his studio. We must rely on our imagination to try and visualize all the potential that Pollock had at his disposal, whereas Nake’s computational approach gives a more concrete point of reference: his program describes, albeit indirectly, the whole space of exploration in terms of computer instructions.

This brings me to one last principle theorized by Morris: that of the visibility of the process, which is lost on at least two levels in Nake’s work. The viewer does not see that the geometrical points in his artwork have been selected (pseudo)randomly, nor can they appreciate that what is in front of them is one instance of a whole class. Nake himself is aware of the latter issue: “No doubt, we need the instance. We want to literally see something of the class. Therefore, we keep an interest in the individual work. We cannot see the entire class. It has become the most interesting, and it has become invisible. It can only be thought” (Nake 2012: 86). Such acknowledgment also includes an admission that the issue cannot be solved: even by materializing one instance, the class remains only an abstract idea, whose most visible form is the program written by Nake. Showing its instructions would also tackle the other invisibility issue, that of the arbitrary, machinic selection of the position of the points in the composition. However, showing a painting (or a print by a plotter) and showing the printout of a program are two profoundly different experiences: the former more sensorial, the latter more intellectual and, moreover, of a very specialized form of intellect that cannot be taken for granted if not with an audience that is familiar with computer programming.

The perceptual immediacy of Pollock's works is missing in Nake's computerized efforts: the flings and the splatters of paint are the final result of Pollock's gestures, but they tap into our past experiences with fluids and fabrics. Even pedestrian accidents with coffee spillages on table cloths contribute to our ability to imagine the artist's acts and his exploration of the space above the canvas. Our familiarity with the force of gravity in which we were born and still live is a key ingredient for the visibility of Pollock's process. Parametric programs and pseudorandom number generators do not have the same direct connection to how we perceive the world, including artworks. The use of computer technology, which has inserted an intermediate layer between the artist and the artwork, seems to also create a level of indirection between the artwork and the viewer. Going against one of the prescriptions of Morris does not necessarily constitute a fatal blow for this kind of artistic endeavors, but in the next paragraph I will show how the distance between humans (both artists and viewers) and artworks is only growing with AI's latest technological advancements.

2.3. *An example from AI art today*

Sixty years have passed by since Nake's first exhibition, and computer technology has experienced a tremendous growth in terms of efficiency: if the ER56 machine he used occupied one whole room and needed between 0.2 and 1.1 milliseconds to perform one addition (HNF 2022), today, the fastest laptop, a machine that fits on our lap, needs less than 1 nanosecond for the same operation (Athow 2024), that is, computers are now tens of thousands times smaller and a million times faster. This means that, obviously, computers are capable of solving problems in much less time than before. Less obviously, this does not expand the definitory boundaries of Computer Science. For a problem to be solved by means of a computer, it has to be amenable to a description in terms of numerical operations constituting a program executed by the device, which entails that subjective and qualitative problems have always been and still are intrinsically out of the reach of computers because they are incompatible with how these machines operate. However, a notable speed-up in computational operations can make previously intractable problems tractable, that is, solutions that existed but required an unreasonable amount of time

for their completion may now become viable. The above-mentioned AlphaGo system is one of these newly attainable solutions: to tackle with automation a game that is almost incomparably more complex than chess (e.g. a chess player has 20 different possible first moves, a Go player has 361) there was the need for a computational power that became available only in the new millennium.
Mario Klingemann is a German artist that exploited the same computing paradigm behind the success of AlphaGo for artistic purposes. The fundamental idea dates back to well before than the dawn of AI, and stems from an attempt at modelling the workings of a neuron as a mathematical function (McCulloch, Pitts 1943). A neuron works by receiving electro-chemical stimuli from other neurons through its dendrites until the accumulated energy in its nucleus reaches a certain threshold, after which the neuron shoots a stimulus in output along its axon towards other cells and discharges itself. A very simple mathematical device can be conceived with a similar behavior: it receives the outputs of other devices and accumulates them; when the total goes beyond a certain value the device sends it out to other devices and resets itself to the initial status. A complex, interconnected set of such devices is called a "neural network" and, since many neurons put together form a brain, the hope was that, by computing the operations of a neural network, a computational form of intelligence would eventually emerge. This line of thought is very controversial, since viewing the brain as a computational system is another metaphor that may overlook the complexities of human experience, identity, and embodiment (Dumit 2021).

Machine Learning is the subfield of AI that specializes in the design and in the training of neural networks. The training consists in feeding numerical data expressing a problem to the input layer of a network and checking what the output layer yields. If the output is the numerical expression of a solution to the problem, then the network is working, otherwise, it needs further training. The difference between the expected result and the obtained result is calculated and used to tune the parameters that express the strength of the connections among the various neurons in the network. After such round of tuning, the network has slightly changed and should be better equipped for solving the problem. Attempt after attempt, when the training is eventually successful, the network's outputs are the expected ones in most cases. Such threshold of acceptability is established by the trainers together with the stakeholders. At that point, the network's training is completed and the system can be deployed to solve problems with real (and not training) data.

Mario Klingemann used not one, but two neural networks, pitting them against each other, forming a software architecture that is called Generative Adversarial Network (GAN). The two networks are adversaries because they are trained for mutually exclusive goals: the first network aims at deceiting the second one by trying to pass synthetic images for photographs of the real world, whereas the latter is trained to detect synthetic images. Klingemann's training of his GAN system paid off: his work, titled "The Butcher's Son" obtained the Gold Award in the 2018 edition of the Lumen Prize, a UK-based initiative that champions the innovative possibilities of creative endeavors at the intersection of art and technology. The artwork is shown in Figure 2, and here follow the words by the artist himself about it.

> This image has been generated entirely by a machine using a chain of GANs (generative adversarial neural networks). In this chain a randomly generated stick-figure is used as an input to the first GAN, which produces a painterly-looking low-resolution proto-image. In several steps, the low resolution image is 'transhanced' and upscaled by another GAN increasing the resolution and adding details and textures. I control this process indirectly by training the model on selected data sets, the model's hyperparameters and eventually by making a curatorial choice, by picking among the thousands of variations produced by the models the one that speaks to me most. (Klingemann 2018)

Two insights stand out from the artist's words, both circling back to the issue that a surge in speed and efficiency does not change some intrinsic characteristics of computational endeavors in art: firstly, the parametric nature of their output still requires a final selection of an instance by the human artist; secondly, when invited to talk about their work, a computer artist seems to still feel the need to illustrate an otherwise invisible creative process.

The process behind *The butcher's son* is as more complex than what enabled *Random polygons* as more powerful and faster are the computer systems of today compared to the 1960s. It is not only a matter of computing power allowing for the use of neural networks, but also of connectivity thanks to the expansion of the telecommunication networks: in the same year when Nake's work was first exhibited, computer scientist Lawrence Roberts made two separate computers in different places exchange digital data over a telephone line for the first time (Leiner *et al.* 1997), whereas in 2021 the lowest estimate counted at least 4.03 billion Internet users around the world (Kemp 2021). Networking for data exchange is as important as computing power when it comes to ML, since a great number of digital instances are needed to ensure the convergence of a neural network towards the desired behavior. The contingency here is not about the internal state of a single computer that determines the value of pseudorandom parameters, but the myriad of computers online that can provide data for training purposes.

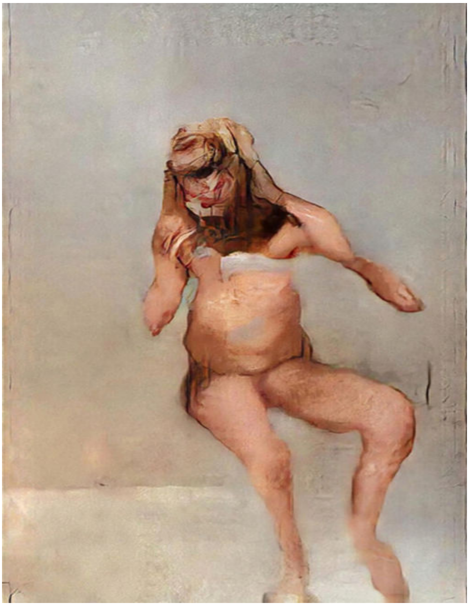

Figure 2: *The butcher's son* (2018) by Mario Klingemann (courtesy of the artist and Onkaos)

Biases in the data can shape the neural network in a way that its output will reflect such biases. A huge scandal erupted, for instance, in 2015, when a black couple in the USA was tagged as 'gorillas' by the Google Photo application, marking the first instance (but not the last) of a racist slur generated by an ML system. There are concerns that the neural network used for person recognition was trained exclusively with images of Caucasian individuals (BBC 2015). One critical aspect of neural networks is that human programmers have no way to check where the bias is located among the millions, if not billions of parameters inside of them.

At first glance, Klingemann's work does not seem to show any racially charged bias, but it carries a striking resemblance with the right panel of

Triptych 1983 by Irish-born British painter Francis Bacon (Bacon 1983). Comparing Bacon and Klingemann may be a bizarre exercise, but I feel compelled to try not only because of the visual likeness of two of their works, but also because their biographies and creative processes could not be more different. Bacon's intense and grim portraits are said to capture the prevalent fears of post-war Europe but also the artist's inner struggles, and his tumultuous personal life may have also influenced his work, adding a darker and more intimate dimension to his art. Anecdotal evidence aside, in the brief time I had the pleasure of enjoying Klingemann's company at a Computer Art event, I did not detect any hints of internal conflicts that might fuel his creative endeavors. This is exactly what anti-biographical stances warn against: the knowledge of an artist's biography is not a necessary condition for the enjoyment or understanding of their work (Solomon 1982). One way of taking the focus away from an artist's life is bringing it to their creative process. Ignoring Bacon's intense biography leaves us with a figurative painter utilizing very traditional techniques. Then the question becomes why did the cutting-edge AI-based process of Klingemann yield a result that is visually so close to the distorted faces and body parts painted by Bacon?

I suspect that contingency is again at play, not as an aesthetic tool, but as temporary circumstances in technology. *The butcher's son* was made in 2018, which is 6 years ago (at the time of writing). This can be considered a very long time, especially in a field characterized by significant financial investments in research and intense competition among numerous big tech companies. Technology can evolve rapidly, if organizations are willing to gather the best talents in the field of AI to earn even the slightest of edges over their competitors. Software based on GAN systems, like Midjourney, is capable today of generating images of persons with an extremely high degree of realism (Midjourney 2024). The improvements in realism between when Klingemann first used GANs for his work and now are so evident that they can be noticed and appreciated even by laypeople. Some readers may recall that one easy giveaway of the synthetic nature of an AI-generated image of a person was their hands: more often than not, the fingers were in unnatural positions or there were more than five per hand. These technical difficulties were related, as it usually happens in ML, to the data used to train the neural networks: there are plenty of digital images of faces, less so of clearly depicted hands. This shortcoming was obviously known to the AI companies, which are constantly engaged not only in product deployment but also in training and retouching their neural networks. The problem was solved sometime last year, and hands in synthetic images now look more realistic than ever (Verma 2023).

Klingemann claims to have made a final curatorial choice to select one instance from the class of images his GAN system generated. This selection process reminds us of what Nake did almost 60 years prior, but surely a neural network, with its millions of parameters, contains the potential for an even more vast class of instances than what a pseudorandom number generator allows for. I wonder whether the still defective realism of the GAN outputs in 2018 had any role in nudging Klingemann towards a visual aesthetic that resembled more some painting style of a famous artist from the past like Bacon. Despite the even bigger function performed today by the computing devices used in creative processes, if a final decision by a human artist is necessary, the arbitrariness of such selection inevitably calls for more investigation, also in the artist's biography.

The visual similarity between Klingemann's work and Bacon's, whether coincidental or not, adds onto the long-standing debate in aesthetics around formalism. Does the aesthetic value of an artwork depend only on what we are able to perceive of it through our senses? Or is it also enhanced by its capacity to provide aesthetic gratification when correctly and completely experienced (Beardsley 1982), which may mean including knowledge about the creative process used by the artist? In this sense, Morris's call for a visibility of the process may be interpreted as a way to facilitate its immediate appreciation. Given the seemingly intrinsic invisibility of the computing behind AI-based artworks, explanations are needed. Whether knowing that a process has been enhanced by means of a computer adds to or detracts from an aesthetic experience may be contingent to the era in which such experience takes place. Indubitably, computers occupy a different role in the audience's imaginary when *The butcher's so*n was created than when *Random polygons* was first unveiled.

3. *Relational contingencies of AI*

3.1. *The relation between AI and computer science*

Relational contingencies are conditions that emerge from situations where AI technology interacts with or relates to other kinds of contexts and endeavors. One fundamental relational contingency arises from the relation between AI and Computer Science. This pairing may seem odd, since AI is universally recognized as a subfield of Computer Science, but it nevertheless deserves attention because the borders between the subdiscipline and the superdiscipline have never been defined clearly and they appear to change in time, following technological and cultural contingencies. The computation-based artistic endeavors I considered so far provide a good starting point for this discourse. There is no doubt that Klingemann's work falls into the category of AI Art, since it makes use of a technology like neural networks that are at the core of the current AI summer, but what about Nake's work?

Random polygons is based on a program that includes a number of calls to a pseudorandom number generating function and that instructs a plotter to draw segments accordingly. Upon initial scrutiny, one may think that Nake's work falls into the category of Computer Art but not into that of AI Art, since the operations that realized it can be found in many other computer-based endeavors that are not associated with AI (like the pseudorandom number generator that, as mentioned before, is a fundamental component of cryptography).

Normally, a classification task like this would be solved by a careful reexamination of the definitions upon which such classification is based. In the case of AI, this is where some definitorial knots call for a conceptual untangling. The definition of AI provided by its very founders in 1955 had a shortcoming in their undiscriminating attention for computational processes: they intended to proceed "on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" (McCarthy *et al.* 2006: 12). Such an assumption may work as a basis for the computational modeling of quantitative problems but does not provide any clue on how to proceed with creative endeavors. Where does artistic creativity lie in this conceptual landscape dominated by machinic precision? The debate is very lively today, especially under the light of the latest AI developments (Anscomb 2022), but perhaps it is asking too much of the founders of AI to expect them to have contemplated the relationship between computation and art 10 years before the first pioneering uses of a computer for creative purposes. Taking historical circumstances into account not only allows for a better contextualization, but it is also at the basis of what I consider the best definition of AI that has been provided so far.

According to American computer scientist Elaine Rich, "Artificial Intelligence (AI) is the study of how to make computers do things that people are better at" (Rich 1985: 117). The brilliance of Rich's definition of AI lies in the fact that it shows AI as a discipline that is contingent to what humans do in a certain historical moment, which helps clarify its complex and dynamic relation with Computer Science. Classic definitions of AI, starting with the one provided by its founders, frame the discipline as an attempt to computationally mechanize activities traditionally performed by humans, while neglecting the fact that traditions change, also thanks to new technologies.

Performing arithmetic operations is a very significant example: this was a typically human task not even a hundred years ago, such that back then the term “computer” had a different meaning than today, that of a person who computes. This is what Computer Science pioneer Alan Turing wrote about a (human) computer: “The behaviour of the computer at any moment is determined by the symbols which he is observing, and his ‘state of mind’ at that moment” (Turing 1936: 250). In this work, Turing intended to propose a technique for automating the execution of arithmetic operations, that is, to describe them with such precision and clarity that it would allow for the construction of a machine (a material object lacking a human-like mind) that could nonetheless perform these operations mechanically, step by step, until the final result was obtained. This goal undoubtedly served as an inspiration for the founders of AI, of whom Turing is considered a predecessor (Shanker 1995). In 1936, the idea of delegating computation to a machine fully qualified as mechanizing a typically human activity and, hence, could be framed as an AI endeavor ante litteram. Now, such delegation is ordinary, even mundane, and electronic computers (no longer human) are incomparably better than human beings at carrying out arithmetic operations. What would have been considered AI then is standard Computer Science today.

From this viewpoint, AI can be seen as a moving target: always at the cutting edge of Computer Science and never fully realized, since each task shifts from the edge to the center of ordinary computer-based activities once it is successfully modeled and implemented. This has happened for arithmetic operations, data processing and analysis, text and image processing, cryptography, and so on. Will it happen for art as well? Nake’s case can provide some insights in this regard. The operations he used in his program to make art are now considered ordinary Computer Science, but there are at least two dimensions along which his contribution retains a leading edge. The historical contextualization called for by Rich’s definetion of AI sheds light on the groundbreaking step taken by Nake and his contemporaries Nees and Noll: they employed computers in a way that was unforeseen by anyone, including the founders of what was then and is once again considered the most advanced computer-based endeavor. Moreover, despite the technological gap, Nake’s work shares some distinctive features with contemporary AI-based endeavors like Klingemann's: the lack of visibility of the creative process and the necessity of an arbitrary selection of an instance from the class of potential outputs of such process. The fact that decades of technological improvements, including the recent Machine Learning explosion, have not altered these traits of computational creative efforts may suggest that already back then these pioneers tapped into something inherently significant regarding the use of artificial devices to automate art.

3.2. *The relation between AI art and the artworld*

Making the value of an artwork dependent on an establishment like an auction house may be controversial and not theoretically sound (Wieand 1981), and since there are many artistic endeavors, also AI-based, that are aimed at criticizing this way of dealing with art (Padgett 2024) this is not meant to be an exhaustive discourse at all, but an analysis of how some AI-based artworks have performed in the art market may offer some interesting insights in connection with Klingemann's work.

The most sensational sale happened in 2018, the year of *The butcher's son*, but the German artist had nothing to do with it. The auction house Christie's made history by auctioning the first AI-based artwork, a print on canvas by the French art collective Obvious titled *Portrait of Edmond Belamy*. This was a low-resolution image that resembled an Edwardian portrait and was framed in gold. The collective lacked an established artistic history, and their work was not based on a particularly innovative technology, still the piece was sold for $432,500, 43 times the estimated price (Kinsella 2018). Obvious used GAN software that had been developed by others and that could only yield outputs in the form of digital images with a limited resolution that needed further enhancements in definition to be printed on a canvas. The sale ignited a lot of controversy, especially among artists who specialized in the use of GANs (Bailey 2018).

Klingemann's work reached the art market via an auction house only the following year: in 2019 Sotheby's auctioned *Memories of Passerby I*, a physical installation comprised of two vertical monitors connected to a computer hidden inside a piece of retro furniture displaying an endless video of painterly faces that appear, merge, and dissolve into one another. The estimated price range was between £30,000 and £40,000 (Sotheby's 2019) and it was indeed sold for £40,000. Although more original and undoubtedly more masterfully programmed and realized, Klingemann's video sculpture did not enjoy the resounding triumph granted to Obvious' framed print on a canvas. Browne (2022) has formulated two hypotheses for this lesser success. One is the simpler and more general law of diminishing returns: the novelty-induced auction euphoria has subsided, and Klingemann's work paid the price of being yet another AI artwork on the market. The other, more complex, hypothesis taps into a possible inertia of the art market, traditionally oriented towards paintings and, hence, less inclined towards a technological device that needs to be plugged into electrical power to be enjoyed (Thornton 2008).

Such tendency, if confirmed, would pit the AI art market against Morris' prescription of process visibility, since a video installation provides an opportunity to show at least part of the creative process that characterizes a GAN system, in terms of the dynamics of the transition from one output to the next. An imposition by the market of a strict adherence to traditional, static objects is an economic contingency that would restrict further technological explorations in the context of AI.

However, the latest exploit by Klingemann on the auction market makes me doubt about its resistance against artworks that require electricity: in January 2024 the artist sold a static visual artwork built with a GAN system curiously titled "First painting created by an AI showing a painting auctioned at Sotheby's to be auctioned at Christie's" for the equivalent of $20,848 in ETH (a cryptocurrency) and in the form of an NFT (a Non-Fungible Token), that is, a unique digital instance protected from copying and manipulation by cryptographic tools (Christie's 2024). Computational technology has come full circle: the pseudorandom numbers that were used for the first pioneering endeavors in Computer Art are now at the foundation of the technology that protects the integrity of the latest outings of ML-based creative processes.

4. *Conclusions*

Intersecting AI and art has proven to be an extremely complex and stimulating enterprise. AI, being at the cutting edge of Computer Science, is constantly evolving, shifting from task to task, and always seeking new, more daring challenges in computational modeling, implementation, and deployment. AI is characterized by two kinds of contingencies. Intrinsic contingencies arise from certain technological tools, such as pseudorandom number

generators and neural networks, which lead to unforeseen situations despite the deterministic nature of computation.
On one hand, the use of AI in art has challenged and expanded the boundaries of what is traditionally considered a creative endeavor. On the other hand, it has highlighted the opportunity to incorporate aesthetic theories to provide computational creative experiments with a more solid conceptual framework. Despite the ever-evolving technological landscape and the acceleration driven by recent ML-based successes, two aspects of AI art remain unchanging: the invisibility of its processes and the necessity of a human-centered act of selecting concrete instances from an abstract class of potential outputs.

Relational contingencies emerge from the interaction of AI with other fields, including the very Computer Science from which AI originates, and the Artworld, where the latest AI art exploits have made a significant impact. These contingencies may shape the boundaries of AI as a discipline and influence its future trajectory. The fascination with automation and the ever-expanding role of data in a networked world may encourage the active removal of human artists from the creative process, steering AI art towards a fully computational and machinic system where the data used to train neural networks are indistinguishable from their outputs. Distopian scenarios are not the only possible outcome of an ever-growing adoption of AI technologies in creative endeavours. There are already proposals for framing AI enhancements in contexts, like data analysis (Manovich 2017) or pattern matching for remixes (Navas 2023), where human artistry is not directly affected.

To keep the artistic discourse alive in a biological, anthropocentric way, it is fundamental for humans to remind themselves that their exclusion from any computational process is hardly ever complete: there are always phases and facets where human intervention is crucial for the endeavor to be meaningful. These niches, which in a zealous process of automation might be viewed as areas requiring improvement, should be recognized and protected.

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