

Open Access Article

Aesthetic Analysis of Cryptoart as an Art Form

Ian Boots Bautista, Maria Violeta Sandico

School of Media Studies, Mapua University, Manila, Philippines

Received: June 1, 2022 ▪ Reviewed: July 4, 2022

▪ Accepted: July 24, 2022 ▪ Published: September 29, 2022

Abstract:

This study addresses the importance of examining the engagement between NFTs and computer art called cryptoart. The research goal is to fill in the lack of discussion regarding the aesthetics of cryptoart in mainstream commentaries by questioning and analyzing the validity of cryptoart as an art form. This paper extends Bautista's (2014) and Zhang et al.'s (2012) work to frame the postmodern qualities of cryptoart and its levels of complexities based on computational aesthetics. Sample works were analyzed through identification and classification from two curated NFT marketplaces - *SuperRare* and *Art Blocks*. The results show that while the cryptoart space is being used to leverage postmodern practices such as connecting artists and audiences and enabling them to see and understand one another as creators of value, and enabling further exploration of the collaborative relationship between artist and computer, the cryptoart explosion threatens to make all art the art of making money - however, works produced by the artist-computer relationship through Generative Adversarial Networks (GANs) is a promising entry-point for leveling up the conversation around AI and artists in the cryptoart space with discourse grounded on how computers could now generate visual outputs and evaluate their aesthetic value automatically. This study could frame the aesthetic design of computer algorithms, simulation, and visualization involved in cryptoart production, where artists, buyers, and collectors are highly engaged. The study also found that the usability and visibility of cryptoart works are enhanced through the GANs and that it can feasibly aid computational aesthetics.

Keywords: cryptoart, NFT, aesthetics, postmodernism, generative adversarial networks.

加密艺术作为一种艺术形式的美学分析

摘要:

这项研究解决了检查 NFT 与称为加密艺术的计算机艺术之间的联系的重要性。研究目标是通过质疑和分析加密艺术作为一种艺术形式的有效性，填补主流评论中关于加密艺术美学讨论的不足。本文扩展了包蒂斯塔(2014)和张等人(2012)的工作，以基于计算美学构建密码艺术的后现代品质及其复杂程度。通过对两个精选 NFT 市场——超级稀有和艺术积木的识别和分类，对样本作品进行了分析。结果表明，虽然加密艺术

空间被用于利用后现代实践，例如连接艺术家和观众，使他们能够将彼此视为价值创造者并相互理解，并进一步探索艺术家和计算机之间的协作关系，但加密艺术爆炸威胁使所有艺术都成为赚钱的艺术 – 然而，艺术家与计算机通过生成对抗网络 (GAN) 的关系所产生的作品是一个有希望的切入点，可以通过话语在加密艺术空间中提升围绕人工智能和艺术家的对话基于计算机现在如何生成视觉输出并自动评估其审美价值。这项研究可以构建涉及加密艺术生产的计算机算法、模拟和可视化的美学设计，艺术家、买家和收藏家高度参与其中。该研究还发现，通过 GAN 增强了加密艺术作品的可用性和可见性，并且它可以切实地帮助计算美学。

关键词：加密艺术、NFT、美学、后现代主义、生成对抗网络。

1. Introduction

The latest computing and communication infrastructure that artists are exploring today is the blockchain (Catlow et al., 2017). While the internet has democratized artistic practice in the digital era (Ryan, 2014), the blockchain is now considered the “new internet” ripe for disruption and speculation (Sharma, 2018). The blockchain is being used to reintroduce notions of scarcity into the freely reproducible digital realm (O’Dwyer, 2018). These smart contracts can hold assets, cryptocurrencies, and non-fungible tokens or NFTs. NFTs can represent photos, animated GIFs, audio, and other digital files, thus birthing a new art form called cryptoart (Franceschet et al., 2021).

Simply put, cryptoart is a media plus token, which is the NFT. The media here is considered in the form of computer art. Computer art uses digital techniques in “multimedia, virtual reality, computer vision, and digital sound” (Marcos, 2007) and operates its approaches, contexts, and experiences to “non-linearity, virtual, and augmented reality, telepresence, net communications, database, and 3D visualization” (Chambel et al., 2007). Computer art is being monetized more than ever as scarce digital commodities with the emergence of NFTs.

Cryptoart is basically “rare” computer art. This is because when computer art is “tokenized” or “minted” on the blockchain, it is at once certified as “one-of-a-kind” and irreplaceable (Eng, 2020) – essentially giving it economic value (Bailey, 2018a), making it prone to speculation. Moreover, cryptoart has been described as art native to the blockchain with its own aesthetic and represents a new and important movement (Bailey, 2018b). It is defined by Finucane (2020) and Franceschet et al. (2021) in four sections: 1) subject matter usually has something to do with cryptocurrency or blockchain technology and is typically still or animated; 2) distributed by blockchain technology and incorporates cryptocurrency in how it operates; 3) produced works are often in close collaboration with the machine, and 4) it’s completely immaterial so that it only exists in digital form through tokenization.

However, what is noticeable in these descriptions is that there are no mentions of aesthetics, which supposedly is the foundation of the production, interpretation, understanding, and enjoyment of art

(Hermerén, 1993; Ranciére, 2009). Seemingly, the descriptions of cryptoart are anchored more on structural and physical forms. Also, Bailey (2018b) did not clearly expound on what aesthetic cryptoart possesses in his definition. With the emergence of cryptoart, the arts were given another monumental shift in perspective given the absence of aesthetic value, along with a shift in the essence of what an art medium can be.

2. From 19th-Century Salons to NFT Marketplaces

The culture surrounding the rising popularity of cryptoart can be compared to that of 19th-century salons, where artists debate art and exhibit their work. Designed to both encourage the development of the fine arts while serving as an outlet for young artists and broaden the dissemination of works of art through exhibitions extended to a public audience (Richman-Abdou, 2020), it is not far from the concept of digital platforms where artists can create, exhibit, and sell their works, called NFT marketplaces. Also, similar to how art movements like Der Blaue Reiter (Erster Deutscher Herbstsalon), Salon Cubists (Salon des Indépendants), and Impressionists (Salon d’Automne) have established and participated in salons to leverage their art and its production, artists specializing in different fields have flocked to NFT marketplaces to achieve the same end.

Indeed, artistic practices change as society, discovery, and technology change. According to Catlow et al. (2017), several things happen when artists approach new technologies: “by making connections that are neither necessarily utilitarian nor profitable, they explore the potential for diverse human interest and experience; they discover expressive and communicative potentials of its tools, devices, systems, and cultures; they make difficult concepts more feelable, legible and fascinating.” Thus, some see cryptoart as a new form of art that democratizes the practice and provides accessibility and cultural recognition to people who are not art-savvy enough to go into an art institution (Wang, 2021). Goltra (2020) sees the rise of cryptoart as the trapping of critical cultural exchange between technology and artists, where artists are given a chance to represent themselves through works of art that reflect digital-native themes

that support the belief that digital culture is already valuable and legitimate. Indeed, technology changes the landscape and brings art to a new dimension.

2.1. The Problem with Cryptoart

Apart from the seeming lack of aesthetic value, cryptoart has also been dismissed as overvalued (Zeilinger, 2018). When works are highly valued, they typically have a critical framework with information drawn from history, culture, aesthetics, and philosophy explaining why they command such high values. However, much of the discourse about the value of cryptoart is that it simply exists in the blockchain, which has also been hailed as a haven for plagiarists, tech opportunists, and scam artists, where distinctions between art and financial assets collapse (Zeilinger, 2018). As an example, the *SuperWorld* marketplace has referred to itself as an NFT Salon, stating that it is not just a marketplace but also “a place where content creators of all kinds can showcase and sell their work, gain exposure, and build a devoted following on blockchain” (SuperWorld, 2021). However, this is a reductionist view of the traditional structure of the salon. Salons were an essential place for exchanging ideas (Kreye, 2014), and yet *SuperWorld* does not have such function and merely acts as a storefront for the exchange of digital assets. The culture surrounding the blockchain has indeed steered the conversation away from aesthetic values and instead has led art to descend into a mere profit-making mechanism (Liu, 2021). In the words of Cooper (2022), making digital art “scarce” through the blockchain “is a crime against nature and a sin against humanity” because “the whole point of the internet is to allow people to send information to each other for almost nothing.”

Because it is profit-oriented, the market has been oversaturated with low-quality pieces, with newer artists ignoring the integrity of their works, focusing instead on producing as much as they can (Liu, 2021). Making art on the blockchain has created a form of unprecedented acceleration – cryptoart is never slow and quiet (Marraccini, 2022). As a result, cryptoart is seen as vapid and amateurish, existing in an environment that does not develop intellectual depth, self-awareness, and aesthetic uniqueness (Storming the Ivory Tower, 2021). When quantity is prioritized over quality, the aesthetic value is compromised. Aesthetics is essential because it plays a fundamental role in guiding attention toward cultural objects and charging them with value and significance at all levels of cultural expression (Porter, 2021). Benjamin (1969) recognized the valuable democratic potential of art’s move toward exhibition value as compensation for its aura diminishing through mechanical reproduction. This is rapidly propagated by the emergence of the NFT marketplaces and the further devaluation of aesthetic uniqueness.

2.2. A Postmodernism Framework

As mentioned, cryptoart is essentially computer art in the blockchain. As such, it also reflects many computer art approaches that are considered postmodern (Humphries, 2003; Chambel et al., 2007). Therefore, the criterion to validate cryptoart as an art form would be postmodernism.

To inquire about the aesthetic value of cryptoart and whether it can be established as an art form, the postmodernism framework adapted from the work of Bautista (2014) that investigated the postmodern beauty of computer art through the levels of complexities by Zhang et al. (2012), will be extended in this study to describe the aesthetic value of cryptoart. Bautista (2014) acknowledged postmodernism as the most appropriate theoretical tool in studying computer art (also cryptoart) because it delineates the roles of the audience as viewers of art, the artists as the creators of art, and the community they live in. It reflects the contemporary situation and is simple and clear in format and execution, characterized by a multiplicity of styles, techniques, subject matter, and presentations (Cappadona-Apostoles, 2009). It does not follow any dominant schools or styles (Herrero, 2005) and is reflective of artistic, cultural, and cognitive developments (Chambel et al., 2007). Taylor (2014) also found that postmodernism is considered the “new systemic cultural norm” in which, through its advancement in various cultural discourses, it has become an important instrument in the analysis of computer art.

2.3. Computational Aesthetics and the Levels of Complexities

The levels of complexities by Zhang et al. (2012) will also be adapted in this study, which is based on computational aesthetics that seeks to investigate how modern technologies could help in the field of arts, especially in enhancing its expressive powers to increase our understanding of aesthetic evaluation, perception, and meaning (Bautista, 2014). Feijs (2019) also applied Zhang et al.’s (2012) study on the levels of complexity in the development of their program to generate work resembling Piet Mondrian’s work. Meanwhile, in developing an automated system to convert piano compositions into paintings, Ali et al. (2021) also related Zhang et al.’s (2012) levels of complexity in their rules-based approach involving minimal human participation and encoding of aesthetic rules to generate abstract paintings automatically. These studies prove that computational aesthetics can be applied to many areas, such as fine art and music, and enable the appraisal of beauty and the automatic generation of aesthetic images.

2.4. Scope and Limitations

Since we are seeing an entanglement between NFTs and computer art, it is important to examine this new

engagement and address the lack of discussion about the aesthetics of cryptoart in mainstream commentaries. While Bautista has found that artists work at more complex levels when producing computer art while attributing the postmodern qualities of indirect human agency, de-authorship, and multiplicity of interpretations (Herrero, 2005), the purpose of this study is to determine at what level of complexity do artists work in producing computer art in the realm of blockchain technology with the added attribute of NFT, and if they retain their postmodern qualities in this market-driven environment.

Other issues with cryptoart, including ownership rights and the medium's carbon emission and its damaging effects on the environment, are excluded in the discussion.

3. Methodology

This paper is a case study of the postmodern qualities and levels of complexities of cryptoart works and productions that will be investigated from two NFT marketplaces - *SuperRare* and *ArtBlocks*.

SuperRare is a curated marketplace in which the projects' metadata are stored off-chain. It has been described as a "social network for art creators and collectors" arguing that collectors and artists should be able to easily interact with each other (Tran, 2020). *SuperRare* is mainly focused on conceptual computer art, where many NFTs are abstract and complex. Users can see the top collectors and artists, how many pieces have been bought or created, how much has been spent, the history of the artwork's owners, and a description of the art.

Meanwhile, *Art Blocks* is a marketplace for "on-demand, on-chain, generative media platforms" (Peaster, 2021). In *Art Blocks*, a collector can pick a style and pay, and a randomly generated version of the content is created by an algorithm. The result can be anything from a static image to an interactive piece. *Art Blocks* has three distinct projects: 1) Curated, which are generative projects hand-picked by the Art Block team; 2) Playground, which is for artists who have been previously on Curated projects, so they no longer must go through the "curated" process again; and 3) Factory, where artists can launch projects quickly without the strict verification process involved in curated projects.

The two platforms have been chosen for their overall market share and the difference between their operations' nature and their shared similarity in curating more conceptual and complex forms of computer art. Several other NFT marketplaces are larger like *OpenSea*, more decentralized, and act as a virtual world like *Decentraland* or employ a gas-free protocol (meaning artists can create NFTs for free) like *Mintable*. Since these marketplaces are non-curated, they are excluded in this study.

The two NFT marketplaces host several artists and

projects from diverse backgrounds and fields. For the *SuperRare* marketplace, the top 50 highest priced works are analyzed from January 2018 to November 2021, while in the *Art Blocks* marketplace, all 41 completed projects from their Curated collection from January 2018 to November 2021, as well as 9 completed projects from the Playground collection are included in the analysis, to round up to 50 *Art Blocks* projects. Other works by the selected artists that have not been minted on the blockchain are therefore not considered cryptoart and are excluded in the discussion.

This case study of *SuperRare* and *Art Blocks* is based on 1) the availability of information and description of works provided in the marketplace; and 2) the availability of information on the artists' process culled from the artists' personal Twitter accounts, blogs, online cryptoart magazines, and Discord servers. This is to identify the individual artists' intentions, focus, artistic processes, and attitudes. If text is not available, the artwork is excluded from the sample.

For *SuperRare*, the highest valued works were chosen to provide insight into why these works demand such high prices in a postmodern framework. For *Art Blocks*, the completed projects from two collections, Curated and Playground, assure that the samples are more conceptual and have been well received by buyers and collectors.

A table of interpretations of postmodern qualities and the levels of complexity, and the qualitative content analysis of the data collected will be discussed in the next section. The table of interpretation for each marketplace includes the following:

- *SuperRare*: Represents the top 50 highest valued in the marketplace from January 2018 to November 2021, level of complexity, human participation, applicability/nature of work, and artistic process commonalities.

- *Art Blocks*: Represents the latest 50 completed projects from the curated and playground collection, level of complexity, human participation, applicability/nature of work, and artistic process commonalities.

These tables of interpretation present what cryptoart contributes to visual culture and provide salient points to a purposeful discussion on the quality and aesthetic values of cryptoart beyond simply fuel for financial speculation. The aesthetic factors considered in the interpretation are the following (Bautista, 2014):

- Art media or material used
- Visual design because of the manipulation of elements and principles of art
- Art content or subject matter

By subjecting cryptoart to these aesthetic factors, its levels of complexity and postmodern qualities can be identified.

The postmodernism framework to describe these aesthetic factors is itemized in Table 1.

Table 1. Postmodern qualities (Bautista, 2014)

Postmodern qualities	
Cappadona-Apostoles (2009)	<ul style="list-style-type: none"> ● Reestablish the audience both as a human being and as a member of a cohesive and identifiable community. ● Participative, interactive, and collaborative - makes the audience feel as if they are part of an interesting community ● Reflective of the contemporary situation ● Simple and clear in format and execution, characterized by multiplicity of styles, techniques, subject matter and presentations
Herrero (2005)	<ul style="list-style-type: none"> ● Community functions like an independent art world; there is a great consideration of individual member's various activities, validation of art by institutions, recognition of artists and their works, identification of exhibition venues, art galleries, etc. ● Meaning is inconclusive - open to a multiplicity of interpretations brought about by different vantage points ● Follows no hierarchy and values de-authorship ● Doesn't follow any dominant school or style; it is random ● Shifts in intellectual practices among artists

The levels of complexities are presented in Table 2.

Table 2. Levels of complexities (Zhang et al., 2012)

Level	Human Participation	Means of Computer Support	Applicability
Level 1	Full	Artists could use existing software to draw paintings manually. Various visual components such as digital brushes, variable-size canvas, palette of colors, and commonly used visual elements may be selected from a database.	Painting and graphic design tools
Level 2	None	Artists need only to provide various attributes and styles, like mathematical formulas, as inputs. The computer program can automatically generate the desired visual outputs.	Fractal art, limited styles of painting
Level 3	None	This has two general approaches – generative and transformational. With the generative approach, paintings that mimic an original artist's style can be produced through computerized rules and algorithms. With the transformative approach, digital images are transformed using a two-dimensional non-photorealistic reading (NPR) into technical illustration, cartoons, watercolor painting and sketches, as well as abstract paintings.	Domain-specific or style-specific paintings and design
Level 4	Minimal	This is the aim of computational intelligence where the machine is creative enough to generate highly aesthetic visual forms through the automatic conceptualization of complex information to abstracted visual formats.	Automated abstract painting and graphic design

4. Results and Discussion

The available texts culled from the marketplace descriptions, artist's websites, online interviews, blogs, and online magazine articles were sufficient to deduce the level of human participation, means of computer support, and artistic process and production, hence the levels of complexity and postmodern qualities can be ascertained through identification and classification. The available tags of the tokenized artworks were also used to identify their nature and applicability.

SuperRare works are mostly Level 1 conceptual computer art, with subject matter relating to cryptocurrency and blockchain culture. With full human participation, digital illustrations, with fifteen works, and 2D and 3D animations, with twenty-three works, are the prevailing categories, with the presence of the postmodern characteristic of pluralism - using pastiche, kitsch, repetition, and appropriation of works of art, characterized by a multiplicity of styles, techniques, and subject matter (Cappadona-Apostoles, 2009). Stylistic aesthetics are heavily influenced by nostalgia drawn from the culture of 60s and 70s psychedelia, 80s punk, and 90s pop culture. The sample from *SuperRare* reflects a low level of complexity works and yet has

commanded high values since the artists are already renowned and have a following in the creative field even before the NFT bubble. The artist *videodrome*, *robness*, *xcopy*, and *hackatao* have multiple works included in the sample because of their reputation in their respective creative fields. Seven works are Level 3, where there is the bare minimum human participation of setting parameters in the code, while the algorithm takes care of the artistic production and produces generative art.

The presence of Level 4 artworks in *SuperRare* is from a series of AI-generated works using Generative Adversarial Networks, or GANs. GANs use machine learning algorithms to build new literature, poetry, and art forms (Wang et al., 2017). They are composed of two neural networks designed to think like a human brain - the "generator," responsible for creating the work, and the "discriminator," responsible for identifying the uniqueness of the work (Goodfellow et al., 2014; Wang et al., 2017). For example, *videodrome* describes his work as "artwork generated by a GAN trained on thousands of nude portrait oil paintings." *videodrome* describes the process as a form of feedback loop in which the discriminator constantly compares whether the images in the dataset sent by the generator

is “fake” or “real.” The generator uses the feedback to adapt and generate images that will deceive the discriminator. The machine failed to learn proper human anatomy and started generating surreal blobs of flesh. However, such accidents are often the most important roads to creative discovery. Not unlike traditional artmaking, the GANs might have produced a perfect rendition of a traditional nude painting if the discriminator had been more “discriminating” (Bailey,

2018a). Works with GAN display Level 4 complexity in which the machine is given autonomy in the creative process. It also reflects the postmodern quality of appropriating and reconfiguring previous works of art into a new object and creating an object capable of independent thinking (Bailey, 2018a), where meaning becomes inconclusive and open to a multiplicity of interpretations brought about by different vantage points (Herrero, 2005).

Table 3. SuperRare summary of analysis

No. of works	Level	Postmodern Qualities	Nature	Artistic process
38	1	<ul style="list-style-type: none"> • Reflective of the contemporary situation (Cappadona-Apostoles, 2009) • Simple and clear in format and execution, characterized by multiplicity of styles, techniques, and subject matter (Cappadona-Apostoles, 2009) 	Digital illustrations, collages, 2D and 3D animations	Artists used computer software to create digital images or reconfigure existing digital images to create new ones.
7	3	<ul style="list-style-type: none"> • Shift in intellectual practices among artists (Herrero, 2005) 	Generative art	Artists used generative code to explore the potential of programming as an expressive language in the framework of generative and process art
5	4	<ul style="list-style-type: none"> • Meaning is inconclusive - open to a multiplicity of interpretations brought about by different vantage points (Herrero, 2005) 	AI art	Produced by GAN trained on thousands of nude portrait oil paintings

In *Art Blocks*, the artist creates a generative script that specifies how many iterations will be available to be generated by the script, which is typically around 500–1000. A script is run to generate a new output once a collector decides to purchase an iteration. What output would be generated will surprise everyone, collectors and artists included. This reflects the postmodern qualities of participative, interactive, and collaborative since the projects make the audience feel like they are part of an interesting community (Cappadona-Apostoles, 2009).

The *Art Blocks* platform has three key features that point toward the future evolution of generative art: 1) Joint creation that leads to the community formation where collectors act as participants in the creative process; 2) On-chain projects enjoy security guarantees; and 3) The Playground gives access to any generative artist to launch generative media projects where the on-chain data can be used as building blocks to create new projects. These three key features make *Art Blocks* function like an independent art world. Individual members’ various activities are excellently considered, and artists and their works are recognized (Herrero, 2005). This communal attribute is precisely why some projects have similar parameters and traits. Moreover, it creates collaborators out of collectors and buyers too by making them participate in project completion every time they purchase a token or create a mint.

All *Art Blocks* projects are generative art therefore the range of complexities is between Levels 3 and 4.

Generative art refers to work produced by letting machines taking over some of the decision-making through the activation of a set of rules by the artists (Boden & Edmonds, 2010; Bailey, 2018c). Galanter (2003) defines it as “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.” As opposed to an algorithmic way (instructs the computer to “do A,” then “do B,” then under certain conditions “do C,” otherwise “do D”), generative art is from a set of specified rules or constraints (“A should always be bigger than B,” “C must never equal D”) (Boden & Edmonds, 2010). Forty-four projects from *Art Blocks* are Level 3 generative art, eleven of which have an added animated and interactive element. For each of these projects, thousands of NFTs are slight variations on a character (see *Algobots* or *Nimbuds*), created by putting them through a program that algorithmically randomizes layers with different accessories, expressions, or colors. This requires no human participation, and the machine is left on its own to generate the work.

However, similar to *SuperRare*, *Art Blocks* Level 4 projects are also created by GANs, with six projects included in the sample. In Level 4 works, the output space of the algorithm is varied enough to justify the thousands of iterations generated from it, with each output offering something completely new that teaches

the system about what else is possible. The *Art Blocks* project *Fidenza* uses this system termed long-form generative art. The logic behind long-form generative art is that the generated works are more sophisticated to ensure that poor results are extremely rare (Hobbs, 2021). This gives collectors and viewers a clear idea of

precisely what the program can generate, whereas, in short-form generative art (mostly Level 3), the output has most likely been cherry-picked for the best, representing a limited view of the algorithm (Hobbs, 2021).

Table 4. Art Blocks summary of analysis

No. of works	Level	Postmodern Qualities	Applicability/ Nature	Artistic process
44	3	<ul style="list-style-type: none"> • Reflective of the contemporary situation (Cappadona-Apostoles, 2009) • Participative, interactive, and collaborative - make the audience feel as if they are being part of an interesting community (Cappadona-Apostoles, 2009) 	Generative art	The artist defined parameters and variables for visual composition to generate unique imagery through each iteration
6	4	<ul style="list-style-type: none"> • Participative, interactive, and collaborative - make the audience feel as if they are being part of an interesting community (Cappadona-Apostoles, 2009) • Reestablish the audience both as a human being and as a member of a cohesive and identifiable community (Cappadona-Apostoles, 2009) 	AI art, Long-form generative art	Artists work with GANs and long-form generative art in which the algorithm corrects and checks itself thereby assuring consistency with each visual output and that bad results would be extremely rare

5. Conclusion

The results show that cryptoart has become trend-centered curiosity with shared practices and methodologies. Today, artists are bringing more ideas and methods to cryptoart, ranging from memes and other internet native genres, which are noticeable aesthetic traits of the most highly valued Level 1 works in *SuperRare*. This pre-occupation with technonostalgic styles surrounding digital trends looks more like a commodity fetish and advocates the “art of money’s sake” sentiment. This study has also found that most cryptoart is hardly compelling and aesthetically underwhelming, with the sample being dominated by Level 1 works with the previously mentioned shared themes and styles. It can be concluded that what truly matters to the buyers is the certification itself, and, unfortunately, not the work that’s being certified. As Brooks (2021) observes, cryptoart, as the visual manifestation of cryptocurrency, is aesthetically impoverished in that it “combines the nuanced social awareness of computer programmers with the soulful whimsy of hedge fund managers. It is art for people whose imaginations have been absolutely captured by a new kind of money you can do on the computer.” However, the study also found that Level 4 works produced by GANs are proof that the relationship between artists and technology has transcended the outdated outlook that computers are simply a tool for creating art, as they have become ideation partners (Goenaga, 2020). With AI, artists can lay down the rules in the dataset that will be fed to the GAN, as opposed to more traditional generative art where there is no room for interpretation (Bailey, 2018a). In the words of Smith and Leymarie (2017), “we can now begin to think of the machine not as the artist’s subject matter or medium, but as creator or co-creator.”

This study agrees with previous studies (Zhang et al., 2012; Smith & Leymarie, 2017) that have concluded that the machine’s capacity to automatically generate various forms of visually aesthetic expressions by autonomously learning the techniques of traditional visual art helps beautify outputs and products. However, what these previous studies have missed was the boom of NFT marketplaces and they did not individually analyze each cryptoart work in a curated marketplace and frame this phenomenon in a postmodern and computational aesthetic lens. This study shows that the cryptoart space in the blockchain can feasibly aid computational aesthetics in studying how computers could now generate visual outputs and evaluate their aesthetic value automatically. The results have opened up a discourse on how Level 4 works in the blockchain can level-up the aesthetic and postmodern discourse in NFT marketplaces so that they can be more like 19th-century salons that operate beyond financial profit.

While cryptoart represents a community of multidisciplinary artists historically excluded from the traditional art world, the resulting culture of the space is worrying – there needs to be more room for dialog about art and the artists behind it. This study addresses that lack by using the levels of complexities based on computational aesthetics and could frame the aesthetic design of computer algorithms, simulation, and visualization that are involved in cryptoart production where artists, buyers, and collectors are highly engaged. As technology and art infuse more into business practices, digital art should do more than provide stimulus in aestheticized production cycles. As Zeilinger (2018) argues - “if contemporary art wants to participate meaningfully in discourses on digital capital, it must recognize an obligation to engage its subjects critically, whether it is performatively (i.e., through

technological means) or through narrative inflection and subversion.”

It is worth noting that some artists have used blockchains to make conceptual art and treat them not just as marketplaces but as media. Myers (2014/2017) launched *Art is* in 2014 (Figure 1), where it uses the Ethereum network to define the concept of art. Essentially, the idea is that people can pay a certain price equal to how certain they were about the correctness of their definitions. It is a creative way of pointing out that art needs to be defined and that the people who define it are those who have the most capital.

The Definition Of Art

1	Art is good because it is epistemologically critiquing identity.	0x000ac2030e4900c31ca6404120c13e647700a201
2	Art is bad because it is logically defined by identity.	0x000ac2030e4900c31ca6404120c13e647700a201
3	Art is moral because it is psychologically embracing of identity.	0x000ac2030e4900c31ca6404120c13e647700a201
4	Art is immoral because it is childishly embracing of emotion.	0x000ac2030e4900c31ca6404120c13e647700a201
5	Art is creepy because it is sophisticatedly reacting to emotion.	0x000ac2030e4900c31ca6404120c13e647700a201
6	Art is interesting because it is conservatively reacting to emotion.	0x000ac2030e4900c31ca6404120c13e647700a201
7	Art is boring because it is liberally commenting on critique.	0x000ac2030e4900c31ca6404120c13e647700a201
8	Art is paradoxically ironically commenting on critique.	0x000ac2030e4900c31ca6404120c13e647700a201
9	Art is slightly creepily embracing critique.	0x000ac2030e4900c31ca6404120c13e647700a201
10	Art is somewhat radically embracing aesthetics.	0x000ac2030e4900c31ca6404120c13e647700a201
11	Art is very queerly resolving aesthetics.	0x000ac2030e4900c31ca6404120c13e647700a201
12	Art is totally problematically resolving aesthetics.	0x000ac2030e4900c31ca6404120c13e647700a201

Figure 1. Art definition (Myers, 2014/2017)

Art shows that the reality of what is in that blockchain is actually more elitist instead of egalitarian in terms of who has the technological understanding and financial capacity. While the cryptoart space is being used to leverage the postmodern practice of connecting artists and audiences and enabling them to see and understand one another as creators of value while furthering the collaborative relationship between artists and computers, the NFT explosion threatens to make all arts the art of making money. Zeilinger (2018) argues that the rapid advancement of financial technologies that assimilate digital art into the ownership-based sphere of the global art market appears to be an extension of neoliberalism tendencies and cognitive capitalism. However, digital art can also be “an important zone of resistance where artists and creative communities have an opportunity to help shape blockchain technologies in ways that challenge conventional perspectives on ownership and the enclosure of cultural commons” (Zeilinger, 2018, p. 3).

This study has confirmed that cryptoart is indeed a facet of postmodernism, thereby requiring critical discourse not only in aesthetics but also in form, content, and concept. It can act as a primer for artists, buyers, and collectors who aspire to enter the cryptoart space so that they can leverage the conversation in NFT marketplaces. However, this study could not address how NFTs challenged the relationship to dematerialization and distribution that were fundamental to computer art and, by extension, cryptoart. Extending this study to include discussions on these points in *the SuperRare* and *Art Blocks* contexts would offer a more comprehensive insight into the shifting concept of art on the blockchain and the

various forces that shape it.

The future requires new forms of critical interventions beyond superficial and artistic gimmicks. As Rodchenko (1920/1921) puts it, “Down with art that aspires to be nothing more than a spot of beauty on the ugly lives of the rich”.

6. Recommendations for Further Studies

Other recommendations for future studies are as follows:

- Descriptive case study of other generative art (Level 3) and art made by GANs (Level 4) in the cryptoart space outside of *SuperRare* and *Art Blocks* and mapping the evolution of the relationship between artists and computers in blockchain technology.
- Explore other artists and their conceptual works that use the blockchain as a medium and not just a marketplace and discover ways to extend the expressive and communicative range of tools, devices, and systems offered by blockchain technology while exploring diverse human interest and experiences that make connections that are neither utilitarian nor profitable
- Critique and analysis of works in larger and non-curated NFT marketplaces like *OpenSea*, *Nifty Gateway*, *Rarible*, or *Decentraland*.
- An aesthetic framework that describes the different genres and stylistic forms of cryptoart found in marketplaces (e.g. GIF art, glitch art, trash art, cyberpunk, psychedelia, etc.).
- The development of an informed critic system situated on the blockchain itself to create a space for dialog, qualitative judgment, and critique.

Acknowledgments

The authors would like to thank the School of Media Studies of Mapua University, Philippines, for covering the publication cost of this research.

Authors’ Contributions

Bautista provided the framework and general outline of the article, while Sandico analyzed the text and images from the marketplaces.

References

- [1] ALI, R.H., FONG, G., & LINSTEAD, E. (2021). Project Metamorphosis: Designing a Dynamic Framework for Converting Musical Compositions into Paintings. *Leonardo*, 55(4), 382–387. https://doi.org/10.1162/leon_a_02133
- [2] BAILEY, J. (2018a). AI Art Just Got Awesome. *Artnome*. Retrieved from <https://www.artnome.com/news/2018/3/29/ai-art-just-got-awesome>
- [3] BAILEY, J. (2018b). What is CryptoArt? *Artnome*. Retrieved from <https://www.artnome.com/news/2018/1/14/what-is->

- cryptoart
- [4] BAILEY, J. (2018c). Why Love Generative Art? *Artnome*. Retrieved from <https://www.artnome.com/news/2018/8/8/why-love-generative-art>
- [5] BAUTISTA, I.B.B. (2014). Levels of Complexity and the Postmodern Beauty of Computer Art. *Journal of Multimedia and Visual Arts*, 1(1).
- [6] BENJAMIN, W. (1969). *Illuminations*. New York: Schocken.
- [7] BODEN, M.A., & EDMONDS, E.A. (2010). What is generative art? *Digital Creativity*, 20(1-2), 21-26. <https://doi.org/10.1080/14626260902867915>
- [8] BROOKS, D. (2021). The Future Is Not Only Useless, It's Expensive. *Gawker*. Retrieved from <https://www.gawker.com/culture/the-future-is-useless-expensive>
- [9] CAPPADONA-APOSTOLES, D. (2009). *The Postmodern Presence of the Sacred: An Eliadean Reading of Postmodernist Art*. Art Papers.
- [10] CATLOW, R., GARRETT, M., JONES, N., & SKINNER, S. (2017). *Artists Re:thinking the Blockchain*. London: Liverpool University Press.
- [11] CHAMBEL, T., CORREIA, L., MANZOLLI, J., MIGUEL, G., HENRIQUES, N., & CORREIA, N. (2007). Creating Video Art with Evolutionary Algorithms. *Computers and Graphics*, 31(6), 837-847. <http://dx.doi.org/10.1016/j.cag.2007.08.004>
- [12] COOPER, R. (2022). The NFT craze has stopped being funny. *The Week*. Retrieved from <https://theweek.com/culture/arts/1008539/the-nft-craze-has-stopped-being-funny>
- [13] ENG, K.F. (2020). *What the Heck is Cryptoart?* Retrieved from <https://medium.com/swlh/what-the-heck-is-cryptoart-41f8af965e92>
- [14] FEIJS, L.M.G. (2019). A program for Victory Boogie Woogie. *Journal of Mathematics and the Arts*, 13(3), 261-285. <http://dx.doi.org/10.1080/17513472.2018.1555687>
- [15] FINUCANE, B. (2020). What is Crypto Art? *Frank Interviews*. Retrieved from <http://www.franknews.us/interviews/340/what-is-crypto-art>
- [16] FRANCESCHET, M., COLAVIZZA, G., SMITH, T., FINUCANE, B., OSTACHOWSKI, M.L., SCALET, S., PERKINS, J., MORGAN, J., & HERNANDEZ, S. (2021). Crypto art: A decentralized view. *Leonardo*, 54(4), 402-405. https://doi.org/10.1162/leon_a_02003
- [17] GALANTER, P. (2003). *What is Generative Art? Complexity Theory as a Context for Art Theory*. Retrieved from https://www.philipgalanter.com/downloads/ga2003_paper.pdf
- [18] GOENAGA, M.A. (2020). A critique of contemporary Artificial Intelligence Art: Who is Edmond de Belamy? *AusArt*, 8(1), 49-64. <https://doi.org/10.1387/ausart.21490>
- [19] GOLTRA, C. (2020). *Unholy Unions: Crypto Art: Artists, Merchants, and Cultural Exchange. Speculations*. Retrieved from <https://speculations.substack.com/p/unholy-unions>
- [20] GOODFELLOW, I.J., POUGET-ABADIE, J., MIRZA, M., XU, B., WARDE-FARLEY, D., OZAIR, S., COURVILLE, A., & BENGIO, Y. (2014). *Generative Adversarial Nets*. Retrieved from <https://arxiv.org/pdf/1406.2661.pdf>
- [21] HERMERÉN, G. (1993). The Relevance of Aesthetics to Art. *Iyyun: The Jerusalem Philosophical Quarterly*, 42, 71-104. Retrieved from <http://www.jstor.org/stable/23350754>
- [22] HERRERO, M. (2005). Encounters with Postmodern Art: Zygmunt Bauman, Sociology and Art. *Irish Journal of Sociology*, 14(1), 130-140. <http://dx.doi.org/10.1177/079160350501400108>
- [23] HOBBS, T. (2021). The Rise of Long-Form Generative Art. *Tyler Hobbs*. Retrieved from <https://tylerxhobbs.com/essays/2021/the-rise-of-long-form-generative-art>
- [24] HUMPHRIES, H. (2003). A Philosophical Inquiry into the Nature of Computer Art. *Journal of Aesthetic Education*, 37(1), 13-31. Retrieved from <https://www.learntechlib.org/p/75511/>
- [25] KREYE, A. (2014). *Salon Culture: Network of Ideas*. Retrieved from <https://www.edge.org/conversation/andrian-kreye-salon-culture-network-of-ideas>
- [26] LIU, M. (2021). In the age of crypto, we must redefine the meaning of “art”. *Harker Aquila*. Retrieved from <https://harkeraquila.com/58315/opinion/in-the-age-of-crypto-we-must-redefine-the-meaning-of-art/>
- [27] MARCOS, A. (2007). Digital Art: When artistic and cultural muse and computer technology merge. *IEEE Computer Graphics and Applications*, 5(27), 98-103. <https://doi.org/10.1109/2FMCG.2007.123>
- [28] MARRACCINI, A. (2022). Retrieved from <https://avmarraccini.wordpress.com/>
- [29] MYERS, R. (2014/2017). *Art is*. Retrieved from <https://rhea.art/art-is>
- [30] O'DWYER, R. (2018). Limited edition: Producing artificial scarcity for digital art on the blockchain and its implications for the cultural industries. *Convergence: The International Journal of Research into New Media Technologies*, 26(4), 874-894. <https://doi.org/10.1177/1354856518795097>
- [31] PEASTER, W. (2021). How to approach the generative art boom. *Bankless HQ*. Retrieved from <https://newsletter.banklesshq.com/p/how-to-approach-the-generative-art>
- [32] PORTER, J. (2021). *The Value of Aesthetic Value*. Retrieved from https://www.researchgate.net/publication/350209856_Value_of_Aesthetic_Value

- [33] RANCIÈRE, J. (2009) *Aesthetics and Its Discontents*. Cambridge: Polity Press.
- [34] RICHMAN-ABDOU, K. (2020). The History of the Prestigious Paris Salon (And the Radical Artists Who Subverted It). *My Modern Met*. Retrieved from <https://mymodernmet.com/paris-salon-history/>
- [35] RODCHENKO, A. (1920/1921). Slogans.
- [36] RYAN, J. (2014). From Dada to the Browser: Internet Art and the Democratization of Artistic Production in the Digital Era. *The International Journal of Critical Cultural Studies*, 12(1), 41-51. Retrieved from <https://www.i-scholar.in/index.php/IJCCSCG/article/view/57201>
- [37] SHARMA, T.K. (2018). Why Are People Referring to Blockchain as the New Internet? *Blockchain Council*. Retrieved from <https://www.blockchain-council.org/blockchain/why-are-people-referring-to-blockchain-as-the-new-internet/>
- [38] SMITH, G.W., & LEYMARIE, F.F. (2017). The machine as artist: An introduction. *Arts*, 6(2), 5. <https://doi.org/10.3390/arts6020005>
- [39] STORMING THE IVORY TOWER. (2021). *The NFT's Aura, or, Why Is NFT Art So Ugly?* Retrieved from <https://www.stormingtheivorytower.com/2021/06/the-nfts-aura-or-why-is-nft-art-so-ugly.html>
- [40] SUPERWORLD. (2021). SuperWorld NFT Salon: The Marketplace for Digital Assets. *AR/VR Journey: Augmented & Virtual Reality Magazine*. Retrieved from <https://arvrjourney.com/superworld-%EF%B8%8F-nft-salon-the-marketplace-for-digital-assets-39fd0aeafde4>
- [41] TAYLOR, G.D. (2014). *When the Machine Made Art: The Troubled History of Computer Art*. New York: Bloomsbury.
- [42] TRAN, K.C. (2020). What is SuperRare? *Decrypt*. Retrieved from <https://decrypt.co/resources/what-is-superrare-3-minute-guide-explained-art-collectible>
- [43] WANG, K., GOU, C., DUAN, Y., LIN, Y., ZHENG, X., & WANG, F.Y. (2017) Generative adversarial networks: introduction and outlook. *IEEE/CAA Journal of Automatica Sinica*, 4(4), 588-598. <https://doi.org/10.1109/JAS.2017.7510583>
- [44] WANG, Q. (2021). Qinwen Wang Frames Crypto Art within an Art and Tech Context. *Whitewall*. Retrieved from <https://whitewall.art/art/qinwen-wang-frames-crypto-art-within-an-art-and-tech-context>
- [45] ZEILINGER, M. (2018). Digital Art as 'Monetised Graphics': Enforcing Intellectual Property on the Blockchain. *Philosophy & Technology*, 31, 15-41. <https://doi.org/10.1007/s13347-016-0243-1>
- [46] ZHANG, K., HARRELL, S., & JI, X. (2012). Computational Aesthetics: On the Complexity of Computer Generated Paintings. *Leonardo*, 45(3), 243-248. Retrieved from <https://www.jstor.org/stable/41550640>

参考文献:

- [1] ALI, R.H., FONG, G. 和 LINSTED, E. (2021). 项目变形：设计将音乐作品转化为绘画的动态框架。莱昂纳多，55（4），382-387。 https://doi.org/10.1162/leon_a_02133
- [2] 贝利, J. (2018 一个)。人工智能艺术变得很棒。艺名。取自 <https://www.artnome.com/news/2018/3/29/ai-art-just-got-awesome>
- [3] 贝利, J. (2018b)。什么是加密艺术？艺名。取自 <https://www.artnome.com/news/2018/1/14/what-is-cryptoart>
- [4] 贝利, J. (2018c)。为什么喜欢生成艺术？艺名。取自 <https://www.artnome.com/news/2018/8/8/why-love-generation-art>
- [5] BAUTISTA, I.B.B. (2014)。计算机艺术的复杂程度和后现代美。多媒体与视觉艺术杂志，1（1）。
- [6] 本杰明, W. (1969 年)。灯饰。纽约：肖肯。
- [7] 博登, 文学硕士和埃德蒙兹, E.A. (2010)。什么是生成艺术？数字创意，20（1-2），21-26。 <https://doi.org/10.1080/14626260902867915>
- [8] 布鲁克斯, D. (2021 年)。未来不仅无用，而且昂贵。傻瓜。取自 <https://www.gawker.com/culture/the-future-is-useless-expensive>
- [9] 卡帕多纳-使徒, D. (2009)。神圣的后现代存在：后现代主义艺术的伊利亚德式解读。艺术论文。
- [10] CATLOW, R., GARRETT, M., JONES, N., & SKINNER, S. (2017)。艺术家回覆：思考区块链。伦敦：利物浦大学出版社。
- [11] CHAMBEL, T., CORREIA, L., MANZOLLI, J., MIGUEL, G., HENRIQUES, N., & CORREIA, N. (2007)。使用进化算法创建视频艺术。计算机和图形，31（6），837-847。 <http://dx.doi.org/10.1016/j.cag.2007.08.004>
- [12] 库珀, R. (2022 年)。NFT 热潮已不再有趣。星期。取自 <https://theweek.com/culture/arts/1008539/the-nft-craze-has-stopped-being-funny>
- [13] 英格, K.F. (2020 年)。加密艺术到底是什么？取自 <https://medium.com/swlh/what-the-heck-is-cryptoart-41f8af965e92>
- [14] FEIJS, L.M.G. (2019)。胜利布吉伍吉的节目。数学与艺术杂志，13（3），261-285。 <http://dx.doi.org/10.1080/17513472.2018.1555687>
- [15] FINUCANE, B. (2020)。什么是加密艺术？弗兰

- 克 采 访 。 取 自
<http://www.franknews.us/interviews/340/what-is-crypto-art>
- [16] FRANCESCHET, M., COLAVIZZA, G., SMITH, T., FINUCANE, B., OSTACHOWSKI, M.L., SCALET, S., PERKINS, J., MORGAN, J., & HERNANDEZ, S. (2021). 加密艺术：去中心化的观点。莱昂纳多，54（4），402-405。
https://doi.org/10.1162/leon_a_02003
- [17] 加兰特，P. (2003年)。什么是生成艺术？复杂性理论作为艺术理论的背景。取自
https://www.philipgalanter.com/downloads/ga2003_paper.pdf
- [18] 戈纳加，文学硕士（2020年）。当代人工智能艺术批判：埃德蒙·德·贝拉米是谁？澳大利亚艺术，8（1），49-64。
<https://doi.org/10.1387/ausart.21490>
- [19] GOLTRA, C. (2020)。邪恶联盟：加密艺术：艺术家、商人和文化交流。猜测。取自
<https://speculations.substack.com/p/unholy-unions>
- [20] GOODFELLOW, I.J., POUGET-ABADIE, J., MIRZA, M., XU, B., WARDE-FARLEY, D., OZAIR, S., COURVILLE, A., & BENGIO, Y. (2014)。生成对抗网络。取自
<https://arxiv.org/pdf/1406.2661.pdf>
- [21] 赫默伦，G. (1993年)。美学与艺术的相关性。伊云：耶路撒冷哲学季刊，42，71-104。取自
<http://www.jstor.org/stable/23350754>
- [22] HERRERO, M. (2005)。遭遇后现代艺术：齐格蒙特·鲍曼，社会学和艺术。爱尔兰社会学杂志，14（1），130-140。
<http://dx.doi.org/10.1177/079160350501400108>
- [23] 霍布斯，T. (2021年)。长篇生成艺术的兴起。泰勒霍布斯。取自
<https://tylerxhobbs.com/essays/2021/the-rise-of-long-form-generation-art>
- [24] HUMPHRIES, H. (2003)。对计算机艺术本质的哲学探究。美育杂志，37（1），13-31。取自
<https://www.learntechlib.org/p/75511/>
- [25] 克雷耶，A. (2014年)。沙龙文化：思想网络。取自
https://www.edge.org/conversation/andrian_kreye-salon-culture-network-of-ideas
- [26] 刘敏 (2021)。在加密时代，我们必须重新定义“艺术”的含义。哈克·拉奎拉。取自
<https://harkeraquila.com/58315/opinion/in-the-age-of-crypto-we-must-redefine-the-meaning-of-art/>
- [27] 马科斯，A. (2007)。数字艺术：当艺术和文化缪斯与计算机技术融合时。IEEE 计算机图形学和应用，5(27)，98-103。
<https://doi.org/10.1109%2FMC.2007.123>
- [28] 马拉奇尼，A. (2022年)。取自
<https://avmarraccini.wordpress.com/>
- [29] 迈尔斯，R. (2014/2017)。艺术是。取自
<https://rhea.art/art-is>
- [30] 奥德怀尔，R. (2018年)。限量版：在区块链上制造数字艺术的人为稀缺性及其对文化产业的影响。融合：国际新媒体技术研究杂志，26（4），874-894。
<https://doi.org/10.1177/1354856518795097>
- [31] 皮斯特，W. (2021年)。如何应对生成艺术热潮。无银行总部。取自
<https://newsletter.banklesshq.com/p/how-to-approach-the-generation-art>
- [32] 波特，J. (2021年)。审美价值的价值。取自
https://www.researchgate.net/publication/350209856_Value_of_Aesthetic_Value
- [33] RANCIÈRE, J. (2009) 美学及其不满。剑桥：政治出版社。
- [34] RICHMAN-ABDOU, K. (2020)。著名的巴黎沙龙的历史（以及颠覆它的激进艺术家）。我的现代遇见。取自
<https://mymodernmet.com/paris-salon-history/>
- [35] 罗德琴科，A. (1920/1921)。口号。
- [36] 瑞安，J. (2014年)。从达达到浏览器：数字时代的网络艺术与艺术生产的民主化。国际批判文化研究杂志，12（1），41-51。取自
<https://www.i-scholar.in/index.php/IJCCSCG/article/view/57201>
- [37] 夏尔马，T.K. (2018年)。为什么人们将区块链称为新互联网？区块链委员会。取自
<https://www.blockchain-council.org/blockchain/why-are-people-referring-to-blockchain-as-the-new-internet/>
- [38] 史密斯，G.W., & LEYMARIE, F.F. (2017)。作为艺术家的机器：介绍。艺术，6（2），5。
<https://doi.org/10.3390/arts6020005>
- [39] 风暴象牙塔。(2021年)。NFT的光环，或者，为什么 NFT 艺术如此丑陋？取自
<https://www.stormingtheivorytower.com/2021/06/the-nfts-aura-or-why-is-nft-art-so-ugly.html>
- [40] 超级世界。(2021年)。超级世界 NFT 沙龙：数字资产市场。增强现实/虚拟现实之旅：增强和虚拟现实杂志。取自
<https://arvrjourney.com/superworld-%EF%B8%8F-nft-salon-the-marketplace-for-digital-assets-39fd0aeafde4>
- [41] 泰勒，G.D. (2014年)。当机器制造艺术时：计算机艺术的麻烦历史。纽约：布卢姆斯伯里。
- [42] 陈，K.C. (2020年)。什么是超稀有？解密。取自
<https://decrypt.co/resources/what-is-superrare-3-minute-guide-explained-art-collectible>
- [43] WANG, K., GOU, C., DUAN, Y., LIN, Y., ZHENG, X., & WANG, F.Y. (2017) 生成对抗网络：介绍和展望。IEEE/民航局自动化学报，4(4)，588-598。
<https://doi.org/10.1109/JAS.2017.7510583>

-
- [44] 王 Q. (2021). Qinwen 王在艺术和技术背景下构建加密艺术。白墙。取自 <https://whitewall.art/art/qinwen-wang-frames-crypto-art-within-an-art-and-tech-context>
- [45] ZEILINGER, M. (2018)。作为“货币化图形”的数字艺术：在区块链上实施知识产权。哲学与技术，31、15-41。 <https://doi.org/10.1007/s13347-016-0243-1>
- [46] ZHANG, K., HARRELL, S., & JI, X. (2012)。计算美学：关于计算机生成绘画的复杂性。莱昂纳多，45（3），243-248。取自 <https://www.jstor.org/stable/41550640>