From Canvas to Code: the Evolution of Generative Art in the AI Era

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Abstract. Traditional art encounters a transformative wave as artificial intelligence takes center stage, challenging our perceptions and creative processes. In this review, we explore the evolution and contemporary landscape of generative art within the context of artificial intelligence. We aim to clarify and categorize the terminology and definitions associated with generative art while emphasizing its collaborative nature, involving both humans and autonomous systems. Throughout the review, we discuss the various phases of generative art from both theoretical and technological perspectives, ranging from early non-computer systems to algorithmic and artificial intelligence systems. Additionally, we delve into the generative artworks and practices, examining the value, ethical and creativity considerations surrounding them. We also analyze the aesthetic judgment and ongoing debates within the field. Finally, we propose a framework for dynamic collaborative interaction and reflect on the potential and future trends in generative art research and development.

Keywords: Generative art, artificial intelligence, algorithmic art, computational aesthetics

1 Introduction

The boom in artificial intelligence technology is rapidly bringing generative art into the public eye. Especially in visual art, it has exploded with amazing vitality. In fact, since the late 1950s to the present, there have been several creative waves in the little-known field of generative art. While generative art has seen unprecedented change and attention empowered by artificial intelligence, little consideration has been given to the other topics behind its fascinating technological spectacle. Since the new form of art technology has not constructed a satisfactory critical framework [1], and there is a general confusion among the public, and even artists, about the various labels and terms used in the field, there is a need to clarify and categorize its definitions. At the same time, in order to better understand the rich connotations of generative art, another task of this paper is to take a more complete view of the evolutionary process of generative art from its origin to the present day. Different from traditional art, the most attractive feature of generative art lies in the process of collaborative creation between human beings and autonomous systems. Therefore, we need to re-examine this art form from a comprehensive perspective, not only from the perspective of theoretical and technological development, to observe its life span and progress in the field of art history,

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but also from the perspective of the dynamic collaboration between human and systems, to stimulate our views on the future of generative art.

In this review, we focus on the field of generative art related to the graphic generation, firstly introducing its main features, and clarifying and categorizing the common labels and terms used in the art field related to it. Then we summarize the evolutionary trace of generative art, taking its technological milestone breakthroughs and roughly classify it into three phases, namely Artist and Non-Computer System, Artist and Algorithmic System, Artist and Artificial Intelligence System. We point out that the current generative art has ushered in a new mode of collaboration under the influence of artificial intelligence.

In Part 3 we discuss the contemporary generative art scene and its rapid popularity driven by technological advances such as artificial intelligence. We also review the controversies and ethical considerations surrounding AI-generated artworks, as well as different perspectives on their artistic value and creative agency. Further, we develop an analysis of the aesthetic judgment of generative art, focusing on the tense debates between different disciplines and theoretical streams, and pointing out that as the content relevance of generative artworks increases, more evaluative factors need to be taken into account.

Finally, we propose a framework for dynamic collaborative interaction in generative art, and then depict and differentiate the behavioral paths of artists' collaborative interaction with autonomous systems during the creative process based on the two most dominant art types within the current field of generative art (i.e., algorithmic art and AI-generative art). Based on the literature research and analysis, we also indicate that although AI-generative art has shown astonishing potential for accomplishing artistic tasks in recent years, AI-driven art generation is still in its infancy, and we put forward a few reflections on the future development trend of generative art research and development.

2 Understanding Generative Art

2.1 What is Generative Art

Generative art is a work of art created in whole or in part using a non-human autonomous system [2]. Distinguished from traditional art creation, creators of generative art create works by activating a set of rules or constraints and have the following characteristics:

i. Rule-based Creation [3]: Generative art is based on rules or constraints established by the artist. These rules serve as instructions for the autonomous system to generate artworks. The artist defines the parameters, algorithms, or guidelines that direct the creative process.

ii. Automation and Autonomy [4]: Generative art involves a level of automation, as the non-human system participates in the decision-making process. Once the rules are set, the system takes over and generates the artwork based on those rules. This grants the artwork a degree of autonomy, with the system determining specific outcomes.

iii. Unpredictability and Emergence [5]: Generative art embraces the element of unpredictability and emergence. As the computer system follows the specified rules and generates the artwork, the outcomes are not predetermined or fixed. Instead, they emerge

through the interaction of the rules and the computational processes, resulting in unique and often unexpected artistic outputs.

iv. Combination of Artistic Intention and Machine Collaboration: Generative art involves a collaboration between the artist's intentions and the capabilities of the computer system. While the artist establishes the rules and constraints, the computer system contributes to the creative process by executing those rules and generating the artwork. This collaboration blends the artist's creative vision with the computational capabilities of the system.

Overall, generative art expands the boundaries of artistic creation by integrating computational processes, rule-based systems, and emergent outcomes, offering new possibilities for artistic expression and exploration.

2.2 Taxonomy of Generative Art

Within the field of generative art, numerous forms of art types and labels have been derived. Boden, Galanter, Dorin et al. have focused on different labels of generative art and attempted to categorize them through their definitions [2] [3] [6]. However, different art types and terms are often intertwined and entangled with each other, making it difficult to form a linearly structured categorization framework. Nonetheless, by clarifying the characteristics of techniques, media, and production methods, we try to help establish a terminological framework for generative art to better distinguish different kinds of subdivisions.

The terms generative art (GA) and computer art (CA) are often used mutually and interchangeably in the art world; in fact, not all GA involves computers. The main characteristic of GA is the intervention of a non-human autonomous system in the creative process, which centers on the setting of rules or constraints, highlighting the rule-driven and autonomic nature of the artistic process. Computer art (computer-assisted art), on the other hand, refers specifically to the type of art that is created with the assistance of computers, and is a specific subset of the broader GA.

In addition to CA, GA includes other subcategories. Electronic Art (EA) is an art form that utilizes electronic technology as media [3]. In a broader definition, EA involves all artistic creations related to electrical engineering and electronics. This highly inclusive definition does not help us to further our understanding of GA, so, inspired by Laposky [7], we focus on the abstract combinations of simple electronic instruments, mathematics, and photography that assisted in part of the design (as in his use of oscilloscopes and displays to capture images of light) in the early years of GA [8]. These works, which draw on physical and natural phenomena, are outside the realm of common computer art and create strange visual effects.

The other subset completely eliminates human involvement, relying on natural, chemical, physical, and mathematical systems to generate artistic images. It also gave birth to many great artistic pioneers (e.g. Piet Mondrian, Kazimir S. Malevich and Wassily W. Kandinsky), whose works of abstract art based on different rules or orders had a significant impact on different genres/styles in the art world.

Algorithmic Art (AA) is a type of art which is programmed to follow a certain procedure to generate a work of art with the assistance of a computer [9]. AA usually consists of combinations of mathematically derived properties with a specific family of algorithms to achieve different patterns of results that output the characteristics of the artwork. This broad

concept encompasses any art that involves programming rules [10], typically Evolutionary Art (EvoA) , Genetic Art (GenA), Fractal Art (FA), Robotic Art (RA), and other different art types. Inspired by biological evolution, EA, evolved from the process of random variation and selective replication that affects the art-generating program itself, improving the visual output through repeated iterations [11]. GenA is often seen as a similar type of art to EvoA, first developed by Holland as a robust search technique in which populations of test points evolve through random variation and selection [11]. In the mid-1980s, FA began to evolve, with an algorithmic concept inspired by mathematics and nature that computes fractal objects and represents the results of the computation as static digital images, animations, and media [12]. RA refers to art forms that are capable of autonomously achieving a certain artistic purpose at the command of the artist. In the field of GA, the earliest pioneers of the practice experimented with combining software and plotters to perform drawing tasks, but the final work still depended on the programmatic input of the artist.

In recent years, the field of AI art (AIGA) has made significant advances, making epochal leaps in both performance and accessibility. Unlike in AA, where the artist is programmed to produce an image output that follows the program's expectations, the outcome is often determined by the algorithm itself. In contrast, AIGA is created using machine learning techniques by training neural networks on large image datasets and using the trained networks to generate new images that match their learned aesthetics [13].

More non-conventional labels are elaborated in Appendix 1. Despite the difficulty of sorting out the main terminological concepts in the field of generative art, it is undeniable that there are still many overlapping and encompassing relationships between the terms (see Figure 1). This reorganization and categorization is intended to further help people understand the richness of art forms under the field of generative art.

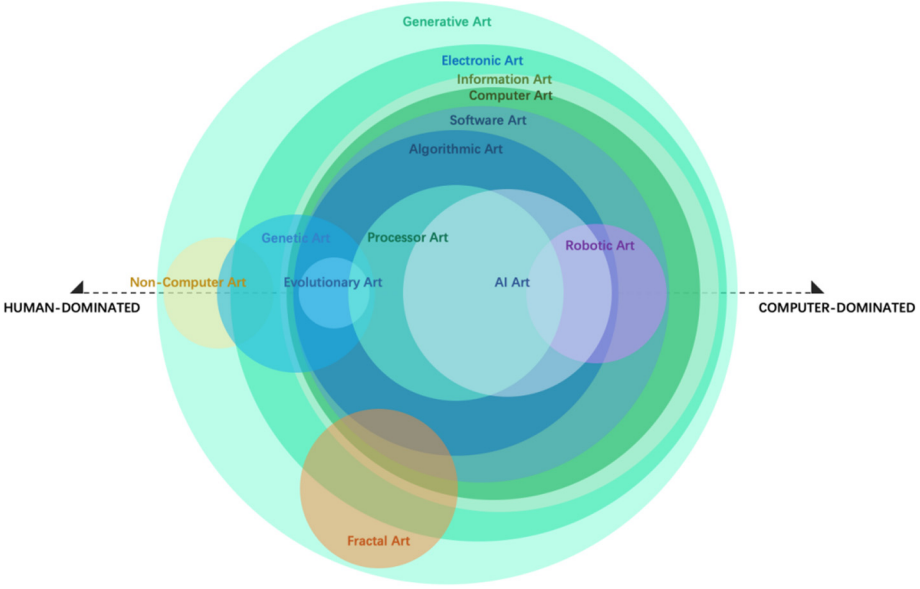


Fig. 1. Taxonomy of Generative Art.

2.3 Theoretical and Technical Development of Generative Art

The roots of generative art can be traced back to the late 1950s, when it was first proposed by a diverse group of artists and computer scientists for use in the context of computer art, referring generally to forms of artistic creation in which computers are involved or generated. Theoretically, generative art has its origins in Cybernetics and General Systems Theory [3], with Norbert Wiener's seminal work Cybernetics being an important landmark in the birth of cybernetics, whose theories had a very significant impact on the art scene in the 1960s and 1970s, leading to numerous artists and engineers became obsessed with this new "episteme" art practice. At the same time, Max Bense's "Generative Aesthetics" established a link with digital art [14] and introduced interdisciplinary terms such as symbology and programming into the field of computer art.

Technological development has been a key dynamic in the evolution of Generative Art, which has always shown amazing vitality in terms of creative practice. Nees's 1965 exhibition "Generative Computergraphik" at the Technical College in Stuttgart, Germany, was an important milestone in the early years of Generative Art [15]. Frieder Nake and A. Michael Noll's exhibitions at the Wendelin Niedlich Gallery and the Howard Wise Gallery in New York were the first public exhibitions of drawings generated by algorithms running on digital computers under program control. Computer art is also gradually by the attention of experts in different disciplines, more and more artists and engineers to give full play to their respective characteristics and advantages, bursting out of a large number of computer-aided generation of art works. For example, Kenneth C. Knowlton's mosaic portraits, Manfred Mohr's Klangfarben series of computer paintings and digital animations, Hiroshi Kawano's OKITAC 5090A and Herbert W. Franke's early digital art works. Vera Molnár, who also began using computers to create algorithmic paintings of simple geometric subjects during the same period, is considered one of the first women to use computers in her artistic practice [16].

The 1970s has witnessed the further establishment of generative art as an artistic practice. The rise of electronics gradually replaced the manual tools of art-making, and real-time imaging became active at the intersection of art, science, and technology. Computers and various image-generating devices became creative tools that facilitated interdisciplinary explorations of art, and in 1970 the School of the Art Institute of Chicago created Generative Systems, a new approach to teaching the integration of art and technology in a hands-on environment [17]. As did Paul Neagu, who founded the Generative Art Group in the United Kingdom. In the nascent period of Generative Art, the main interest was in exploring the power of random creativity, with practitioners working to reduce human control and to create art through different software, complex programs and tablet plotters, visual display units (VDUs) and even more complex forms of print and video. Harold Cohen developed the program AARON [18], which uses a set of formal rules and image-making strategies to automatically generate line drawings with the aid of a drawing device. It is more an exploration of process than a production of content. Although they experiment with different scientific methods of creation, they are in fact pseudo-random and complex shapes based on the subjective judgment of the practitioners themselves. Therefore, these works are considered as "subjective abstract" symbols that contain the aesthetic experience and formal preferences of the authors, and this kind of computer art cannot be generalized, but can only be interpreted as an aesthetic product.

In the late 20th and early 21st centuries, generative art became a common practice, and its boundaries continued to widen as more and more disciplines came together to form a broader and more complex interdisciplinary perspective. At this stage, creators were full of infinite visions for generative art, and philosophers, artists, engineers, designers, musicians, architects, and other multidisciplinary experts adopted more diverse generative approaches, which also resulted in more complex construction systems. For example, Brian Eno proposed "generative music" in 1995, Celestino Soddu generated infinite iterations of a 3D model of a city through the program Argenia in his Italian medieval town marking project [19], and Jared Tarbell's Substructure. Tarbell's Substrate. On the other hand, technology is becoming more accessible to the general public, and the creation of easy-to-use programmatic tools has dramatically boosted the capacity of non-technical groups to create art. 2001's Processing, developed by the MIT Media Lab, kicked off the generative visual arts boom, providing a richer approach to design while increasing creative efficiency. Processing, p5.js and other advanced programmatic tools have greatly reduced the technical threshold of generative art, and played the prelude to human-computer cooperation in art creation.

In 2014, with the Generative Adversarial Nets (GAN) proposed by Goodfellow [20], the high-speed development of technology and the explosive growth of AI paintings profoundly changed the creation paradigm of artists, and made the generative art, which had been on the fringe of the art world for a long time, rapidly enter the public's eyes. At this stage, the subjectivity of human creation is further weakened and stripped, and a variety of efficient generators with rapid turnover gradually become the leading role in art creation. GAN [21] [22], DeepDream [23] [24] [25] [26], Neural Style Transfer (NST) [27] [28] [29], Artificial Intelligence Creative Adversarial Network (AICAN) [13] [30], Diffusion Model [31] [32] [33], more and more artists and designers have started to use these computer vision generation technologies as tools for their creative practice and have contributed to the flourishing of AI art activities (see Figure 2). In the vast process of AIGA, many incredible artworks have emerged, such as Portrait of Edmond Belamy created by Obvious Group, AI installation Memories of Passersby I created by Mario Klingemann, and even the artworks produced by AI robot Ai-Da. Unlike the previous two phases, with the development of many generators such as Stable Diffusion, DALL-E2, Midjourney, etc., generative art has gradually increased in controllability from complete randomness, and the content of creation has also gone from simple linear geometrical patterns to more and more realistic and lifelike levels, and the interest of artists and the general public has shifted from the process and changes to the ethical issues of the way of creating art and the reflection on the possibility of artificial intelligence. Although different artists present their works in diverse styles through different generative algorithms and even creative means, they share a similar motivation: to discuss the relationship between human beings, technology, and art, and to explore through their works the convergence of computer vision and art to create a new form of art.

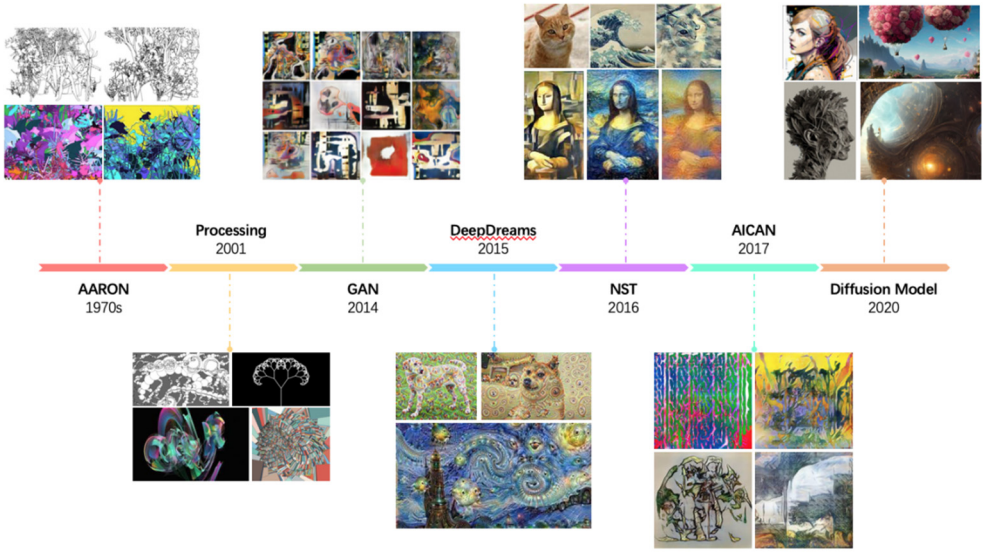


Fig. 2. Illustration of Technological Milestones of Generative Art.

3 Contemporary Generative Art Scene and Aesthetic Judgement

3.1 Shocking Auction Prices and Frenetic Art Practices

The creative practice of generative art has never ceased, although it used to remain on the fringes of the blurred junction of computer science and art until the rise of emerging technologies such as artificial intelligence and the explosive popularity of AIGA caused it to spread rapidly from academia to the public eye and injected the greatest vitality ever into contemporary art. At the same time, this surge has brought about arguments and numerous ethical questions surrounding the artistic value of AI artworks.

As the public's tastes and interests become more diverse, a new openness to art has emerged, catalyzing trials and explorations in the field of AI-generated art. Beyond the national creative boom led by generative platforms/tools such as Midjourney and Stable Diffusion, a series of more significant and representative art landscapes have also erupted. In October 2018, Christie's ignited the AI art market with a marketing strategy that proclaimed itself "the first auction house to offer a work of art created by an algorithm" [34]. In the Prints & Multiples sale, the Obvious collective's Portrait of Edmond Belamy sold for $432,500. Mario Klingemann's AI installation, Memories of a Passerby I, became the first AI artwork to be sold at Sotheby's. Klingemann's notable works include a series of 79,530 self-portraits exhibited at Nature Morte gallery in 2018. In 2016, Sophia, a robotic artist developed by David Hanson, collaborated with Italian digital artist Andrea Bonaceto to create the NFT artwork "Sophia Instantiation", which realized an impressively high auction The work realized an impressively high auction price. Hong Kong artist Victor Wong created the first AI ink painter generated by a robotic arm based on different input parameters. The robot Ai-Da, developed by Aidan

Meller, was launched in 2019 and has been hailed as "the world's first surreal AI robotic artist." In 2021, Ai-Da held a solo exhibition of his paintings at the Design Museum in London, titled Ai-Da: Portrait of a Robot, and brought widespread social impact and attention to the project. In addition to computer graphics, Ai-Da also uses a robotic arm to draw, paint, and even sculpt more diverse art practices, learning from observation with an in-eye camera.

Edmond's high price tag was accompanied by more pressing value judgments, creative identity disputes and other ethical issues. Klingemann and others did not agree with the validity of its value. They argue that its production lacks judgment; Barrat agrees that it is neither interesting nor novel [35]. Also questioned the independence and sophistication of GAN, highly likely to perpetuate the biases held by their developers. On the contrary, the artistic properties of AI-generated images are unquestionable in the eyes of artists in the AI community. Richard Lloyd, head of the Prints & Multiples, noted that their motivation for the selection was the process of creating the work, which minimized human intervention to reflect the pure formal creativity of the machine [34]. Ben Luke considered Edmond to be a work of artificial intelligence with a profound conservatism and was wary of its impact on the art market [36]. Epstein et al. reveal Belamy's responsibility conundrum and find a strong hierarchy of responsibility and credibility in generative art community [37].

3.2 Subjectivity and Creativity

Meanwhile, in other fields artists and art critics are engaged in heated discussions about the authorship and ethics of artworks created by AI. Art has been seen as the last barrier to human privilege. The creative process of generative art challenges the traditional notion of authorship because the autonomy and unpredictability of generative works often produce results beyond the artist's initial expectations, making the role of the artist more than that of the sole creator of a work of art. Ma argues that AI paintings deprive humans of their subjectivity and, with their accelerated development, gradually ascend to the main body of creativity [38]. Barale recognizes the disintegration of the "absolute" human creator and states that the creativity of generative art comes from "the interplay between man and machine" [39]. Chamberlain et al. identified a bias against computer-generated art that can be reversed when contextual cues are present or when anthropomorphic features are exhibited [40]. Hong et al. also showed that individuals' evaluations of AI-generated art are influenced by preconceived notions of the AI's creative abilities [41]. Chiarella et al. reveal a negative bias in AI-generated art compared to human-created works, which is reduced when AI-generated art is independently assessed [42]. These findings emphasize the role of a priori knowledge, biases, and contextual frames in shaping perceptions and assessments of generated art, contributing to a deeper understanding of creative agency and authorship in generated art.

Another interesting topic was the creativity of AI. Danto logically dismissed the creativity of AI: arguing that AI painting is, by nature, a summary of past aesthetic experience done through data, and produces nothing new [43]. In contrast, Kalyanaraman argues that when these artistic algorithms are trained to generate specific images, the artistic part actually emerges as a process performed and practiced by humans [35]. Ritchie lists criteria and assessment methods for attributing creativity to computer programs [44]. Colton et al. in 2009 suggest that the purpose of computer creativity research is to build software that exhibits creative human behavior [45]. DiPaola et al. evaluate the innovative and aesthetic value of DeepDream generated art [23].

Overall, AIGC has been recognized as a movement in art practice driven by technological innovation. Its rise is not a purely artistic movement, but rather the result of an interdisciplinary collaborative innovation: combining the fields of machine learning, artificial intelligence, engineering, design, sociology, and experimental psychology, which rely on AI and AI technology to create visual art, assist in art analysis, and advance art theory. Unlike traditional art, which pursues aesthetic value judgments, AI art has brought forth a multi-dimensional evaluation system from different disciplinary perspectives, of which "creativity" has become one of the evaluation criteria agreed upon by all sectors. Whether artists, critics or engineers, every individual, group and organization is emphasizing the importance of innovation in algorithms, forms and contents of AI art [13] [46] [47] [48]. Another important role in the AI art-making process is AI tools designed to help humans perform artistic tasks that are considered creative. The related innovation problems and challenges are varied: they include designing systems for efficient exploration of large instance spaces; automatic generation of systematic evaluations of creative domains; designing systems for fostering human creativity; formalizing concepts of creativity and originality; designing scenarios for efficient collaboration between humans and machines for creative tasks; and understanding the dynamics of creative collective systems [48].

3.3 Aesthetic Judgement in Generative Art

Aesthetics has always been a fascinating topic in art and science. In 1965 Max Bense introduced the concept of " Generative Aesthetics" - an art theoretical approach that applies mathematics and science to the process of creating and analyzing art [14], i.e., seeking to quantify the aesthetic experience and to computerize the creation and evaluation of art. In the field of generative art, however, quantifying aesthetic judgments has been a complex and challenging task. Unlike the traditional psychology of aesthetics (PA) approach commonly used in the field of fine art, computational aesthetics (CA) analyses are usually based on large image datasets [49] [50] [51] [52], employing methods such as experimentation [53] or digging into online assessment data [54], and reporting the results using success rates or RMS errors, while psychologists tend to use correlation measures. Johnson et al. have provided a thorough review in their review [55].

From a Formalist perspective, generative art is motivated by how to create aesthetically pleasing artworks. Physics and mathematics scholars have focused on the visual features and statistical properties of the images themselves, and it is widely recognized that the intricate balance of regularities and surprises in artworks has an impact on aesthetic pleasure. The use of symmetry [56], the golden ratio, and number sequences in artistic creation demonstrates the partial dependence of art on the mathematization and regularization of artistic expression. Regular fractal works more closely mimic natural objects and thus may be more aesthetically appealing [57]. However, regularity can also have a degree of rigidity, where occurrences and unpredictable components may be more effective in generating aesthetics, and vice versa, where excessive occurrences may lead to confusion and anxiety [56] [58]. Lakhal et al. found the existence of some quantitative criteria (e.g., algorithmic complexity) that can influence aesthetic judgments through a combination of image generation, and large-scale preference surveys [59]. Forsythe et al.'s study also found the influence of other visual features (e.g., composition, familiarity, etc.) on aesthetic judgments, and pointed out that color is an important feature that is integral to people's perception of the beauty of art [57]. Iigaya et al.

used machine learning to also demonstrate that it is possible to explain human preferences for artwork through the physical visual properties of images [60]. With the development of artificial intelligence and the establishment of more large-sample-capacity databases, more and more studies on automatic image aesthetics assessment support the Formalist viewpoint [61] [62], and we anticipate that the quantification of different aspects of form will allow us to discover a more diverse set of aesthetic evaluation criteria and to generate different branches in the field of art in order to construct efficient evaluation systems.

On the other hand, the Constructivist position argues against the prevalence of a causal relationship between feature-based stimuli and aesthetic experience. They advocate an individual actively constructed aesthetic experience and focus on the artist's intention and emotional expression during the creative process. Such notions are supported by the research of McCormack et al. who evidenced a lack of perceptual correlation between the complexity of the generated art images and aesthetics and emphasized the need to consider a wider range of factors beyond visual appearance [63]. More research in the field of cognitive science has revealed the influence of individual factors such as personality tendencies, personal history, individual relevance, specific meaning construction, and context on aesthetic judgments [64]. However, Johnson et al. also point out that "This gives rise to an immediate problem for computer art systems, which have no emotional qualia to form the basis of expression"[55]. The absence of experience and feeling was particularly noticeable in the early days of generative art in works composed of descriptive text or diagrams and geometric shapes (e.g., early works by Frieder Nake, Herbert W. Franke, Vera Molnar, and others). However, the development of AI-generating techniques and tools supports practitioners in creating more embodied and enriched content and allows them to enhance their ideas and expressions through AI [13] [33]. Therefore, we suggest that in the future the content, emotional, creative subject, social and other influences of these artworks be included in the field of research on generative art complexity and aesthetic prediction in order to obtain better results.

4 Working with Generative System

With the advancement of technology, artists, intelligent media and artworks converge in dynamic interactions and reconstruct a fascinating system of art creation. Unlike the traditional way of fine art creation, the intervention of intelligent media not only affects the possibility and predictability of the output work, but also profoundly changes the creative behavior, ideas and purposes of the artist. In the previous section we have introduced the two most dominant types of creation in the field of generative art, namely algorithmic art and AI art, through a categorization of terms, and in this section we focus on the intricate dynamics and interactions unfolding in the production process of algorithmic art and AI art. In the last, by understanding this interplay, we can gain insight into the evolving relationship between human creativity and computational systems.

4.1 Working with Generative System

Initiative and Intention

The initiation phase of generative art creation involves the distribution of tasks and responsibilities between the artist, the algorithmic system and the AI model. First, the art

creator needs to choose the appropriate algorithmic system. Symbol-based algorithms employ explicit rules and more transparent decision-making that match specific compositional rules, whereas statistically-based connectionist AI systems enable responsive artworks based on interactions [9]. In addition, artists have the power to define their artistic intentions, conceptualize the desired visual effects, and establish a creative direction for the artwork. They mobilize their artistic vision, subjective perspective and aesthetic sensibility to guide the generative process. Rule-driven systems also have greater autonomy than traditional art, which is determined by the artist's own will [3]. The evolution of technology has accelerated the acquisition of decision-making power by autonomous systems, and the gradual abolition of hard-coded techniques by higher-order algorithms indicates a continuing struggle between human intervention and autonomous systems [65].

Mediation in Generative Processes

Intelligent media play a crucial role in mediating the generative process between the artist and the artwork. In algorithmic art, artists engage in a collaborative dialog with the algorithms they design. They explore the interplay between the artist's intentions and the emergent properties of the algorithm, adjusting parameters and rules to achieve the desired visual expression [1]. The artist's intervention acts as a guiding force that shapes the algorithm's output. In AI art, artists partner with the AI system. They interact with the model during the training phase, providing prompt phrases, feedback, and improving the process. The artist strikes a delicate balance between guiding the AI's artistic intent and accepting the unpredictable output, allowing the AI system to realize its unique creative potential.

The Control and Emergence

Generative artists embrace the emergent behavior produced by chance and unpredictability. They observe, explore, and investigate unexpected patterns, and discover possibilities beyond what was intended. Algorithmic artists are more concerned with the process of creation than the result, i.e., the emergent behaviors and complex patterns that arise form the interactions of the algorithm's components [13]. In contrast, creators in AI art take a more collaborative and exploratory view and are interested in the outcome of their visual output.

Dialogues and Feedback Loops

Artists in algorithmic art interact more directly and explicitly with the algorithm, actively modifying and fine-tuning its parameters and rules to achieve a particular visual output. The artist's intervention is critical in shaping the appearance and behavior of the artwork [3]. Authors in AI art actively iterate and interact with the generative system by providing various forms of initial input [66], training the AI model, and then observing and evaluating the generated results. This exchange leads to new creative directions, discoveries, and insights, and fosters an ongoing dialog between the artist and the system [67].

4.2 Generative Art Dynamic Collaborative Interplay Framework

For the first time, we have built a dynamic collaborative interplay framework for generative art creation (see Figure 3). The framework divides the process of generative art creation into four distinct phases and vividly depicts the existence of at least two divergence and convergence phenomena in the process. The first phase involves ideation and idea generation, where artists draw upon their background, knowledge, and cognition to produce a multitude of

artistic concepts. This phase is characterized by the mass production of ideas, depending on the artist's individual intentions. In the second phase, known as the constructive phase, artists interact with autonomous systems. In order for artists' ideas to be realized with the help of computers, they need to translate complex concepts into code or simple descriptions. The third phase sees the computer taking an active role in generating a vast number of outputs based on the artist's instructions. This phase is characterized by the emergence of endless variations and possibilities as the computer explores the artistic space. Finally, in the fourth phase, artists carefully review the generated outputs and select those that best align with their artistic intent. They consider visual, conceptual, and emotional aspects, while also being open to surprises that may surpass their initial expectations. If unsatisfied, artists revise their instructions and make adjustments to guide the computer until the desired image is achieved. The four phases provide a structured framework for the iterative and collaborative process of generative art creation, allowing artists to explore, experiment, and refine their artistic visions.

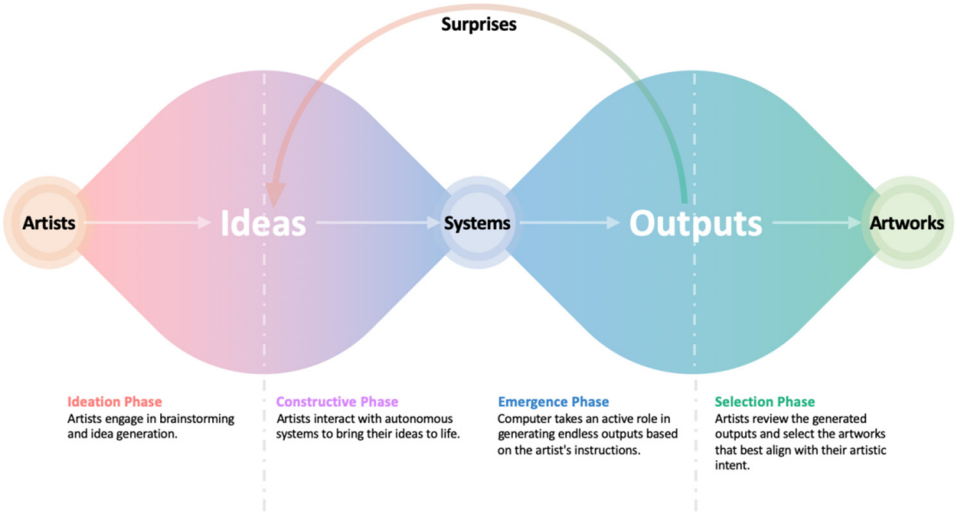


Fig. 3. Generative Art Dynamic Collaborative Interplay Framework.

5 Working with Generative System

Artificial Intelligence has exploded exponentially [68] since the 21st century and has demonstrated amazing performance in many disciplines. As techniques such as generative adversarial networks and diffusion modeling continue to improve, artistic creativity, once considered a human privilege, has been impacted and challenged like never before. In Section 2, we review the major technological changes since the birth of generative art, and it is not difficult to find that generative art is still in an infant stage [69] in the vast process of artificial intelligence, and there are still many problems waiting for the next technological breakthroughs, such as the formalized understanding of the content logic and the controllability of model training. At the same time, the generative speed, quality and diversity

of AI still need to be continuously optimized, so that generative art tools can really change the creative process of art. Combined with related research, this paper proposes that driven by the development of AI technology, generative art will show the following trends.

5.1 Technology Trends

We can envision the emergence of new technologies that will further advance the field of generative art. The development of large-scale language models (LLMs) such as GPT [70], BERT [71], and others have already demonstrated their potential in a variety of creative applications. The ability of these models to understand and generate human-like text makes them invaluable tools for generating narrative-driven artworks, poetry, and interactive stories [72]. With further advances, these language models may become even more adept at understanding context, emotion, and aesthetics, allowing them to produce highly complex and nuanced generative art output [73]. Second, cutting-edge AI drawing tools such as Midjourney, DALL-E, and Stable Diffusion open up new avenues for generative artists. As these tools continue to evolve, we can expect more sophisticated functionality, enhanced user control, and improved integration with other generative systems. In addition, advances in hardware, such as faster processors, increased storage capacity, and improved graphics rendering, will provide artists with even more powerful tools for creating generative art.

5.2 Change of Agents

As generative art becomes more accessible and collaborative, we can expect a wider range of participants to enter into the creation of art. The democratization of generative art may lead to a more diverse and inclusive artistic community, promoting interdisciplinary collaboration and pushing the boundaries of artistic expression [13]. Furthermore, the rise of AI-generated art may blur the lines between human and machine creativity. Artists may increasingly work with AI systems as creative partners, exploring the unique artistic perspectives and outcomes that emerge from this symbiotic relationship [67]. The role of the artist may evolve from that of a singular creator to that of a curator or facilitator, shaping and guiding the generative process rather than controlling all aspects of artwork creation.

5.3 The Production Method of Art

The integration of real-time data and dynamic inputs may introduce a new dimension to generative art [74]. Artists can combine live broadcasts, social media data, environmental factors, or other external sources of information to create dynamic and responsive generative systems that evolve and adapt. Secondly, Multimodal builds links between different systems of knowledge, and also provides new creative and interactive experiences for artists and the general public [75] [76] [77].

5.4 Other: Authorship, Copyright and Ethical Issues

The rapid development of generative art has given rise to complex issues surrounding authorship, copyright, and ethical considerations [21]. The collaborative nature of generative art, co-created by artists and autonomous systems, challenges traditional notions of individual authorship. The question of who holds the rights to AI-generated artwork and how attribution should be allocated has become a pivotal area of exploration [78]. Legal frameworks and copyright laws may require reevaluation and adjustments to accommodate these novel forms

of artistic creation [79]. Furthermore, ethical concerns regarding AI-generated art, such as biases and fairness, demand urgent discussion and resolution.

6 Conclusions

With the rapid development of artificial intelligence technology, the world is on the verge of the biggest shift in the way art is created and perceived since the birth of modernism, whether artists or the general public are ready for it or not. In this paper, we first outline the labels and terms commonly used in the field of generative art and try to clarify the intricate relationships between them; then we look at the whole process of the history of generative art and sort out its theoretical origins and technological development; then we focus on the prosperous landscape of the development of contemporary generative art and the issues raised about value judgments, creative subjects and identities, and innovativeness; review the current state of research on the aesthetic assessment in the field of generative art; finally, we construct a list of the main research topics in the field of generative art, and we discuss the current state of research. Finally, we construct a framework for the main dynamic synergistic interactions in the field of generative art, and make a wishful thinking about the future development of generative art.

References

[1] Candy, L., Edmonds, E., & Poltronieri, F. (2018). Explorations in Art and Technology. Springer London. https://doi.org/10.1007/978-1-4471-7367-0

[2] Galanter, P. (2003). What is Generative Art? Complexity Theory as a Context for Art Theory. 22.

[3] Boden, M. A., & Edmonds, E. A. (2009). What is generative art? Digital Creativity, 20(1–2), 21–46. https://doi.org/10.1080/14626260902867915

[4] Edmund, B. (1963). COMPUTERS and AUTOMATION.

[5] Galanter, P. (2016). Generative Art Theory. In C. Paul (Ed.), A Companion to Digital Art (1st ed., pp. 146–180). Wiley. https://doi.org/10.1002/9781118475249.ch5

[6] Dorin, A., McCabe, J., McCormack, J., Monro, G., & Whitelaw, M. (2012). A framework for understanding generative art. Digital Creativity, 23(3–4), 239–259. https://doi.org/10.1080/14626268.2012.709940

[7] Laposky, B. F. (1953). ELECTRONIC ABSTRACTIONS.

[8] Laposky, B. F. (1969). Oscillons: Electronic Abstractions. Leonardo, 2(4), 345. https://doi.org/10.2307/1572117

[9] Edmonds, E. (2018). Algorithmic Art Machines. Arts, 7(1), 3. https://doi.org/10.3390/arts7010003

[10] Verostko, R. (1994). Algorithmic Art. http://www.verostko.com/algorithm.html

[11] Karl, S. (1991). Artificial Evolution for Computer Graphics. Computer Graphics, 25(4), 319–328.

[12] Bovill, C. (1996). Fractal Geometry in Architecture and Design. Birkhäuser Boston. https://books.google.com/books?id=w5ptaiGsac4C

[13] Mazzone, M., & Elgammal, A. (2019). Art, Creativity, and the Potential of Artificial Intelligence. Arts, 8(1), 26. https://doi.org/10.3390/arts8010026

[14] Bense, M. (1965). Aesthetica: Einführung in die neue Aesthetik.
[15] Nake, F. (2018). The Pioneer of Generative Art: Georg Nees. Leonardo, 51(3), 277–279. https://doi.org/10.1162/leon_a_01325
[16] Malloy, J. (Ed.). (2003). Women, Art, and Technology. The MIT Press.
[17] Kirkpatrick, D. (1980). Sonia Landy Sheridan. Woman's Art Journal, 1(1), 56. https://doi.org/10.2307/1358020
[18] Dietrich, F. (1987). The Computer: A Tool for Thought-Experiments. Leonardo, 20(4), 315. https://doi.org/10.2307/1578526
[19] Soddu, C. (1991). SIMULATION TOOLS FOR THE DYNAMIC EVOLUTION OF TOWN SHAPE PLANNING.
[20] Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., & Bengio, Y. (2014). Generative Adversarial Nets. 9.
[21] Cetinic, E., & She, J. (2021). UNDERSTANDING AND CREATING ART WITH AI: REVIEW AND OUTLOOK. 18.
[22] Shahriar, S. (2022). GAN computers generate arts? A survey on visual arts, music, and literary text generation using generative adversarial network. Displays, 73, 102237. https://doi.org/10.1016/j.displa.2022.102237
[23] DiPaola, S., Gabora, L., & McCaig, G. (2018). Informing artificial intelligence generative techniques using cognitive theories of human creativity. Procedia Computer Science, 145, 158–168. https://doi.org/10.1016/j.procs.2018.11.024
[24] Miller, A. I. (2019). The Artist in the Machine: The World of AI-Powered Creativity. The MIT Press. https://doi.org/10.7551/mitpress/11585.001.0001
[25] Mordvintsev, A., Olah, C., & Tyka, M. (2015). Inceptionism: Going Deeper into Neural Networks.
[26] Nguyen, A., Yosinski, J., & Clune, J. (2019). Understanding Neural Networks via Feature Visualization: A survey (arXiv:1904.08939). arXiv. http://arxiv.org/abs/1904.08939
[27] Gatys, L. A., Ecker, A. S., & Bethge, M. (2015). A Neural Algorithm of Artistic Style (arXiv:1508.06576). arXiv. http://arxiv.org/abs/1508.06576
[28] Gatys, L. A., Ecker, A. S., & Bethge, M. (2016). Image Style Transfer Using Convolutional Neural Networks. 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2414–2423. https://doi.org/10.1109/CVPR.2016.265
[29] Jing, Y., Yang, Y., Feng, Z., Ye, J., Yu, Y., & Song, M. (2020). Neural Style Transfer: A Review. IEEE Transactions on Visualization and Computer Graphics, 26(11), 3365–3385. https://doi.org/10.1109/TVCG.2019.2921336
[30] Elgammal, A., Liu, B., Elhoseiny, M., & Mazzone, M. (2017). CAN: Creative Adversarial Networks, Generating "Art" by Learning About Styles and Deviating from Style Norms (arXiv:1706.07068). arXiv. http://arxiv.org/abs/1706.07068
[31] Cao, H., Tan, C., Gao, Z., Chen, G., Heng, P.-A., & Li, S. Z. (2022). A Survey on Generative Diffusion Model (arXiv:2209.02646). arXiv. http://arxiv.org/abs/2209.02646
[32] Song, Y., Sohl-Dickstein, J., Kingma, D. P., Kumar, A., Ermon, S., & Poole, B. (2021). Score-Based Generative Modeling through Stochastic Differential Equations (arXiv:2011.13456). arXiv. http://arxiv.org/abs/2011.13456
[33] Yang, L., Zhang, Z., Song, Y., Hong, S., Xu, R., Zhao, Y., Shao, Y., Zhang, W., Cui, B., & Yang, M.-H. (2022). Diffusion Models: A Comprehensive Survey of Methods and Applications (arXiv:2209.00796). arXiv. http://arxiv.org/abs/2209.00796

[34] Christie's. (2018, December 12). Is artificial intelligence set to become art's next medium? Christie's.
[35] Tim, S., & Naomi, R. (2018, September 25). Has Artificial Intelligence Given Us the Next Great Art Movement? Experts Say Slow Down, the "Field Is in Its Infancy." https://news.artnet.com/art-world/ai-art-comes-to-market-is-it-worth-the-hype-1352011
[36] Ben, L. (2018, December 17). We must not let the art market hoodwink us in the AI debate. The Art Newspaper.
[37] Epstein, Z., Levine, S., Rand, D. G., & Rahwan, I. (2020). Who Gets Credit for AI-Generated Art? IScience, 23(9), 101515. https://doi.org/10.1016/j.isci.2020.101515
[38] Ma, C. (2019). The End of Art and Artificial Intelligence. Arts Criticism, 10, 130–142. https://doi.org/10.16364/j.cnki.cn11-4907/j.2019.10.015
[39] Barale, A. (2021). "Who inspires who?" Aesthetics in front of AI art. Philosophical Inquiries, 9(2), 195–220. https://doi.org/10.4454/philinq.v9i2.367
[40] Chamberlain, R., Mullin, C., Scheerlinck, B., & Wagemans, J. (2018). Putting the art in artificial: Aesthetic responses to computer-generated art. Psychology of Aesthetics, Creativity, and the Arts, 12(2), 177–192. https://doi.org/10.1037/aca0000136
[41] Hong, J.-W., & Curran, N. M. (2019). Artificial Intelligence, Artists, and Art: Attitudes Toward Artwork Produced by Humans vs. Artificial Intelligence. ACM Transactions on Multimedia Computing, Communications, and Applications, 15(2s), 1–16. https://doi.org/10.1145/3326337
[42] Chiarella, S. G., Torromino, G., Gagliardi, D. M., Rossi, D., Babiloni, F., & Cartocci, G. (2022). Investigating the negative bias towards artificial intelligence: Effects of prior assignment of AI-authorship on the aesthetic appreciation of abstract paintings. Computers in Human Behavior, 137, 107406. https://doi.org/10.1016/j.chb.2022.107406
[43] Danto, A. C. (2004). The Philosophical Disenfranchisement of Art. Columbia University Press.
[44] Ritchie, G. (2007). Some Empirical Criteria for Attributing Creativity to a Computer Program. Minds and Machines, 17(1), 67–99. https://doi.org/10.1007/s11023-007-9066-2
[45] Colton, S., Lopez de Mantaras, R., & Stock, O. (2009). Computational Creativity: Coming of Age. AI Magazine, 30(3), 11. https://doi.org/10.1609/aimag.v30i3.2257
[46] Dorin, A. (2013). Chance and complexity: Stochastic and generative processes in art and creativity. Proceedings of the Virtual Reality International Conference: Laval Virtual, 1–8. https://doi.org/10.1145/2466816.2466837
[47] Elliott, L. (2019). Art, Intelligence and Creativity. The RUSI Journal, 164(5–6), 110–119. https://doi.org/10.1080/03071847.2019.1694262
[48] Machado, P., Romero, J., & Greenfield, G. (Eds.). (2021). Artificial Intelligence and the Arts: Computational Creativity, Artistic Behavior, and Tools for Creatives. Springer International Publishing. https://doi.org/10.1007/978-3-030-59475-6
[49] Deng, J., Dong, W., Socher, R., Li, L.-J., Kai Li, & Li Fei-Fei. (2009). ImageNet: A large-scale hierarchical image database. 2009 IEEE Conference on Computer Vision and Pattern Recognition, 248–255. https://doi.org/10.1109/CVPR.2009.5206848
[50] AMIRSHAHI, S. A., HAYN-LEICHSENRING, G. U., DENZLER, J., AND REDIES, C. Jenaesthetics subjective dataset: analyzing paintings by subjective scores. In European Conference on Computer Vision (2014), Springer, pp. 3–19
[51] MOHAMMAD, S., AND KIRITCHENKO, S. Wikiart emotions: An annotated dataset of emotions evoked by art. In Proceedings of the eleventh international conference on language resources and evaluation (LREC 2018) (2018).

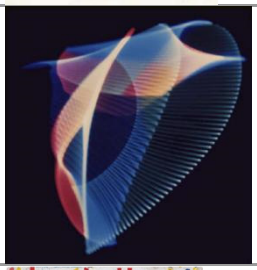
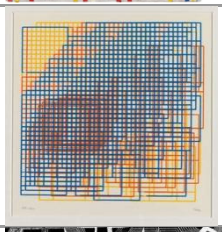
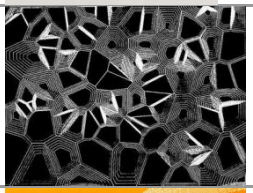
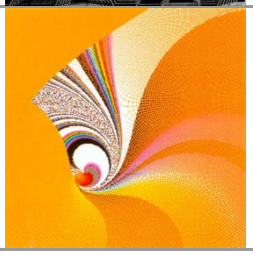
[52] ACHLIOPTAS, P., OVSJANIKOV, M., HAYDAROV, K., ELHOSEINY, M., AND GUIBAS, L. Artemis: Affective language for visual art. arXiv preprint arXiv:2101.07396 (2021)
[53] S. Hacker and L. von Ahn, "Matchin: eliciting user preferences with an online game," in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '09, pp. 1207– 1216, Boston, MA, USA, April 2009
[54] R. Datta, D. Joshi, J. Li, and J. Z. Wang, "Image retrieval: ideas, influences, and trends of the new age," ACM Computing Surveys, vol. 40, no. 2, pp. 5:1–5:60, 2008
[55] Johnson, C. G., McCormack, J., Santos, I., & Romero, J. (2019). Understanding Aesthetics and Fitness Measures in Evolutionary Art Systems. Complexity, 2019, 1–14. https://doi.org/10.1155/2019/3495962
[56] McMANUS, I. C. (2005). Symmetry and asymmetry in aesthetics and the arts. European Review, 13(S2), 157–180. https://doi.org/10.1017/S1062798705000736
[57] Forsythe, A., Nadal, M., Sheehy, N., Cela-Conde, C. J., & Sawey, M. (2011). Predicting beauty: Fractal dimension and visual complexity in art: Predicting beauty in art. British Journal of Psychology, 102(1), 49–70. https://doi.org/10.1348/000712610X498958
[58] Bouchaud, J.-P. (2008). Models of Randomness and Complexity, from Turbulence to Stock Markets. Leonardo, 41(3), 239–243. https://doi.org/10.1162/leon.2008.41.3.239
[59] Lakhal, S., Darmon, A., Bouchaud, J.-P., & Benzaquen, M. (2020). Beauty and structural complexity. Physical Review Research, 2(2), 022058. https://doi.org/10.1103/PhysRevResearch.2.022058
[60] Iigaya, K., Yi, S., Wahle, I. A., Tanwisuth, K., & O'Doherty, J. P. (2020). Aesthetic preference for art emerges from a weighted integration over hierarchically structured visual features in the brain [Preprint]. Neuroscience. https://doi.org/10.1101/2020.02.09.940353
[61] Liu, D., Puri, R., Kamath, N., & Bhattacharya, S. (2020). Composition-Aware Image Aesthetics Assessment. 2020 IEEE Winter Conference on Applications of Computer Vision (WACV), 3558–3567. https://doi.org/10.1109/WACV45572.2020.9093412
[62] Zhao, L., Shang, M., Gao, F., Li, R., Huang, F., & Yu, J. (2020). Representation learning of image composition for aesthetic prediction. Computer Vision and Image Understanding, 199, 103024. https://doi.org/10.1016/j.cviu.2020.103024
[63] McCormack, J., & Cruz Gambardella, C. (2022). Complexity and aesthetics in generative and evolutionary art. Genetic Programming and Evolvable Machines, 23(4), 535–556. https://doi.org/10.1007/s10710-022-09429-9
[64] Wassiliwizky, E., & Menninghaus, W. (2021). Why and How Should Cognitive Science Care about Aesthetics? Trends in Cognitive Sciences, 25(6), 437–449. https://doi.org/10.1016/j.tics.2021.03.008
[65] Flusser, V. (2011). Into the universe of technical images. University of Minnesota Press.
[66] Elasri, M., Elharrouss, O., Al-Maadeed, S., & Tairi, H. (2022). Image Generation: A Review. Neural Processing Letters, 54(5), 4609–4646. https://doi.org/10.1007/s11063-022-10777-x
[67] Tojin, E., Daniel, F., Josh, F., & Lokesh, V. (2023). How Generative AI Can Augment Human Creativity.
[68] Tang, X., Li, X., Ding, Y., Song, M., & Bu, Y. (2020). The pace of artificial intelligence innovations: Speed, talent, and trial-and-error. Journal of Informetrics, 14(4), 101094. https://doi.org/10.1016/j.joi.2020.101094
[69] Hanson, D. (2017). AI is 'very smart' but still in its 'infant' stage: Hanson Robotics. https://www.cnbc.com/video/2017/03/02/ai-is-very-smart-but-still-in-its-infant-stage-hanson-robotics.html

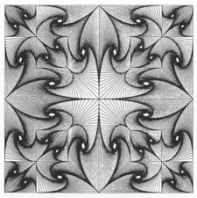
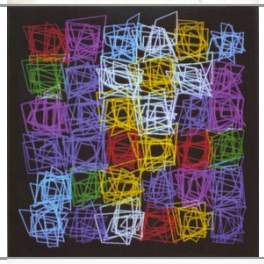
[70] OpenAI. GPT-4 Technical Report[J]. arXiv preprint ,2023
[71] Devlin, Jacob and Chang, Ming-Wei and Lee, Kenton and Toutanova, Kristina. BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding[J].arXiv preprint arXiv:1810.04805,2018.
[72] Zhao, W. X., Zhou, K., Li, J., Tang, T., Wang, X., Hou, Y., Min, Y., Zhang, B., Zhang, J., Dong, Z., Du, Y., Yang, C., Chen, Y., Chen, Z., Jiang, J., Ren, R., Li, Y., Tang, X., Liu, Z., … Wen, J.-R. (2023). A Survey of Large Language Models (arXiv:2303.18223). arXiv. http://arxiv.org/abs/2303.18223
[73] Kocoń, J., Cichecki, I., Kaszyca, O., Kochanek, M., Szydło, D., Baran, J., Bielaniewicz, J., Gruza, M., Janz, A., Kanclerz, K., Kocoń, A., Koptyra, B., Mieleszczenko-Kowszewicz, W., Miłkowski, P., Oleksy, M., Piasecki, M., Radliński, Ł., Wojtasik, K., Woźniak, S., & Kazienko, P. (2023). ChatGPT: Jack of all trades, master of none. https://doi.org/10.1016/j.inffus.2023.101861
[74] Zhou, J., Ke, P., Qiu, X., Huang, M., & Zhang, J. (2023). ChatGPT: Potential, prospects, and limitations. Frontiers of Information Technology & Electronic Engineering. https://doi.org/10.1631/FITEE.2300089
[75] Girdhar, R., El-Nouby, A., Liu, Z., Singh, M., Alwala, K. V., Joulin, A., & Misra, I. (2023). ImageBind: One Embedding Space To Bind Them All (arXiv:2305.05665). arXiv. http://arxiv.org/abs/2305.05665
[76] Wu, C., Yin, S., Qi, W., Wang, X., Tang, Z., & Duan, N. (2023). Visual ChatGPT: Talking, Drawing and Editing with Visual Foundation Models (arXiv:2303.04671). arXiv. http://arxiv.org/abs/2303.04671
[77] Zhang, Z., Zhang, A., Li, M., Zhao, H., Karypis, G., & Smola, A. (2023). Multimodal Chain-of-Thought Reasoning in Language Models (arXiv:2302.00923). arXiv. http://arxiv.org/abs/2302.00923
[78] Eshraghian, J. K. (2020). Human ownership of artificial creativity. Nature Machine Intelligence, 2(3), 157–160. https://doi.org/10.1038/s42256-020-0161-x
[79] Kalpokiene, J., & Kalpokas, I. (2023). Creative encounters of a posthuman kind – anthropocentric law, artificial intelligence, and art. Technology in Society, 72, 102197. https://doi.org/10.1016/j.techsoc.2023.102197

Appendix

1 Definition and Artworks in GA Family

Term	Definition	Representative work
Generative Art	generate entirely or partially using an autonomous system (Galanter, 2003)	 *Théâtre D'opéra Spatial* (Jason Allen, 2022)

Computer Art	generate with the assistance of a computer (Edmund, 1963)		*Hummingbird* (Kerry Strand, 1968)
Electronic Art	generate involves electrical engineering and/or electronic technology (Paul & Christiane, 2006)		*Oscillon 1* (Ben F. Laposky, 1952)
Non-Computer Generative Art	rely on non-computer systems such as nature, chemistry, physics, mathematics		*New York City 1* (Piet Mondrian, 1941)
Algorithmic Art	generate by programming to follow a certain procedure (Edmonds, 2018; Verostko, 1994)		*Walk-Through Raster* (Frieder Nake, 1972)
Evolutionary Art	generate and explore complexity that does not require human understanding of the specific process involved (Karl, 1991)		*Cell pattern 3* (Leslie Mezei, 1974)
Genetic Art	generate by abstracting biological evolutionary processes and simulating them on a computer (Holland, 1975)		*Digitalbild1* (Herbert W. Franke, 1984)

Fractal Art	generate by calculating fractal objects and representing the calculation results (Mandelbrot, 1977; Bovil & Carl, 1996)		*Spears* (Steve Derby, 1969)
Robotic Art	generate via machine to autonomously achieve a certain artistic purpose at the command of the artist (Harold, 1973)		Ai-Da's self-portrait (Ai-Da, 2019)
Processor Art	generate using the processing power of the computer to calculate input in a way which involves a real-time processing of data, whether from external sensors in the physical environment or from structures within the code itself (Thor, 2002)		no title (Desmond Paul Henry, 1965)
Software Art	generate following a formal instruction code and/or which addresses cultural concepts of software (Florian Cramer, 2002)		*Dialog Between Emotion and Method* (Vera Molnar, 1986)
AI Art	generate using machine learning techniques by training neural networks on large image datasets and using the trained networks to generate new images that match their learned aesthetics (Mazzone & Elgammal, 2019)		*Edmond de Belamy* (Obvious, 2018)
Information Art	generate with a wealth of information processing technology (Stephen, 2003)		*Star Kennedy* (Haruki Tsuchiya, 1967)