Generative Art & Generative Adversarial Networks: The Future of the Movement

Ryan Maciel

The recent development of "AI Art" has grabbed the attention and disrupted the sensibilities of the art world and the greater public alike. While this new mode has generated some spectacular early results, it has yet to develop the theoretical focus that might yield a powerful and concise movement. A good place to start in shaping this movement is connecting it to an extant form of artistic thought, namely Generative Art. This discipline has a rich history and corresponding theoretical backing, which can then be refined and applied to AI Art. Philip Galanter offered a widely accepted definition for the category in 2003:

> Generative Art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.[1]

We can trace many examples of Generative Art, so defined, throughout art history. Sol LeWitt, was a painter and sculptor known for his involvement in the conceptual and minimalist art movements. His work is studied through a generative lens in Rosalind Krauss' "LeWitt in Progress." Here Krauss analyzes the artist's 1974 work, *122 Variations of Incomplete Open Cubes*. This work features 122 wooden models of the edges of a cube, painted white, each with a different number and configuration of edges removed. Krauss writes, "LeWitt's work insistently applies its generative principle in each of its possible cases."[2] This is a sculptural generative system, which in its stark repetition works as a counterpoint to the"false and pious rationality"[3] of modernist art.

The logic of Generative Art has been extended not just to individual works or artists, but to artistic thought itself. Andre Breton, one of the founders of surrealism defined surrealism as "Pure psychic automatism by which one proposes to express...the actual functioning of thought, in the absence of any control exerted by reason, exempt from all aesthetic or moral preoccupations."[4] Here the artist's psyche is the automata—the creative process become machine. In attempting to expose this machine of unmediated thought, the surrealists worked within the bounds of Generative Art.

In addition to those artists quite familiar to canonical western art history, the many who contributed to the Computer Art movement certainly deserve inclusion as Generative Artists. These artists emerged during the development of early computing systems. They utilized a wide variety of mark-making techniques in conjunction with early computers to create works backed by arduous geometric computations. Their work explored new spaces of infinite repetitions and

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[1]Philip Galanter. (2003). What is generative art? Complexity theory as a context for art theory.
[2] Rosalind Krauss, "LeWitt in Progress," *October* 6 (1978): p. 55
[3] ibid: p. 60
[4]Andre Breton, *Surrealist Manifesto*, 1924.

variations, rigorously defined mathematical worlds perturbed by random noise that were unthinkable before the artificial minds of computers came along to assist in creating them. Some of these pioneers included Desmond Henry, Manfred Mohr, Georg Nees (Fig 1, left), Frieder Nake, Lillian Schwartz (Fig 1, right) and many more.

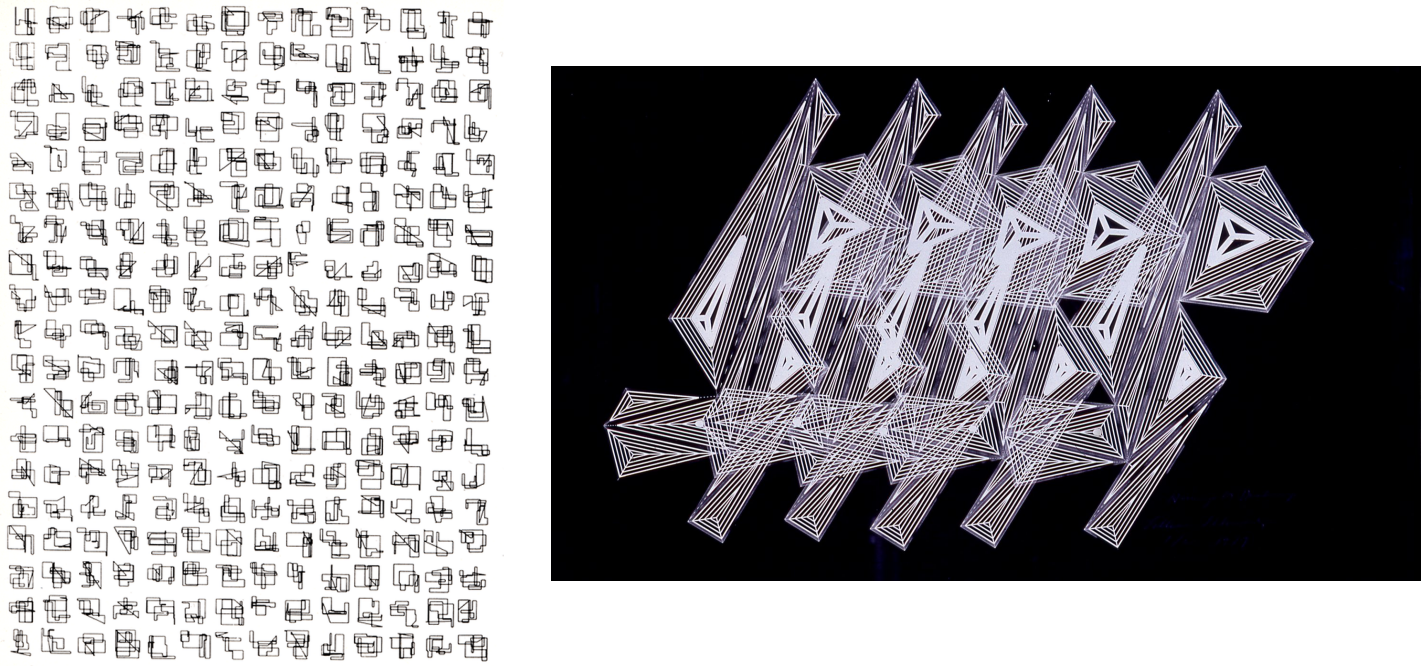

Fig. 1 Left: Georg Nees untitled drawing included in the 1965 exhibition “computer graphik.”
Right: Lillian Schwartz “Homage To Duchamp” (1981)

Following in the footsteps of these early pioneers, current artists working with AI and particularly Generative Adversarial Networks (GANs) are exploring creative spaces just recently opened up by advances in machine learning. However, I would argue that the pure novelty of their tools and results have been blinding. Apps that can create infinite digital paintings or create a convincing scene based on just a few words of description are incredible feats, but the feeling that similar systems will create the future of art are perhaps unfounded. There is a need for art historical theorization and critique of these works that extends beyond simple admiration for their unfamiliar qualities. In the following we consider an early theorization of systems-based (Generative) art and its connection to GAN art. From here we present some contemporary GAN artists and the types of subjects their work addresses. From these starting points I offer a brief manifesto of GAN art. Considering both its past precedents and future aspirations gives a road map to what can become significant in this emerging art form.

Working in System Esthetics

A number of theoretical frameworks have emerged for the analysis of Generative Art. Jack Burnham's 1968 essay, "System Esthetics" lays some important foundations for the discipline. The work identifies a contemporary transition "from an *object-oriented* to a *systems-oriented culture.* Here change emanates, not from *things*, but from *the way things are done*."[5] This cultural shift corresponds to new ways of thinking about and creating artworks. Instead of focusing on monumental, singular works—the masterpiece—artists now engage fluidly and continuously with systems. Particularly, systems related to everyday life and industry. Burnham attacked the separation of traditional (object oriented) art objects from the real world, proclaiming: "the significant artist strives to reduce the technical and psychical distance between his artistic output and the productive means of society."[6] This turn of art from the sacred object and its emanating aura to the technological systems increasingly embedded in our daily lives is the guiding principle for what he calls "Systems Esthetics." Despite the essay's age, this esthetic framework is profoundly applicable to our current understanding of Generative Art and the recent emergence of AI art. Exploring its central concepts can give us insight into the current state of the art and possibilities for its future.

One of the core ideas is that systems artwork evades ownership and "aura." The essence of Generative Art is in the complete system doing the generating, not single "snapshots" of the system at a given point. Burnham writes, "...all phases of the life cycle of a system are relevant. There is no end product which is primarily visual, nor does such an esthetic rely on a 'visual' syntax."[7] This has implications for the institution of art ownership in a generative context. Burnham suggests that within the new paradigm of the systems esthetic, "...possession of a privately fabricated work is no longer important. Accurate information takes priority over history and geographical location."[8] This seems to reference the "aura" of a work of art. Walter Benjamin's 1935 essay "The Work of Art in the Age of Mechanical Reproduction," describes a work's aura as, "its presence in time and space, its unique existence at the place where it happens to be...[Including] the history to which it was subject throughout the time of its existence."[9] In Benjamin's work, mechanical reproduction threatens this notion of aura, but Burnham seems to be going further here. He suggests that neither the aura nor the reproduction is important. What is critical is the information as it exists presently and as it changes over time within the system. This accurate information can be enough to fully describe the system, and in essence *is* the system.

This break from the aura and the reproduction allows the works to be much more resistant to traditional boundaries:

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[5] Burnham, Jack. "System Esthetics." *ARTFORUM*, 1968. p. 31
[6] ibid. 31
[7] ibid. 32
[8] ibid. 32
[9] Benjamin, Walter. *The Work of Art in the Age of Mechanical Reproduction*, 1935.

> "The systems approach goes beyond a concern with staged environments and happenings; it deals in a revolutionary fashion with the larger problem of boundary concepts. In systems perspective there are no contrived confines such as the theater proscenium or picture frame. Conceptual focus rather than material limits define the system."[10]

In its immersion in the larger world, a system-based work breaks free from its confines. The botanical specimen once encased in a sealed glass becomes the jungle it was plucked from. Accordingly, the type of work needed to create these systems exceeds the typical bounds of art making. Systems and Generative Art require a strong reliance on interdisciplinary approaches. Sculptors can "no longer think like sculptors, but they assume a span of problems more natural to architects, urban planners, civil engineers, electronic technicians, and cultural anthropologists."[11] Perhaps this is why Generative Art is increasingly computationally-based. As computational approaches become more ubiquitous to solving interdisciplinary problems, they become more and more useful in the creation of Generative Art.

The type of artmaking outlined here has found its apotheosis in the explosive emergence of AI art in recent years. Much excitement has been stirred up because of these systems' remarkable ability for mimicry. Synthesizing an image of your cat in the style of a Picasso or an original portrait akin to the old masters has gone from impractical to trivial over the course of a few years. While the impressiveness of this feat is clear, its artistic value is much murkier. Applying Burnham's esthetics to this art yields a much more nuanced discussion and can shed light on its future. However, an understanding of the mechanics of these systems, particularly GANs is essential to providing significant criticism.

GANs

Generative Adversarial Networks (GANs) are a novel way of creating Generative Art computationally. The basis of GANs are artificial neural networks (ANNs). These are a particular type of computer program that mimics processes in animal brains. They are built from groupings of neurons—units which accept many inputs from other neurons and pass outputs to many other neurons. Just as in animal brains, these neurons can be trained to connect either more strongly or more weakly to one another. This process allows them to effectively find the best configuration for a given task and is the basis for learning. Computer scientists have found these programs to be incredibly effective in a wide variety of applications, but most interesting for our purposes are those used for image processing.

One of the most important applications of these networks in recent years is in object recognition. In this formulation one labels the outputs of a neural network as different types of objects such as "house" or "person" or "car." By inputting many images of each object and incrementally changing the connections between neurons to output the correct output label, you can "train" a network to recognize objects in images. This was a huge breakthrough for computer vision, as the problem of recognizing all but a handful of specific objects was very difficult using

[10] Burnham 32
[11] ibid 34

rule based approaches—where programmers essentially have to describe to a computer what to look for to recognize a given object.

As neural network based computer vision technology progressed, scientists began trying to use it for image generation rather than just categorization. One of the first major breakthroughs in this area was Generative Adversarial Networks (GANs). As mentioned earlier, GANs are a particular type of artificial neural network created by Ian Goodfellow in a 2015[12] computer science paper. The main idea is to pit two neural networks against one another. The first is the "generator" network which generates synthetic images, the second is the "discriminator" network which tries to decide if input images are real or synthetic, created by the generator. Essentially, the generator tries to trick the discriminator into mistaking the synthetic images for real ones. At the end of the training process, the generator creates images that look like real images of a house or a person or any number of subjects, but none of them are objects that exist in the real world.

This is where artistic interest in GANs comes from. These synthetic images are not simple agglomerations of sets of images, nor do they fall down the rabbit hole of (often kitschy) image filters. The generated images represent some actual understanding of what an object looks like and what components are important to making it look that way. We know this because of our ability to explore a GANs' "latent space." This term in general describes a mathematical space in which similar points lie close to one another. In the context of GANs, the synthetic images are generated using a continuous function. This means that each image is like a point on a geometric grid. If you move that point by changing the parameters of the generator network even slightly, you get images that are similar to the original, but not quite the same. More interesting is that some of these parameters can represent complicated features of images such as how much a human face is smiling or the orientation of an object in space. This arrangement indicates that the machine doesn't just spit out images that are good at tricking people, but that it has an understanding of the abstract features of the objects it is generating.

The GAN Artists

Investigating the ways emerging artists are incorporating these new ways of seeing into their works can help us understand how they are transforming art-making. One of the most prevalent of these artists is Mario Klingemann. He is considered a pioneer in the field of algorithmic and neural-network based art whose work "Uncanny Mirror" (Figure 1) is especially relevant to our discussion of Generative Art. It is an installation with a large screen and a camera. As viewers approach the screen, the camera records their image and feeds it to a GAN which uses it as a starting point to generate a portrait. Had the work stopped here, we might consider it Glitch Art, just a filter that distorts the image of a viewer. However, the GAN constantly learns new representations of humans from those that approach it, thereby fitting into our conversation of Systems Esthetics. The artwork is the whole generative system, not a single snapshot of its state. The way it constantly changes and interacts with its surroundings allows it to explore a

[12] Ian Goodfellow. "Generative Adversarial Networks" (2014)

phenomenological field much wider than traditional visual arts has previously been able to provide.

Fig. 2 Still from Mario Klingemann's "Uncanny Mirror"

Other artists create works that interact more concretely with the physical world. Robbie Barrat and Ronan Barrot's collaborative work "Infinite Skulls" sets up a dialogue between traditional oil painting and GAN art approaches. Barrot is a french painter whose practice involves creating small paintings of skulls with paint left over on his palette when finishing or pausing work on a canvas. He has created a corpus of 450 skulls throughout his painting career in this way[13]. Technologist and Generative Artist Robbie Barrat worked with these images to create a GAN which generates images of skulls mimicking Barrot's style and execution. Through a process of curation and exploration in the GAN's latent space, Robbie selected outputs that were later UV printed onto plexiglas. Ronan would then edit these prints, adding scoring, or layers of oil paint—creating a very literal collaboration between artist and machine[14].

[13] Robbie Barrat and Ronan Barrot, "Infinite Skulls," Infinite skulls (Avant Galerie, 2019), https://avant-galerie.com/en/infinite-skulls.
[14] Bailey, Jason. "AI Artist Robbie Barrat and Painter Ronan Barrot Collaborate on 'Infinite Skulls.'" Artnome. Artnome, February 7, 2019.

In the essay “Barrot/Barrat: An Unexpected Guest in the Studio,” included in the gallery’s media coverage of the resulting exhibition, Fabrice Bertrand interrogrates the meaning of this collaborative and confrontational work. The essay is interested in the history and meaning inherent in both sides of the work. Ronan’s oil paintings carry a rich context, “pregnant with history, time and proficiency,” whereas the GANs that Robbie created are “kept in vitro, shut out from any external reference. Starting from random noise, they operate a-historically...”[15] Calling a GAN a-historic is not just an imaginative turn of phrase. Since GANs typically need datasets much larger than 450 images, Robbie had to edit the original images, stretching, distorting and adding noise so that the networks would have more data to work with. Any sort of history, context or emotion of a painting is ripped away by the grinding rationality of the software. Bertrand also recognizes the power of the GAN as a new way of seeing. Robbie’s work creates “...a new gaze cast upon [Ronan’s] work, filtered through the X-ray stream emanating from a machine devoid in itself of any personal will and committed to imitation”

Fig. 3 oil on canvas, UV print on plexiglas from Robbie Barrat and Ronan Barrot’s Infinite Skulls, 2019

Helena Sarin is another artist who works at the intersections of physical media and GAN art. She wrote for Artnome, “From the very beginning of my work with GANs I’ve been committed to using my own data sets, composed of my own drawings, paintings, and photography.” She justifies this practice on aesthetic grounds, agreeing with fellow artist, Anna Ridler that “Everyone is working with the same data sets and this narrows the aesthetics [of AI

[15] Fabrice Bertrand, “Barrot/Barrat: An Unexpected Guest in the Studio” (2019)

Art].”[16] In addition to this particular devotion to hand-crafting every step of the process, Sarin has developed a unique style of GAN art in which multiple neural network architectures are used in tandem on the same dataset. The results of these networks are then collaged together and combined into highly-detailed, high-resolution works (Fig 3).

Fig 4. Helena Sarin’s “Indian Summer” (2018)

Other artists and researchers are dealing with issues around the large image datasets that power GANs and other machine learning applications. Joy Buolamwini is a computer science researcher who describes herself as a “poet of code on a mission to show compassion through computation.”[17] Buolamwini is a person of color and when working on a project powered by facial recognition software, she noticed that the algorithm only recognized her face effectively when she wore a white mask. She realized that the models she was working with had coded-in racial biases. This sparked a project in which she analyzed the datasets used to create facial analysis software. She found that “in some cases they contained 75% male faces and over 80% lighter faces.” This is an incredible flaw that harkens back to old photographic film that was optimized to render white faces and performed poorly for darker complexions. Not only does this leave out a massive group of people from using the technology, but has real world effects for the most marginalized groups in society. In her activism, Buolamwini criticizes the use of facial analysis technology by police forces with little oversight—especially given inequalities in

[16] Jason Bailey, “Helena Sarin: Why Bigger Isn't Always Better with Gans and Ai Art,” Artnome (Artnome, November 27, 2018)

[17]Joy Buolamwini, “Joy Buolamwini: Examining Racial and Gender Bias in Facial Analysis Software” Google Arts and Culture (Google, 2019),

performance across racial and gender lines. There are documented cases of people being wrongly detained because of inaccurate facial recognition models[18].

It is clear that there are new and exciting directions that GANs can take AI Art. The question is whether these will lead to truly novel, vision-expanding art or remain sequestered to the (mostly) soulless, technocratic beanie baby collecting craze that has captured much recent generative works minted as NFTs. Approaching the discipline with an eye towards history and theoretical rigor is what will give it staying power beyond the fad popularity it is currently enjoying. Connecting the history and theoretical rigor of Generative Art with considerations of the current state of GAN art and its future can chart a path towards a cohesive GAN art movement. Below is a first attempt at that combination: a sketchy and cursory outline of a manifesto of GAN art.

GAN Art Manifesto

- GANs are pieces of industrial machinery created at costs in the millions of dollars by some of the most prominent corporations and state funded research labs in the world. The history of computer vision research is deeply tied to that of surveillance capitalism, the military-industrial complex and policing regimes. It's no coincidence that such colossal effort has gone into facial recognition models[19]. As Burnham describes, the GAN artist absolutely does reduce the "technical and psychical distance between his artistic output and the productive means of society." Thus, these artists must be acutely aware of exactly what those "productive means" are and what that can mean within the context of their artwork.
- GANs eat history. The context of a training dataset, its references, its culture, its entire history are stripped away in the process of training a GAN. The artifacts used for training often must be deliberately stripped of these aspects in order for training work best—the artist has no choice. However, this opens opportunities for re-assignment of context and meaning. Artists can imbue the resulting system with new interpretations, new context and grafted histories. This is a huge avenue of artistic possibility enabled by GANs.
- The misdirection (in which images must be a-historicised, deconstructed, confused) required to train GANs allows the artist to consider previously inaccessible influences. What does it mean for a neural network to be influenced by the artist's brainwaves[20]? Haake created systems that could interface with the atmospherics of a room in a museum—GANs can interface with the live, high dimensional atmospherics of an entire continent. One of the most interesting opportunities for the art form will be carving out unexpected relationships between previously unconnected sources.

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[18]Ahiza García-Hodges, Chiara Sottile, and Jacob Ward, "Man Wrongfully Arrested Due to Facial Recognition Software Talks about 'Humiliating' Experience," NBCNews.com (NBCUniversal News Group, June 26, 2020)

[19] One of the largest AI research firms in China, Huawei tested software to recognize the faces of Uighur Muslims and automatically report them to police. Arjun Kharpal, "China's Huawei Tested A.I. Software That Could Identify Uighur Muslims and Alert Police, Report Says," CNBC (CNBC, December 10, 2020)

[20] Ken Tan, "On the Collaborative Space between Humans and Non-Humans," Artist Sougwen Chung on the collaborative space between humans and non-humans (The Creative Independent, February 20, 2020)

- Issues of provenance take on a whole new dimension with GANs. Much of the creative labor involved in creating this art is directed at curating training datasets. Even in the short history of this movement, there are well documented cases of datasets being used without credit. A collective called "Obvious" created a work entitled "Portrait of Edmond de Belamy" using a dataset curated by Robbie Barrat, then only 19 years old. The work was sold at auction for over $400,000 and Barrat went uncredited[21]. Questions of authorship become murky here, but certainly Barrat's labor was significant in the creation of the work.
- Issues of dataset construction become increasingly important to consider for GANs that have been trained on images of heritage objects or works of art or photographs of people. As we have seen in Buolamwini's work, datasets can inherit the underlying biases of their curators. Artists must be self-critical and vigilant to guard their works from inheriting these biases—especially for datasets that they did not curate.
- There is a tendency in art history to portray art movements as reactive and dialectical. Each generation and school of artist is shown as reacting to those who came directly before them. While the truth of this portrayal can be argued, it is interesting to note that GANs cannot do this. When GANs are trained on particular art styles or movements, they accept their training unquestionably. While they might introduce interesting variations on present themes, they certainly do not have the capacity to create distinctively opposed responses to those themes. Thus, it is in the hands of the GAN artists to consider how their works fit (or exist in opposition to) the movements that came before them and to shape their networks to reflect those decisions.
- GANs are true *systems* in Burnham's sense of the word. Therefore, they should seek to break the boundary spaces imposed on them. As Burnham writes, "In systems perspective there are no contrived confines such as the theater proscenium or picture frame."[22] The particular restriction of reducing a GAN's output to a single still frame is certainly one of these "contrived confines." In his insightful essay "Appreciating the Performative Quality of Computer Generated Art," Filippo Lorenzin writes: "computer-generated art calls for a deeper and insightful understanding of what it means to create art in collaboration with a machine, a perspective that cares more about the performative quality of its making than its crystallization in tangible forms."[23]
- GAN architectures that use images as starting points for computation are one way to break out of the single-frame boundary. We see this in Mario Klingemann's "Uncanny Mirror." By taking camera input from the exhibition space, the input to the GAN is changed, and different possibilities can be explored by the viewers. However, this approach does introduce limitations. While still unpredictable, the output possibilities are

[21] Vanessa Chang, "Ghost Hands, Player Pianos, and the Hidden History of Ai," Sougwen Chung (愫君), October 21, 2019
[22] Burnham 32
[23]Filippo Lorenzin, "Appreciating the Performative Quality of Computer Generated Art," Hyperallergic, February 8, 2022

limited to the artist's choice of interesting results. This prevents exposing some of the less interesting parts of the network but possibility excludes many other interesting parts.

- Clement Greenburg argued in "Modernist Painting" that each form of art should strive to master "that [which] was unique in the nature of its medium."[24] For GANs, the latent space is certainly the most unique aspect of the medium. As explained earlier, the latent space allows exploration of images arranged continuously in order of particular features that the network has identified. This might be certain shapes or textures, or any number of visual transformations. Many practitioners find the exploration of this space the most exciting part of their practice. However, this exploration often ends with the reduction of the GAN to a single, easily reproducible frame. Finding new ways to expose this unique aspect of the medium—the latent space—to audiences should be a first-priority goal in the development of GAN art.

[24] Clement Greenberg. "Modernist Painting"*Art and Literature*, Spring 1965

Bibliography

Bailey, Jason. "AI Artist Robbie Barrat and Painter Ronan Barrot Collaborate on 'Infinite Skulls.'" Artnome. Artnome, February 7, 2019. https://www.artnome.com/news/2019/1/22/ai-artist-robbie-barrat-and-painter-ronan-barrot-collaborate-on-infinite-skulls.

Bailey, Jason. "Helena Sarin: Why Bigger Isn't Always Better with Gans and Ai Art." Artnome. Artnome, November 27, 2018. https://www.artnome.com/news/2018/11/14/helena-sarin-why-bigger-isnt-always-better-with-gans-and-ai-art.

Barrat, Robbie, and Ronan Barrot. "Infinite Skulls." Infinite skulls. Avant Galerie, 2019. https://avant-galerie.com/en/infinite-skulls.

Benjamin, Walter. The Work of Art in the Age of Mechanical Reproduction, 1935.

Bertrand, Fabrice "Barrot/Barrat: An Unexpected Guest in the Studio" (2019) https://storage.avant-galerie.com/static/infinite-skulls/INFINITE-SKULLS-texte-fabrice-bertrand-en.pdf

Breton, Andre. Surrealist Manifesto, 1924.

Buolamwini, Joy. "Joy Buolamwini: Examining Racial and Gender Bias in Facial Analysis Software - Google Arts & Culture." Google Arts and Culture. Google, 2019. https://artsandculture.google.com/story/joy-buolamwini-examining-racial-and-gender-bias-in-facial-analysis-software-barbican-centre/BQWBaNKAVWQPJg?hl=en.

Burnham, Jack. "System Esthetics." ARTFORUM, 1968.

Chang, Vanessa. "Ghost Hands, Player Pianos, and the Hidden History of Ai." Sougwen Chung (愫君), October 21, 2019. https://sougwen.com/ghost-hands-player-pianos-and-the-hidden-history-of-ai.

Galanter, Philip. "6th Generative Art Conference, January 2003," n.d. Accessed May 5, 2022.

García-Hodges, Ahiza, Chiara Sottile, and Jacob Ward. "Man Wrongfully Arrested Due to Facial Recognition Software Talks about 'Humiliating' Experience." NBCNews.com. NBCUniversal News Group, June 26, 2020. https://www.nbcnews.com/business/business-news/man-wrongfully-arrested-due-facial-recognition-software-talks-about-humiliating-n1232184.

Greenberg, Clement. "Modernist Painting"Art and Literature, Spring 1965

Ian Goodfellow. "Generative Adversarial Networks" (2014) https://doi.org/10.48550/arXiv.1406.2661

Kharpal, Arjun. "China's Huawei Tested A.I. Software That Could Identify Uighur Muslims and Alert Police, Report Says." CNBC. CNBC, December 10, 2020. https://www.cnbc.com/2020/12/09/chinas-huawei-tested-ai-software-that-could-identify-uighurs-report.html.

Krauss, Rosalind. "LeWitt in Progress." October 6 (1978): 46. https://doi.org/10.2307/778617.

Lorenzin, Filippo. "Appreciating the Performative Quality of Computer Generated Art."

Hyperallergic, February 8, 2022. https://hyperallergic.com/710156/appreciating-the-performative-quality-of-computer-generated-art/.

Tan, Ken. “On the Collaborative Space between Humans and Non-Humans.” Artist Sougwen Chung on the collaborative space between humans and non-humans. The Creative Independent, February 20, 2020. https://thecreativeindependent.com/people/artist-sougwen-chung-on-the-collaborative-space-between-humans-and-non-humans/.