6. Drawing, design and algorithms. Theoretical statements and experimental practice for a shared *poiesis* in the age of Artificial Intelligence

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Drawing has always preceded any construction activity in the design process. The act of drawing constitutes a moment of organizing ideas, managing resources and forecasting results, which is made possible by using dedicated tools. The introduction of the computer as a drawing tool has brought about an epochal change: in addition to contracting execution time and increasing the accuracy of the sign, the computer allows drawing in a practical simulated three-dimensional space, enabling the expression of more articulated forms.
Initially used as a functional *digital drafting table*, differing little, from a conceptual point of view, from the traditional modes with ruler and square, the use of the computer has progressively conditioned the design process so much, that today it's difficult to separate it from design practice. With the new millennium, economic and cultural changes have accelerated the advent of a digital and globalized society. Increased computer literacy has involved designers, leading them to investigate the processes underlying the operation of daily-used digital tools. The conscious use of the computer stimulated a new type of modelling based on information-processing logic and freed

the designer from the traditional CAD software constraints.
This increased mastery has enabled a growing group of researchers and designers to develop their own drawing applications adapted to their specific individual design and research experiences. The form is now studied and generated by drafting algorithms, systematic procedures based on a succession of uniquely interpretable instructions that lead the computer to achieve a given goal. The discipline of drawing has thus evolved from iconic representation to the formalization of relationships and processes.

6.1 New paradigms for the discipline of drawing

In this new paradigm, different design instances can be articulated in emergent relational structures that require new theoretical analysis tools and understanding, capable of maintaining a high level of design coherence. It is necessary to manage the interaction among multiple parameters through diagrams capable of articulating programmatic interactions that operate as reactive systems in domains where real and virtual are increasingly overlapping. The etymon of the term virtual, from Latin *virtus*, meaning strength but also capacity or faculty, leads back to the concept of possibility, that is, of unexpressed potential far from opposing the real, representing a different mode of the existing (Levy, 1997). This meaning accurately interprets those phenomena related to the technological and social evolution that led to the advent of the Metaverse. This new paradigm transcends the concepts of hypertextuality and multimedia associated with the Internet's first phase through simulated three-dimensional environments. In those domains, virtual, augmented or mixed reality technologies mediate the fruition of meanings and interaction with objects and other users. Whether it is a virtual space in the Metaverse based on VR/AR technology or an application dedicated to a specific context, digital simulations require an abnormal amount of heterogeneous data to be processed. Thus, several models of AI capable of detecting, classifying and describing the data needed to make the entities' and objects' behaviours in virtual spaces plausible have evolved in parallel

with the establishment of digital realms. Continuous computing acceleration has already made various AI applications available, which quickly emerged from research environments to project themselves onto the market, quickly becoming pervasive realities capable of generating text, images, videos, and musical themes from simple textual input. The potential expressed by these tools is reminiscent of the transformative impact of CAD applications, a revolution that has profoundly altered the way we think about, design, and represent objects, spaces, and cities.

These questions highlight the need for framing AIs in the evolution of digital design and modelling and a greater understanding of the operation principles by a deeper analysis of human-machine interaction, which goes beyond the causal assumption *I write a word, I get an image*, and anticipates the challenges, with particular attention to ethics, posed by the use of these tools. Compared to algorithmic modelling, the advent of AI poses an inevitable and far more destabilizing question about authorial subjectivity and the emergence of new, plural and composite forms of collaboration between man and machine.

6.2 Algorithms for design: Computational Design and AI

Although often considered a single entity, Computational Design and Artificial Intelligence (AI) are two different approaches derived from a common matrix. Both rely on the use of algorithms to derive solutions or results, but the goals, methods, and degree of process autonomy are significantly different. Computational Design is the label that, over a decade, has summarized several approaches known as parametric modelling, algorithmic modelling, evolutionary modelling, and generative modelling. Even today, the terms are often combined (e.g., parametric-generative modelling, generative-emergent, algorithmic-evolutionary, etc.) to highlight one or more aspects related to the concomitant rise of digital technologies and postmodern complexity science in the design world.

The cross-fertilization between systemic theories, which study the

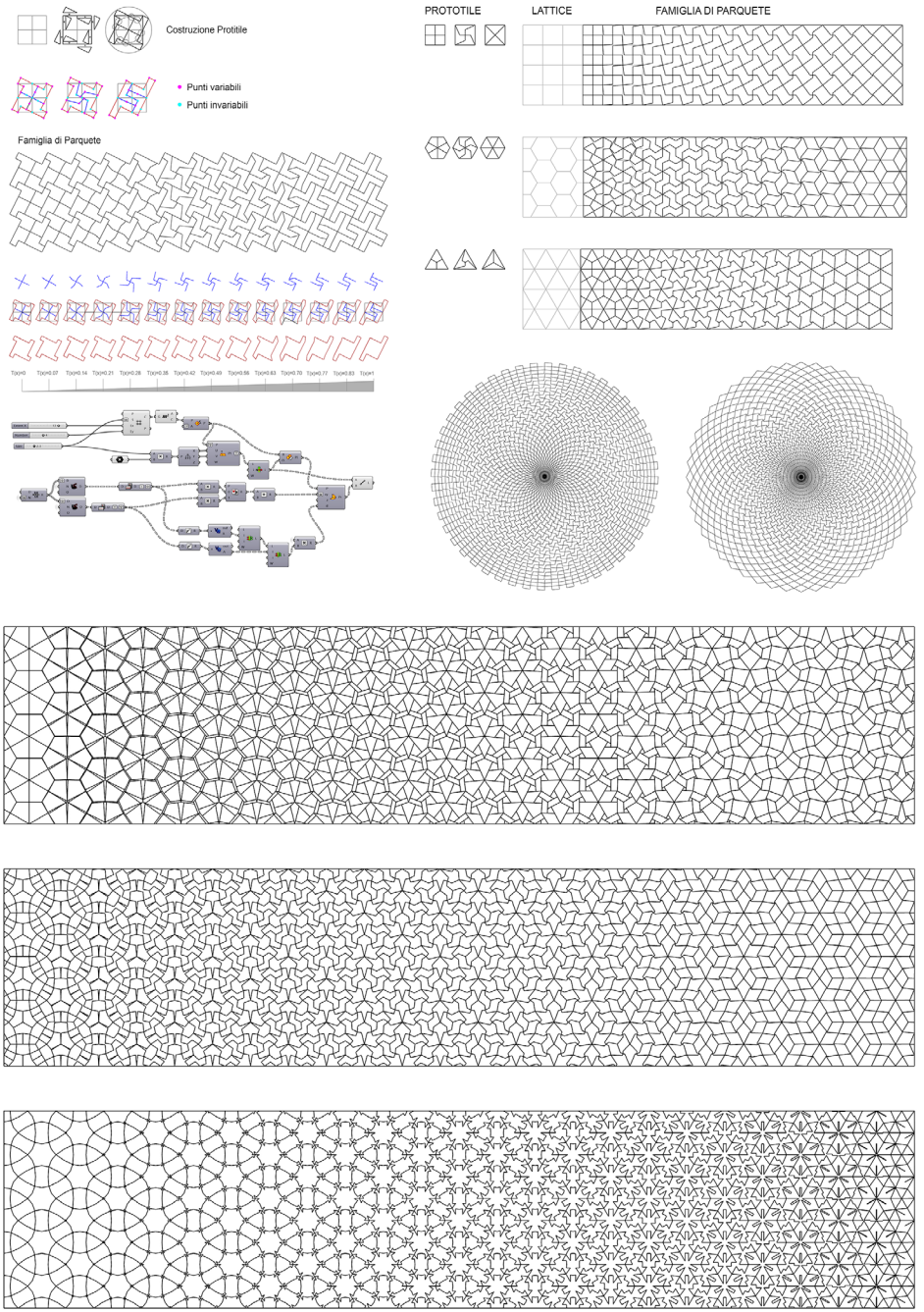
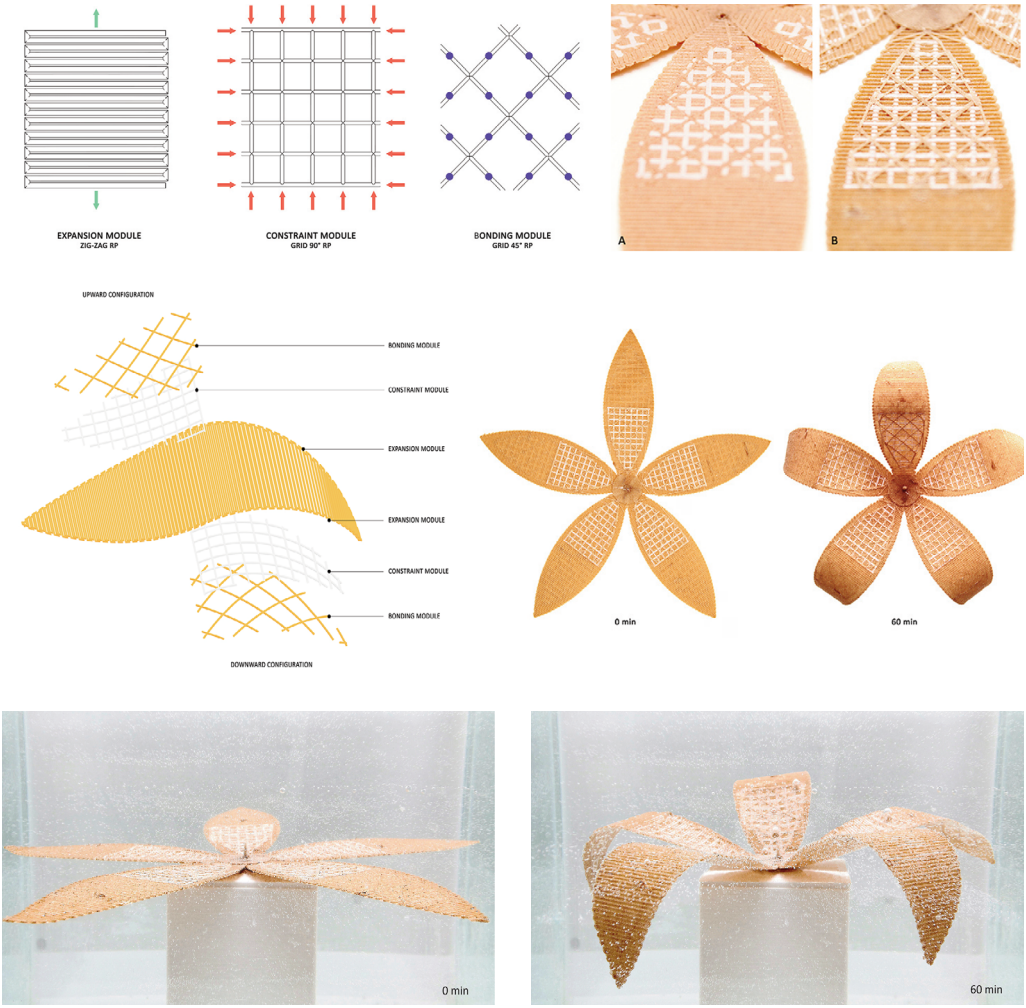


Figure 1.
Parquette deformation study, a dynamic pattern creation and control exercise, was realized using Grasshopper, a visual aid for scripting Rhino Mcneel software. Source:G. Buratti, 2023.

ability of complex systems to self-organize while maintaining equilibrium, computer processes and design practice, has indeed defined an interesting conceptual and research framework (Codgell, 2018).

6.3 Computational Design

Computational Design involves a conscious use of the computer tool that goes beyond the function of representation and visualization, allowing control of the codes by which the processor constructs form. This is usually done through visual aids for scripting, applications that make formal relationships explicit by bringing out their interconnections and dependence on parameters that influence the algorithmic path outcome (Figure 1). The outputs are, in turn, usable as input data for further commands to form a data network, an ideogrammatic morpheme of multiple achievable outcomes. This interconnective structure clarifies the positions of the algorithms that become procedures (Migliari, 2000) corresponding to the formulation of the model's interpretive hypothesis and the multiplication of its representations. Among the usable applications, Grasshopper, a Rhinoceros plug-in from McNeel, has become the iconic tool for this current trend. Used internationally and enriched by a series of add-ons, it has proved to be a tool capable of responding to the many issues inherent in the need for increasingly integrated design, which promotes a research direction based on the centrality of the code-procedure concept. Form is not defined as a priori but results from refining conceptual, communicative, structural, and geometric instances, leading to the most responsive result (Figure 2). The designer focusses on the process, created ad hoc to achieve the best possible outcome in response to specific design problems. Through the computer tool, it is possible to synchronously manage a considerable amount of data related to the different stages of the design process, addressing previously unassailable morphological problems (Figure 3).
One of the most pervasive and influential design theories of our time has thus been reversed, overcoming arbitrary stylistic commonalities in the search for a language that is not predetermined but contingent, freeing the design act from any preconceptions, traditions or trends.



Using Terzidis' words (2003), «for the first time perhaps, the design might be aligned with neither formalism nor rationalism but with intelligent form and traceable creativity». Ultimately, Computational Design is an approach that uses computer algorithms and computational capability to automatically generate a set of design solutions based on specific parameters and constraints that meet designer requirements. The growing potential and evolution of the method have led to further exploration of heuristic optimization strategies peculiar to mathematics and computer science, which are helpful in the search for efficient solutions in the face of large amounts of data, called Evolutionary Algorithms.

Figure 2.
The fabrication of biologically inspired and hygro-responsive morphologies with Wood Polymer Composites (WPCs), highlights how control of kinematics through computational design enables dynamic mechanisms of shape change in response to environmental factors. Source: M. Filippucci, G. Pelliccia, 2023.

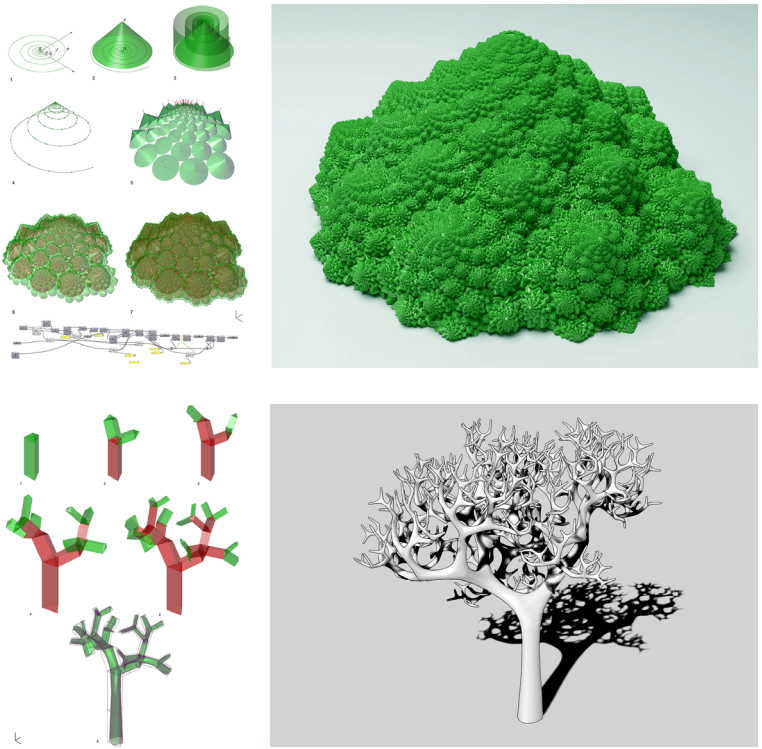


Figure 3. Computational morphogenetic study on biological growth processes. (above) Growth principles of Roman cabbage; (below) branch development of a deciduous plant. Source: G. Buratti, 2021.

6.4 Evolutionary algorithms

Genetic or Evolutionary Algorithms are procedures based on the Darwinian principle that predicts that organisms best suited to a specific ecosystem have a greater chance of survival, transmitting advantageous characteristics to subsequent generations. Used as a design tool they allow, by iterative processes of random recomposition homologous to sexual reproduction, to obtain the morphologies that best meet the formalizable and quantifiable conditions (materials, physical and temporal constraints, set purpose, user interaction, economic and production factors) that distinguish any project. Compared with traditional algorithms, procedures that are easier to follow step by step, Genetic Algorithms act with a certain degree of autonomy, due to the randomness of the recombination processes. They fall to all intents and purposes within the field of study of Artificial Intelligence, enshrining a new evolutionary leap for drawing and representation.

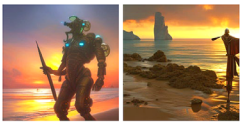
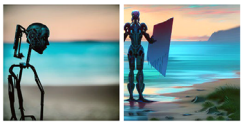
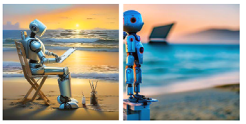
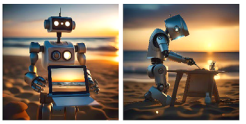
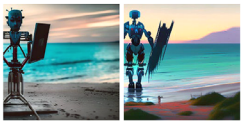
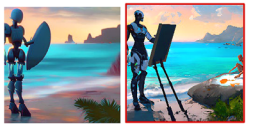
6.5 New frontiers: AI for representation

Generative AIs could create novel content based on prior data, but the function principles differ significantly from Computational Design. Today, the application domains of these tools range from obtaining text, images, videos, and musical motifs from simple textual input. However, the development of AIs has been a tortuous process, covering some seventy years of highly purposeful moments that have alternated with periods of stagnation.

Ever since the conference at Dartmouth College in 1956, where John McCarthy introduced the evocative definition of Artificial Intelligence sanctioning the actual birth of the discipline, the evolution of software able to reproduce capabilities typical of human cognition such as interaction with environment and people, learning, adaptation, understanding and planning, has been closely linked to technological, scientific and contextual advances (Buratti *et al*., 2021). Unsurprisingly, the last decade of hardware acceleration has produced numerous tools capable of generating images from natural language text descriptions. This application uses highly advanced algorithms: Artificial Neural Networks (ANNs), which are computational models that use a connectionist approach to calculation. In a primary interface named Prompt, you type words or simple phrases that describe the image you want to get. A source image can also be used in some cases, although integration with written text is often required to obtain interesting results. In most cases, the link between the typed lemma and the signified image is made using the Prior device, which relates the written word to a database of taxonomized images. All images that refer to the terms used will then be selected from the database the algorithm draws on. The development of datasets has been facilitated over time by the never-ending growth of the Internet: millions of images associated with their respective text descriptions are already available on the Web, managed by the Hyper Text Markup Language (HTML), which allows the layout and formatting of Web pages, labelling and recognizing the different elements of a multimedia page. It is possible to reconstruct considerable datasets quickly through the <Img> and <Alt> tags, which identify an image and the textual part that explains its content. The construction of the data

collection plays a crucial role in the training and operation of these applications: if the inputs are missing, of poor quality, or biased, the results will be corresponded. The collected data must be processed and transformed into a new image that meets the specifications provided by the user via prompts. This is the most technologically complex moment: it is not enough to compose an image patchwork to obtain an innovative reworking, but the concept of Latent Space must be introduced.

Latent Space is the virtual device that provides the processor with structured and quantified information on a picture's qualitative parameters. It is a multidimensional space that considers 500 or more variables, among those found to be most efficient in image generation during training. Within these spaces are parameters that a human would hardly distinguish, but for a computer, they create meaningful regions and clusters that can capture the image's essence.
Each point in Latent Space defined by the words can be regarded as the ingredient in the *recipe* that generates a possible image (Figure 4). Compared to the processes used in Computational Design, neural network-based machine learning algorithms analyze large amounts of data to draw autonomous conclusions or predictions.
The path to the image is characterized by a process of hermeneutic circularity based on repeated trials in search of the best results. There are no fixed rules for how a neural network-based AI outputs information so the results may be surprising and unexpected regarding effectiveness or graphical technique. Still, they are often far from the user's initial mental prefiguration. As for the possible use for design purposes, other than visual communication, the results are not controllable enough for project use, except in the initial concept stages, more as suggestions than as actual technical/constructive deliverables.
Unlike algorithmic modelling, where handling large amounts of data is under the designer's control, the parameters remain hidden in Latent Space in generative AI applications. In both tools, the first result often doesn't meet the designer's needs. Still, while algorithmic modelling makes it easy to interpret and modify variables, with AIs the process is too haphazard for the highly hierarchical and time-optimized path any project implies. This does not detract from the fact that AI has enormous transformative potential, perhaps more significant than the

Words typed in prompt	Dall-e 2	Midjourney	Stable Diffusion
2° ATTEMPT Generative AI, artificial intelligence drawing, a paintbrush, a beach at sunset			
4° ATTEMPT Generative AI, artificial intelligence drawing, a paintbrush, a beach at sunset, calm Mediterranean Sea			
5° ATTEMPT A humanoid robot, it paints on a beach at sunset, painter's ease, calm Mediterranean Sea, no photorealistic.			
7° ATTEMPT A humanoid robot, it paints on a beach at sunset, painter's ease, calm Mediterranean Sea, no photorealistic. (*repetition*)			

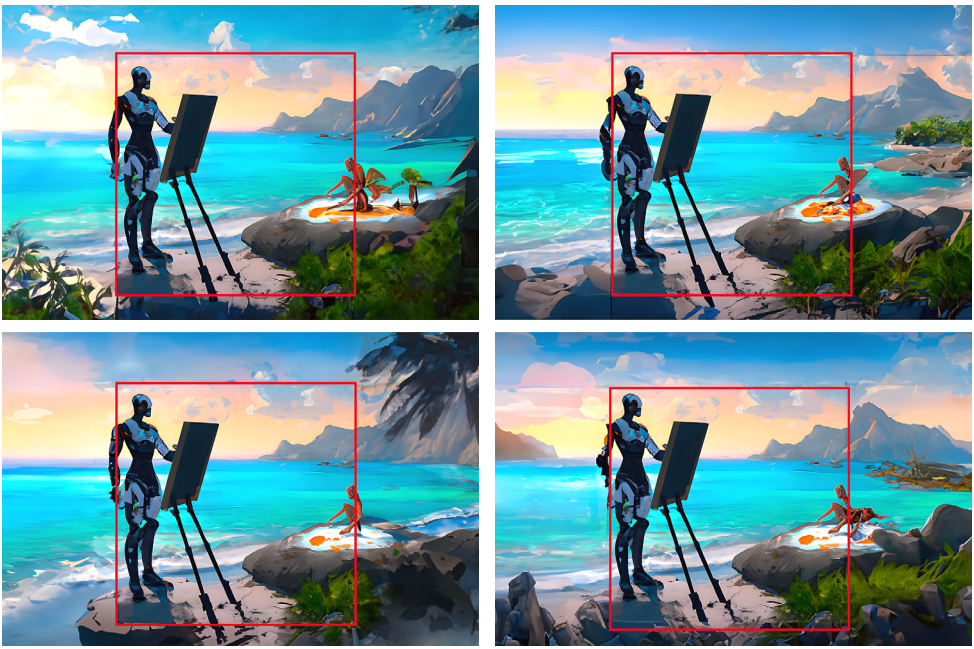


Figure 4.
Example of results of the three main text-to-image Artificial Intelligences available today from the same text instructions. A series of attempts are often required before the desired result is achieved. It is necessary to understand the operating logic of AI specifications in order to use them properly. The image framed in red was later chosen for an outpainting operation with Adobe's AI Firefly. Source: G. Buratti.

impact of CAD applications of the last century. The incredible development speed related to the peculiar workings of neural networks is not comparable to that of any other technology in human history (Figure 5), making it difficult to produce any development forecasts.

6.6 Conclusion

Beyond the general interest aroused and the ensuing social uproar, the continuity of AI with the Computational Design processes, which have long been in robust development, is evident. The elements of real innovation concern the poietic process – which has always been partly delegated to the technology used, from the pencil to the modelling software – the availability of an unthinkable realism linked for the first time to the tool and not to the author.

More than an authentic dialogue with the computer, it is possible to speak of a further anthropological mutation of the human/machine relationship. It is not yet possible to establish a proper conversation in the etymological sense of *cum-versare* (*cum*=with; *versare*= to turn around, to find oneself), that is, of dialogical confrontation. These AIs receive instructions, and only then can they sift, select and process

Midjourney v.1 (February 2022) Midjourney v 5.2 (October 2023)

Figure 5.
Images were obtained by AI Midjourney using the same prompt indications. The continuous training to which users subject AIs has promoted a significant improvement in results in a short time.
Source: G.Buratti.

unimaginable amounts of data. Despite textual input, the prompt does not have much in common with the natural language we write and speak daily; it is somehow a hybrid between natural language and programming codes. With machines, at least for the present, there can be no real communicative relationship, hence the randomness of fruitful and surprising, now frustrating and disappointing, results that can be obtained. At present, the detectable advantages are:

1. A significant time saver, especially for correction operations and cleaning up an image, the time savings are considerable substantial, allowing the user to focus on creative processes.
2. New features such as Outpainting and Inpainting. For generic or background images, excellent results can be generated quickly, while specific depictions may take time or effort to achieve.
3. Image graphic quality. The results obtained are often high-level visual solutions.

However, these positive aspects are accompanied by some key critical issues:

1. Lack of *originality*: the outputs created are based on the database and the training received. This leads to continuously dealing with the same data in a continuous repetition and recomposition of existing patterns.
2. Content distortion: Generative AI uses training data to generate new information. If the former contains distortions, the obtained data will reflect those biases. The quality of training data is essential to create plausible and realistic data. The ethical component related to what is produced with these tools is often mislead by the term *intelligence*, by which these tools are classified. Humans are endowed with moral principles that discern right from wrong based on cognitive concepts dictated by upbringing and culture of reference. A generative AI follows the designer's programming and is not conscious of motivations or any consequences of what it generates. Some applications have already been criticized for creating stereotype-based images that risk fuelling misogynistic and racist behaviour. This is also why the AI Safety Summit, held in London in November 2023, outlined a common

strategy for all stakeholders to establish the ethical criteria and moral challenges posed by this technology.

3. The traditional concept of intellectual and/or artistic authorship is challenged: no longer a well-defined author, but a diffuse distribution of authorship, where both human and machine, including those who designed and trained it, participate in the result. On the one hand, there is the question of protecting authorial rights about the content used to train the algorithms. On the other hand, can the works produced by generative AI be protected by copyright?

The first question is the most complex, as it challenges the basic operating principle of neural networks: the need to use large amounts of existing data for training. At the writing of this paper (March 2024), the World Intellectual Property Organization is examining this issue, intending to establish regulatory principles. At the same time, many authorship rights holders, from image repository companies such as Getty Images through prominent newspaper publications to graphic designers, artists and photographers, have taken legal steps to protect their work.

Future research should study which operations of the design process can be delegated to machines, leaving designers to focus on highly creative activities. From this perspective, design becomes a matter of choice: machines produce countless variations, while humans choose according to their own visions and purposes.
This involves a shift from tactics to strategy (Picon, 2020), from how to why, ushering in a new way of understanding the profession, more akin to the role of curator rather than that of craftsperson.

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