Analyzing the Evolution of AI-Generated Art Styles Using Time Series Analysis: A Trend Study on NFT Artworks

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ABSTRACT

This study investigates the development of AI-generated art styles within the growing non-fungible token (NFT) market. Using time series analysis, the research identifies key trends and shifts in art styles from 2022 to 2024, revealing how various art forms, algorithms, and mediums evolved in response to technological advancements and market forces. Data was collected from a sample of 10,000 NFT artworks, categorized by creation date, style, and algorithm usage. Exploratory Data Analysis (EDA) techniques, including line graphs and heatmaps, were employed to visualize and interpret trends across different art styles and AI tools. Results indicate a significant increase in the popularity of styles like surrealism and realism, with deepdream and GANpaint algorithms being frequently associated with these styles. Stacked area charts further highlighted the proportional growth of art styles over time, providing insights into both short-term popularity spikes and long-term trends. The findings suggest that the integration of AI algorithms significantly influenced the rise of specific art genres, with certain algorithms correlating strongly with particular styles. Practical implications for artists and collectors include the potential for data-driven insights to guide creative choices and investment strategies. The study's limitations, such as the lack of broader market data, provide a foundation for future research to explore the intersection of AI-generated art, NFT marketplaces, and cultural influences. The paper concludes that AI and NFTs are reshaping the traditional art market, presenting new opportunities for creativity, ownership, and artistic value in a digital age.

Introduction

NFT emerged as a transformative force in the art market, fundamentally altering how digital art was created, owned, and traded. NFTs are unique digital assets that utilize blockchain technology to verify ownership and authenticity, setting them apart from traditional digital files that could be easily replicated. This unique characteristic allowed NFTs to represent ownership of both digital and physical artworks, creating a new paradigm for artists and collectors alike [1]. Unlike conventional artworks, which often rely on physical presence and traditional means of provenance, NFTs provide a digital certificate of ownership that is stored on the blockchain, making it transparent and immutable. This transparency fostered a sense of trust and security in digital transactions, which was previously a significant barrier in the digital art space. The rapid adoption of NFTs within the art market reflected a broader trend towards accepting digital assets as legitimate forms of art investment. Traditional art institutions and

players increasingly entered the NFT space, validating its significance and potential. The integration of NFTs into the art world facilitated the creation of new online marketplaces, such as OpenSea and Foundation, where artists could sell their works directly to collectors, bypassing traditional intermediaries like galleries and auction houses [2], [3]. This direct-to-collector approach democratized art sales, empowering artists by enabling them to retain a larger share of the profits from their work. Furthermore, the blockchain-based nature of NFTs introduced the possibility for artists to earn royalties from secondary sales, providing an ongoing revenue stream that was not typically available in the traditional art market [4], [5].

The rise of artificial intelligence (AI) in digital art significantly transformed artistic practices, challenging traditional notions of creativity, authorship, and the artist's role. AI-generated art refers to artworks created with the assistance of AI algorithms, which could analyze, learn, and generate visual content based on vast datasets. This technological advancement expanded the creative possibilities for artists and democratized art creation, allowing individuals without formal artistic training to produce high-quality works in a matter of minutes [6], [7]. AI tools such as generative adversarial networks (GANs) and neural style transfer enabled artists to explore new aesthetics and push the boundaries of visual expression beyond what was previously possible with traditional media. AI's integration into the art world led to the emergence of new artistic genres and forms of expression. Generative art, for instance, utilized algorithms to create unique pieces and gained popularity for its ability to produce novel aesthetics that often challenged human creativity [8], [9]. The capacity of AI to simulate the creative process and generate works that were sometimes indistinguishable from those created by humans raised important questions about authorship and originality in art. As AI-generated artworks became more prevalent, the distinction between human and machine-created art blurred, prompting ongoing discussions about the value and significance of each [10], [11]. These debates were central to understanding the evolving role of the artist in an increasingly digital and automated world.

The interaction between AI-generated art and NFTs also underscored the evolving nature of art consumption and appreciation. As collectors became more familiar with AI-generated works, their perceptions of value and artistic merit shifted, potentially leading to greater acceptance of machine-created art as a legitimate form of artistic expression [10]. However, acceptance was not universal; some critics argued that AI-generated art lacked the emotional depth and intentionality inherent in human-created works, which could influence market dynamics and consumer preferences [12], [13]. This divergence in opinion highlighted the ongoing tension between technological innovation and traditional artistic values, raising questions about the future of art and the evolving criteria for what constituted meaningful artistic expression. The evolution of AI-generated art styles presented several challenges and gaps in understanding, especially as the field advanced rapidly and intersected with various disciplines such as ethics, aesthetics, and technology. One of the most significant challenges was the perception and valuation of AI-generated art compared to human-created works. Studies indicated a prevailing bias against AI art, where viewers often attributed less artistic value to works produced by machines, largely due to assumptions about the effort and intentionality involved in their creation [14], [15]. This bias complicated the acceptance of AI art within traditional art circles and raised questions about the criteria used to evaluate

artistic merit, highlighting the need for new evaluative frameworks that could accommodate the unique characteristics of AI-generated art.

Understanding trends in AI-generated art, particularly related to NFT, was crucial for collectors, artists, and platforms engaged in this rapidly evolving landscape. The convergence of AI and NFTs reshaped the art world's creative process, market dynamics, ownership structures, and perceptions of value. As AI-generated artworks became more prevalent and diversified, stakeholders needed to stay informed about these trends to navigate the complexities of the NFT art market effectively. For collectors, staying informed about trends in AI-generated art was essential for making informed purchasing decisions. As AI technologies advanced, the quality and style of AI-generated artworks continuously evolved, directly impacting their market value. Collectors who understood these trends were better equipped to assess the potential appreciation of their investments. The growing acceptance of AI art within the broader art community suggested that demand for such works could increase, thereby enhancing their value over time [16], [17]. Moreover, collectors increasingly considered sustainability and ethical implications associated with AI-generated art, which influenced their purchasing preferences and willingness to pay premiums for artworks that aligned with their values [17], [18]. This shift indicated that awareness of trends informed financial decisions and aligned with collectors' personal values and social consciousness. Conversely, artists could leverage insights into AI-generated art trends to enhance their creative practices and explore new artistic possibilities. Understanding the evolving capabilities of AI tools enabled artists to integrate these technologies into their workflows, producing innovative works that resonated with contemporary audiences. Furthermore, being aware of market trends helped artists strategically position their work within the NFT space, thereby maximizing visibility and sales potential [19], [20]. As AI-generated art gained mainstream recognition, artists who adapted to these changes discovered new avenues for expression and revenue generation. This adaptability became increasingly important as the line between traditional and digital art forms continued to blur, offering artists opportunities to expand their reach and redefine their creative identity.

The rapid growth of AI-generated art within the NFT space presented new opportunities for artists and investors but also highlighted significant gaps in understanding how these art styles have evolved over time. Despite the increasing popularity of AI-generated artworks as NFTs, there was a lack of detailed trend analysis that specifically examined the progression of these styles and themes. Existing literature often addressed AI-generated art and NFTs separately or focused on broader market dynamics without delving into the specific trajectories of AI-generated styles within the NFT market. This gap in research left stakeholders without clear, data-driven insights into how AI-generated art styles were developing, which algorithms were gaining prominence, and how market preferences were shifting over time. As a result, artists, collectors, and investors were operating in a landscape with limited guidance on the evolving trends, making it challenging to make informed decisions regarding the creation, acquisition, and valuation of AI-generated NFTs. The absence of comprehensive trend analysis also hindered the ability of artists to strategically align their creative outputs with market demands and for investors to identify promising investment opportunities. A deeper understanding of how AI-generated art styles evolved could provide valuable insights into the future direction of the NFT art market, allowing stakeholders to

anticipate shifts in artistic and technological preferences. Without such analysis, there was a risk of missing critical patterns that could influence the market's development, including the adoption of new AI algorithms or the emergence of novel artistic themes that resonate with collectors. Addressing this problem required a focused study that leveraged time series analysis to uncover the evolution of AI-generated art styles within the NFT space, offering actionable insights that could drive better decision-making for all involved.

The primary objective of this research was to analyze the evolution of styles and themes in AI-generated art over time within the NFT market using time series analysis. This approach aimed to identify prominent trends, shifts in artistic styles, and the adoption patterns of different AI algorithms in creating digital artworks. By employing time series analysis, the study sought to map out the trajectory of AI-generated art, capturing the nuances of how specific styles gained or lost popularity over defined periods. The goal was to generate a clear and comprehensive picture of the NFT art landscape, highlighting the dynamic interplay between technology, creativity, and market forces. These insights were intended to provide stakeholders, particularly artists and investors, with a robust foundation for understanding the current state and future potential of AI-generated art within the NFT ecosystem. The scope of this research was specifically limited to AI-generated artworks within the NFT market. This focus allowed for a targeted exploration of the intersection between AI technologies and digital art within the unique framework of NFTs, where concepts of ownership, authenticity, and scarcity played pivotal roles. The study did not extend to broader applications of AI in art outside of the NFT context or consider traditional digital artworks without NFT integration. This narrow scope ensured that the analysis remained concentrated on the most relevant aspects of the evolving digital art market. The significance of this research extended to various stakeholders, including artists, collectors, investors, and NFT platforms. For artists, understanding the evolving trends in AI-generated art could inform their creative processes and strategic positioning within the NFT market. For collectors and investors, insights into style evolution and algorithm adoption offered valuable information for making informed purchasing and investment decisions.

Literature Review

AI-Generated Art

AI integration into the art world has a rich and evolving history, marked by significant advancements that have transformed creative practices and expanded the boundaries of artistic expression. AI's journey in the realm of art began with early experiments in computer-generated imagery, but the development of sophisticated algorithms truly revolutionized AI-generated art. One of the most notable breakthroughs in this field was the introduction of GAN in 2014 by Ian Goodfellow and his colleagues. GANs operate through a unique adversarial process involving two neural networks—the generator and the discriminator—that work against each other in a continuous feedback loop. The generator creates images, while the discriminator evaluates these images against real ones, providing feedback that guides the generator to improve its outputs [21]. This iterative process enabled the creation of highly realistic images, which allowed artists and technologists to explore new creative possibilities and pushed the boundaries of what could be achieved through AI. In addition to GANs, Variational Autoencoders (VAEs) played a significant role

in the evolution of AI-generated art. VAEs are deep learning models that encode input data into a compressed representation and then decode it to generate new data points that resemble the original. This approach has been particularly effective in tasks such as style transfer and image synthesis, where VAEs can blend different artistic styles to create novel visual experiences [22], [23]. The combination of GANs and VAEs facilitated the development of hybrid models, which leveraged the strengths of both approaches to produce artworks that were not only visually compelling but also rich in stylistic diversity. These advancements opened up new avenues for artists to experiment with their work, leading to a broader acceptance of AI as a creative tool in the art community.

Beyond image generation, AI's application in art extended to more complex tasks, such as creating images from textual descriptions. Tools like DALL·E and Midjourney exemplified this advancement, utilizing advanced algorithms to generate detailed visual representations based on descriptive prompts [24], [25]. This capability showcased AI's potential to bridge the gap between language and visual art, allowing for a more intuitive and accessible form of artistic creation. These tools not only democratized art-making by lowering the barriers to entry but also sparked important discussions about the nature of creativity and authorship. As AI-generated works began to challenge traditional notions of artistic expression, questions arose about the role of the human artist versus the machine in the creative process [26]. This debate underscored the evolving relationship between technology and art and the need for new frameworks to evaluate and appreciate AI-generated art. The rise of AI in art also spurred developments in art education and curation. AI tools were increasingly used to analyze artistic styles, assist in teaching, and even curate exhibitions, reshaping how art was created, taught, and appreciated [27], [28]. In educational settings, AI provided students with interactive platforms to explore various art styles and techniques, fostering a deeper understanding of the creative process. Meanwhile, AI-assisted curation offered new ways to organize and present art in museums and galleries, enhancing the viewer's experience by tailoring exhibits to personal preferences or historical contexts. This integration of AI into the broader art ecosystem highlighted the potential for collaboration between human artists and AI systems, fostering a new era of creativity that blended cutting-edge technology with traditional artistic practices.

NFTs and Their Role in Digital Art

NFT emerged as a revolutionary mechanism for defining ownership and authenticity in the digital art landscape. An NFT is a unique digital asset that represents ownership of a specific item or piece of content, typically secured on a blockchain, which is a decentralized digital ledger. Unlike cryptocurrencies such as Bitcoin or Ethereum, which are fungible and can be exchanged on a one-to-one basis, NFTs are non-fungible, meaning each token has distinct properties and cannot be exchanged on a like-for-like basis [2], [29]. This distinction makes NFTs ideal for representing digital art, as each token can be uniquely associated with a particular artwork, ensuring that the piece is one-of-a-kind or part of a limited edition. The mechanics of NFTs in art involved several key components, starting with creating the NFT through a process known as "minting." Digital art is uploaded to a blockchain platform during minting, and a unique token is generated to represent that artwork. This token includes metadata encompassing details such as the creator's information, ownership history, and even links to the digital artwork itself [4], [30]. The most common

blockchain for NFTs is Ethereum, which supports smart contracts—self-executing contracts with the terms of the agreement directly embedded in code. These smart contracts facilitate the transfer of ownership and can include provisions for royalties, allowing artists to earn a percentage of future sales whenever the NFT changes hands [4], [31]. This capability provided a novel revenue stream for artists, which contrasted sharply with traditional art markets where artists typically do not benefit from secondary sales.

The impact of NFT on the valuation and distribution of digital art was profound, reshaping the art market landscape in several significant ways. NFTs provided a mechanism for establishing ownership and authenticity in the digital realm, which had historically been challenging due to the ease with which digital files could be replicated. This unique characteristic of NFTs introduced new dynamics in how digital art was valued and distributed, fundamentally altering the traditional paradigms of the art market [29], [32]. By securing digital artworks on a blockchain, NFTs ensured that each piece was distinct, verifiable, and traceable, thereby addressing long-standing issues of provenance and authenticity that often plagued digital art transactions. One of the most notable impacts of NFTs was the democratization of the art market. Traditionally, artists relied on galleries, auction houses, and other intermediaries to sell their work, often facing significant barriers related to access, exposure, and profit-sharing. NFTs allowed artists to bypass these traditional gatekeepers, enabling them to sell their art directly to collectors through online marketplaces such as OpenSea, Rarible, and Foundation [33], [34]. This shift broadened participation in the art market by making it more accessible to a wider range of artists, including those who might not have had the opportunity to exhibit in conventional spaces. Additionally, NFTs empowered artists to retain a larger share of the profits from their sales, as they could set their prices, control the distribution of their work, and even earn royalties from secondary sales facilitated by smart contracts [35]. This direct-to-collector model not only enhanced financial opportunities for artists but also fostered a more equitable art market ecosystem. The NFT phenomenon also transformed the valuation of digital art, as the scarcity introduced by NFTs led to a new understanding of value in the digital art space. Each NFT was unique or part of a limited edition, making it verifiable and inherently scarce—a quality that significantly influenced collectors' willingness to invest in digital art. Collectors increasingly paid substantial sums for NFT artworks, driven by factors such as perceived rarity, the reputation of the artist, and the cultural or historical significance of the work [36]. The NFT market saw record-breaking sales, with some digital artworks fetching millions of dollars, thereby setting new benchmarks for the valuation of digital art. For example, high-profile sales, such as Beeple's "Everydays: The First 5000 Days," which sold for $69 million at Christie's, underscored the growing acceptance and valuation of NFTs within both the art and investment communities.

Previous Studies on Art Trend Analysis

The exploration of AI-generated art, particularly in the context of NFT, revealed several notable gaps in the existing literature. Although there was an expanding body of research on AI in art and the implications of NFTs individually, the intersection of these two domains remained underexplored. This underrepresentation highlighted a critical need for more focused studies that address the unique dynamics introduced when AI-generated art is tokenized as

NFTs, affecting aspects such as valuation, ownership, and audience perception. One significant gap identified was the limited focus on AI-generated art as NFTs. Many studies addressed AI-generated art or NFTs separately, but few examined the unique implications of these elements converging. For instance, research by [37] discussed the perception of AI-generated art broadly but did not delve into how these perceptions might change when the art was tokenized as an NFT. This omission suggested a need for research that specifically investigated how the NFT framework altered the valuation, ownership, and reception of AI-generated artworks. The process of tokenization, which introduced concepts of scarcity and unique ownership in the digital realm, potentially shifted both the market dynamics and the cultural significance of AI-generated art. Yet, these effects were not sufficiently covered in the literature.

Another critical area that remained underexplored involved the complexities of attribution and responsibility in AI-generated art, particularly within the NFT context. Research [38] highlighted the challenges of attribution in AI-generated art, raising questions about who deserved credit for artworks created by AI—whether it was the algorithm, the programmer, or the artist who provided the input. However, there was limited exploration of how these issues were compounded when AI art was sold as NFTs. The NFT marketplace added another layer of complexity to these questions, as it involved the distribution of digital assets and the monetization and legal ownership of creative works generated by algorithms. Understanding the implications of ownership and authorship in the NFT space was crucial, especially as artists navigated the challenges of copyright and intellectual property in the digital realm. However, this was an area where existing research was notably sparse. Additionally, ethical considerations surrounding AI-generated art were often discussed in the literature, but there was a lack of comprehensive analysis regarding the ethical implications of AI art within the NFT market. Studies such as those by [39] touched on the ethical dilemmas associated with AI-generated art, including issues like data bias and the potential for exploitation. However, these discussions did not extend sufficiently into how these ethical issues played out in the NFT market, where the commodification of creativity and environmental concerns related to blockchain technology were significant factors. The environmental impact of NFTs, in particular, posed serious ethical questions, given the high energy consumption associated with blockchain transactions. Yet, this aspect received limited attention in studies focused on AI-generated art.

Method

The research method for this study consists of several steps to ensure a comprehensive and accurate analysis. The flowchart in figure 1 outlines the detailed steps of the research method.
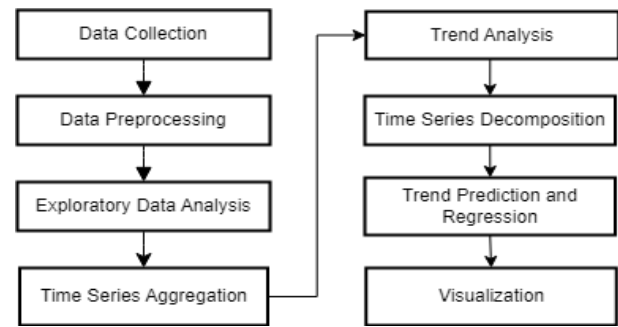
Figure 1 Research Method Flowchart

Data Collection

The study utilized a comprehensive dataset of AI-generated artworks, specifically curated to analyze the evolution of art styles within the NFT market. The dataset comprised key fields including "ArtworkID," "Title," "CreationDate," "Algorithm," "Category," and "Description." Each artwork was uniquely identified by an "ArtworkID," which served as a primary key, ensuring that each entry in the dataset represented a distinct piece of art. The "Title" field provided a brief identifier for each artwork, while the "CreationDate" documented the date on which the artwork was generated. The "Algorithm" field captured the specific AI model or technique used to create the artwork, such as Generative Adversarial Networks (GANs) or Neural Style Transfer (NST). The "Category" field classified the artworks into different styles or themes, such as abstract, surreal, or impressionistic, enabling the analysis of stylistic trends over time. Finally, the "Description" field offered additional context or details about each artwork, which could include information about the artist's intent or the conceptual background of the piece. The data for this study were sourced from various NFT marketplaces and public repositories that specialize in AI-generated art, such as OpenSea and Foundation. These platforms provided a rich selection of artworks that spanned a wide range of styles and AI algorithms, making them ideal for this analysis. To ensure the dataset's reliability and relevance, a thorough data cleaning and preprocessing process was conducted. This included handling missing values, standardizing date formats, and ensuring consistency in the categorization of art styles. Missing values, particularly in the "Algorithm" and "Category" fields, were addressed through imputation techniques or, where necessary, by excluding incomplete entries to maintain the dataset's integrity. Dates were standardized to a uniform format (YYYY-MM-DD) to facilitate accurate time series analysis, and categorical inconsistencies were resolved by aligning similar styles under standardized categories, reducing the variability introduced by differing nomenclature across sources. In addition to cleaning and standardizing the data, efforts were made to enhance its analytical value by enriching the dataset with additional metadata where available. For instance, data enrichment included linking artworks with their respective market performance metrics, such as sales prices and transaction volumes, where this information was accessible. This allowed for a more nuanced understanding of how specific AI-generated styles performed in the NFT market over time. The preprocessing stage also involved the normalization of text fields, such as the "Description," to remove extraneous characters and improve the quality of any text-based analysis that was conducted as part of the study.

Exploratory Data Analysis (EDA)

EDA phase was essential for gaining initial insights into the dataset and understanding the distribution and trends of AI-generated artworks within the NFT market. To explore the distribution of artworks across time and categories, a variety of visualization tools were employed, including histograms, bar charts, and time-series plots. Histograms shown in Figure 2 were used to examine the frequency distribution of artworks over different time periods, revealing peaks in creation dates that suggested surges in activity or popularity of certain styles.
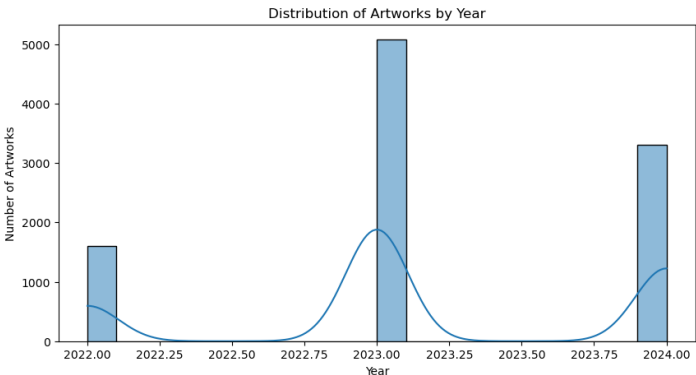

Figure 2 Distribution of Artworks by Year

Bar charts as in Figure 3 were utilized to compare the prevalence of different art categories and algorithms, allowing for a straightforward comparison of the number of artworks produced within each category or using specific algorithms. These visualizations provided an immediate sense of how certain styles and algorithms were distributed across the dataset, highlighting patterns such as the dominance of particular styles or the increasing use of advanced AI techniques like GANs over time.
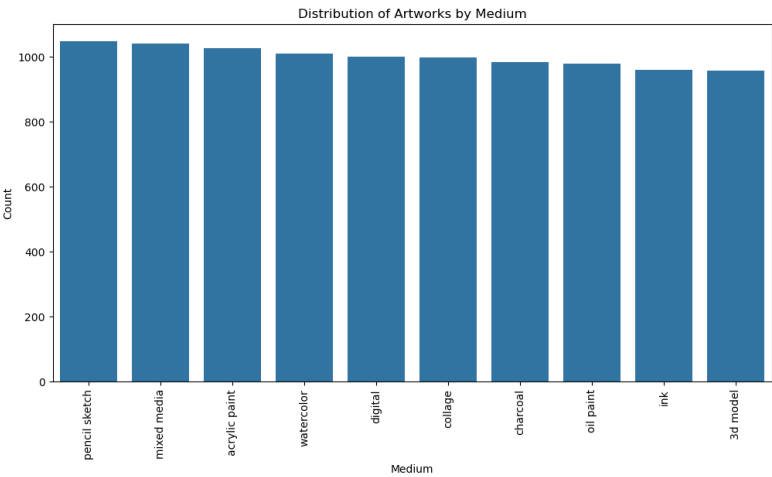

Figure 3 Distribution of Artworks by Medium

Time-series plots, shown in Figure 4, were also used to visualize trends in art categories, offering a preliminary look at how different styles evolved throughout the study period.
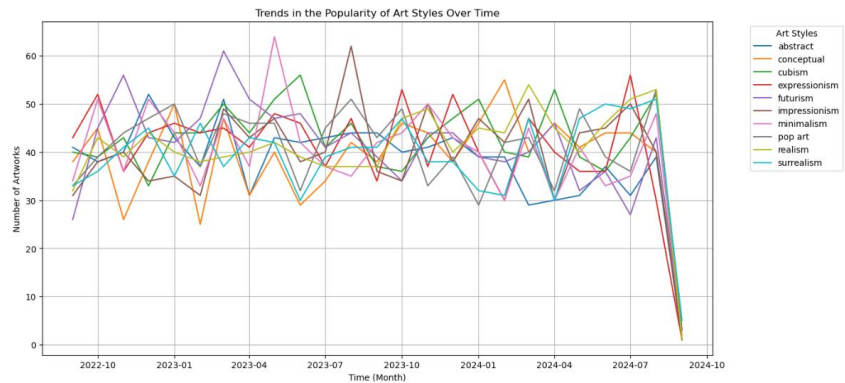
Figure 4 Trends in the Popularity of Art Styles Over Time

These plots mapped the frequency of artworks within each category over time, allowing for the identification of trends, such as the rise or decline of specific styles. The use of time-series plots was particularly valuable for spotting seasonal patterns or irregular spikes in certain art categories, which could be correlated with broader events in the NFT market or advancements in AI technology. For instance, the plots revealed periods when abstract styles surged, potentially aligning with technological developments or shifts in collector preferences. This initial visualization step provided a foundational understanding of the temporal dynamics within the dataset, setting the stage for more detailed time-series analysis later in the study. Descriptive statistics further complemented the visual analyses by providing quantitative summaries of the data. The calculation of mean, median, and mode for categories and algorithms over time offered insights into central tendencies and variability within the dataset. For example, the mean and median values helped identify the most common creation periods for certain styles, while the mode highlighted the most frequently used algorithms in generating artworks. These statistical measures were crucial for understanding not just which styles or algorithms were prevalent, but also how their usage varied across different time intervals. Additionally, examining the spread and distribution of these values helped identify outliers or anomalies that might warrant further investigation, such as unexpected peaks in the use of a specific algorithm.

Time Series Analysis

The time series analysis aimed to explore the evolution of AI-generated art styles within the NFT market, employing a structured approach to identify patterns and trends over time. The analysis was conducted in several steps, each building on the previous one to provide a comprehensive view of the temporal dynamics of AI-generated artworks. The first step involved aggregating the dataset into monthly and yearly intervals to facilitate the analysis of time trends. Aggregating the data allowed for the identification of broader patterns by smoothing out short-term fluctuations that could obscure underlying trends. The monthly aggregation provided a more granular view, capturing seasonal variations and short-term shifts in the popularity of specific art styles or algorithms. In contrast, the yearly aggregation helped to identify longer-term trends, offering insights into the overall trajectory of AI-generated art styles in the NFT market. This dual approach ensured that the analysis captured both the fine details and the broader shifts in the dataset, setting a solid foundation for the subsequent decomposition and modeling steps.

Following aggregation, the time series data were decomposed into their constituent components—trend, seasonal, and residual—using Seasonal Decomposition of Time Series (STL). This decomposition was crucial for isolating the different factors that influenced the evolution of art styles over time. The trend component captured the long-term direction of the data, indicating whether the popularity of certain styles or algorithms was increasing or decreasing over time. The seasonal component highlighted recurring patterns or cycles within the data, such as peaks in the creation of specific styles during particular months or seasons. The residual component represented the irregular, non-systematic variations, which could be attributed to external factors or random fluctuations. By separating these components, the STL decomposition provided a clearer understanding of the underlying drivers of changes in AI-generated art styles, allowing for more targeted analysis and interpretation of the results. To quantify the identified trends and make predictions about future developments, linear regression models were applied to the trend component of the decomposed time series data. Linear regression was used to fit a line through the trend data, providing a mathematical representation of the direction and rate of change over time. This approach allowed for the estimation of future values, offering insights into which styles or algorithms were likely to gain or lose popularity. The regression models provided both a visual and numerical understanding of the trends, highlighting which factors were most strongly associated with increases or decreases in specific art styles. These predictive insights were valuable for stakeholders seeking to anticipate market shifts and align their strategies accordingly. The final step involved applying moving average smoothing to the time series data to highlight long-term trends and reduce the noise inherent in the dataset. Moving averages helped to smooth out short-term fluctuations, providing a clearer view of the overall direction and patterns in the data. This technique was particularly useful for reinforcing the findings from the linear regression models, as it confirmed the presence of consistent trends while filtering out random or transient variations. The smoothed data offered a more stable representation of the evolving landscape of AI-generated art within the NFT market, enhancing the interpretability of the results and allowing for more robust conclusions about the trajectory of different styles and algorithms.

Visualization

The visualization component of the analysis played a crucial role in illustrating the evolution of AI-generated art styles within the NFT market. Various visualization tools were employed to provide a clear and intuitive representation of the data, facilitating the interpretation of complex time series patterns and correlations among different variables. The visualizations were designed to capture the dynamic changes in the popularity of art styles, the relationships between algorithm usage and style categories, and the overall composition of the art market over time.

Line graphs were used to depict the trends in the popularity of various art styles across different time periods, as shown in Figure 4. These graphs plotted the frequency of artworks within each style category against time, allowing for a straightforward visualization of how each style evolved. The line graphs highlighted key trends, such as the rise or decline of specific art styles, enabling a clear identification of which styles gained popularity and which waned over the study period. For instance, the line graphs revealed that certain styles, like

abstract and surreal, experienced significant growth during specific intervals, possibly correlating with technological advancements or shifts in collector preferences. This visual approach provided an effective way to observe temporal changes and offered insights into the cyclical or seasonal patterns that characterized the art styles within the NFT market.

Heatmaps in Figure 5 were employed to explore the correlation between algorithm usage and art style categories, providing a visual representation of the intensity and distribution of relationships across these variables. The heatmaps displayed algorithm usage on one axis and style categories on the other, with color gradients representing the frequency or strength of the association. This visualization helped to identify which algorithms were most commonly used to generate specific art styles, offering insights into the technological preferences and creative strategies within the AI-generated art community. For example, the heatmaps demonstrated that certain algorithms, like GANs, were heavily associated with particular styles such as abstract and impressionistic, suggesting a trend in the adoption of specific AI techniques for creating distinct artistic effects. The use of heatmaps thus facilitated a deeper understanding of the intersection between technology and artistic expression in the NFT space.
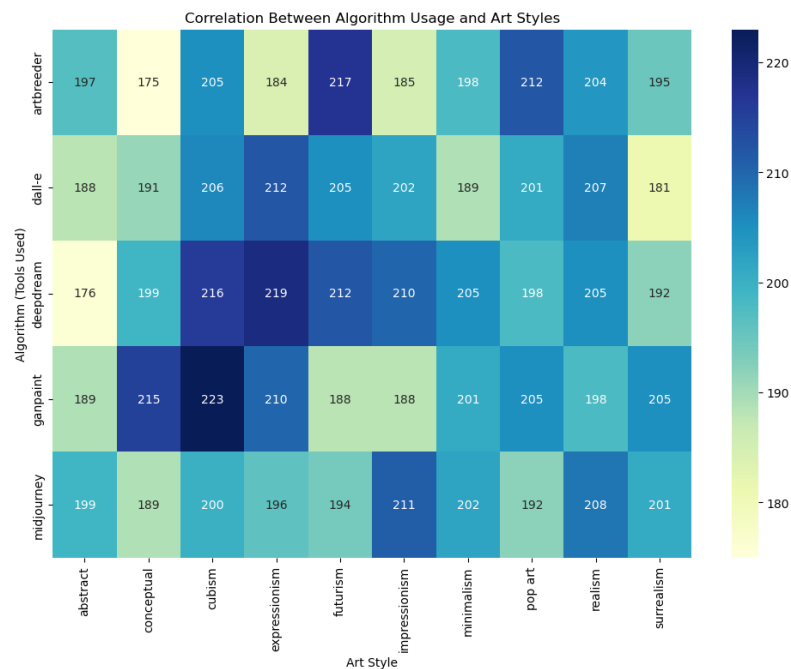

Figure 5 Correlation Between Algorithm Usage and Art Styles

To visualize the relative composition and shifts in the distribution of art styles over time, stacked area charts were used, shown in Figure 6. These charts depicted the proportion of each art style as a part of the whole market, allowing for an assessment of how the dominance of certain styles changed throughout the study period. The stacked area charts provided a cumulative view of the data, highlighting the evolving landscape of AI-generated art within the NFT market by showing how the contributions of different styles fluctuated. This visualization was particularly useful for understanding the broader market dynamics and how various styles interacted over time, revealing periods where certain styles became more prominent while others diminished. For example,

the charts illustrated a notable increase in the share of generative and algorithmic art styles, reflecting the growing influence of advanced AI technologies in shaping the NFT art market.
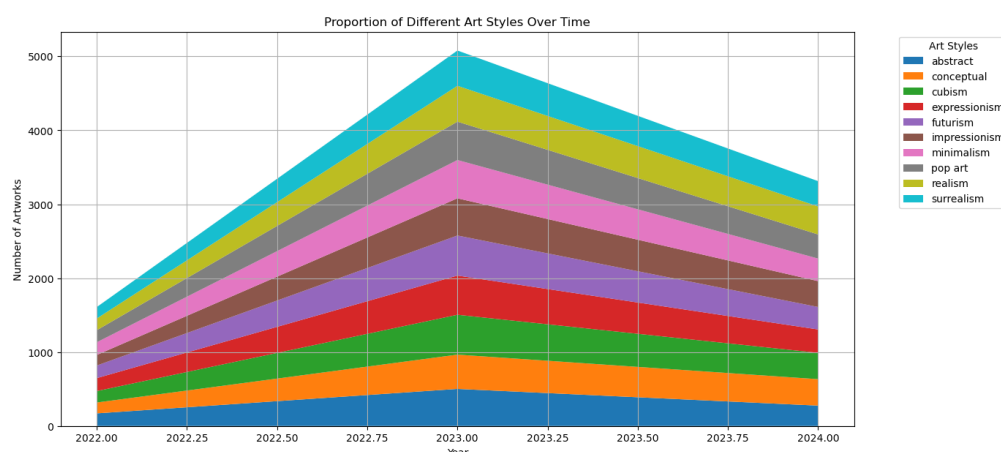
Result and Discussion

Trend Analysis Results

The trend analysis conducted on the dataset of AI-generated artworks revealed significant patterns in the evolution of art styles within the NFT market. The time series analysis identified clear trends in the popularity of various art categories over the study period, illustrating how certain styles gained prominence while others declined. Key findings included notable increases in the popularity of abstract and surreal art styles, particularly during periods corresponding with advancements in AI technologies and heightened market interest in digital art. Conversely, styles such as cubism and impressionism showed relatively stable trends with minor fluctuations, indicating a consistent but less dynamic presence in the NFT market. These observations suggested that the appeal of AI-generated art was closely tied to both technological innovation and evolving collector preferences. Line graphs were employed to visualize these trends, depicting the rise and fall of specific art categories over time. The line graphs showed a marked increase in abstract and surreal styles beginning in early 2023, coinciding with the broader adoption of advanced AI tools such as MidJourney and DeepDream. This surge was reflected in the data, where abstract art, for example, peaked in frequency during mid-2023, suggesting a growing collector interest in artworks that leveraged the latest AI algorithms. In contrast, more traditional styles like cubism maintained a steady but lower level of production, indicating that while these styles continued to have a presence in the market, they did not experience the same level of fluctuation or growth as more experimental categories. The summarized data on frequency and trend coefficients for each art style provided further insights into these trends. As shown in the tables, abstract art emerged as the most frequently occurring category, with a steady upward trend coefficient indicating increasing popularity over time. The frequency data highlighted that abstract artworks accounted for a significant proportion of the total dataset, reflecting their strong market presence. Meanwhile, the trend coefficients for cubism and other traditional styles remained relatively flat, suggesting that these styles were less influenced

by temporal changes in the NFT market. This distinction between styles with dynamic trends versus those with more stable trajectories underscored the role of technological innovation in driving the evolution of AI-generated art.

The trend analysis also revealed important correlations between the use of specific algorithms and the popularity of certain art styles. Heatmaps depicting the relationship between algorithm usage and style categories showed that algorithms like GANs were predominantly associated with abstract and surreal art, reinforcing the notion that cutting-edge AI technologies were central to the development of these styles. The findings suggested that as new AI tools emerged, they played a critical role in shaping the artistic output of creators in the NFT space, influencing not only the aesthetics of the artworks but also their market reception. The dataset contains 10,000 unique artworks, each identified by a distinct `Artwork_ID`, indicating that there are no duplicates. The `Creation_Date` spans from September 4, 2022, to September 2, 2024, with a mean date around early September 2023. This suggests that the artworks were created over a two-year period, with the median creation date being late August 2023, indicating a relatively recent concentration of data. There are 15 unique artists represented in the dataset, with "MidJourney" being the most frequent, contributing 694 artworks. This shows that certain artists, like MidJourney, are more prolific or popular within the dataset. The artworks encompass 10 distinct art styles, with "cubism" being the most common, appearing 1,050 times. This suggests a diverse representation of styles, though cubism is notably prevalent. Artworks were created using 10 different mediums, with "pencil sketch" being the most frequently used, appearing 1,048 times. This indicates a variety of artistic techniques are employed in creating the artworks. The dataset includes five distinct tools used to generate the art, with "deepdream" being the most common tool, used in 2,032 instances. This highlights the prominence of specific AI tools in the creative process of these artworks. The `Popularity_Score` ranges from 0 to 1, with a mean of approximately 0.497, suggesting a balanced distribution of popularity among the artworks. The score has a standard deviation of 0.289, indicating some variability in how popular these artworks are perceived.

Six distinct regions are represented, with "South America" being the most frequent, appearing 1,728 times. This may reflect a significant concentration of artworks associated with that region or a regional focus within the dataset. There are 10 unique art genres, with "Portrait" being the most common genre, occurring 1,049 times. This suggests a diverse range of genres, though portraits are particularly prevalent. The artworks are associated with 10 different platforms, with "Dribbble" being the most frequent, accounting for 1,086 entries. This suggests that Dribbble is a significant platform for showcasing these artworks. Each artwork has a unique `Image_URL`, ensuring that each entry is linked to a distinct image file, which is crucial for maintaining the dataset's integrity and verifying the uniqueness of each artwork.

Distribution of Art Styles displays the count of artworks for each art style. The distribution across styles is relatively uniform, with each style, including cubism, realism, expressionism, futurism, pop art, impressionism, minimalism, surrealism, conceptual, and abstract, having counts around 1,000 artworks. This suggests a balanced representation of different art styles within the dataset, without a single style overwhelmingly dominating. Distribution of Artworks by Year shows the number of artworks created over time, specifically

between 2022 and 2024. There are noticeable peaks in creation activity, particularly in early 2023, where the number of artworks significantly increased, reaching its highest point. This peak suggests a period of heightened activity in the creation of AI-generated artworks, possibly influenced by technological advancements or increased market interest during that time. There is also a smaller peak toward the end of 2022 and another rise starting in early 2024, indicating varying levels of engagement with AI-generated art over the years. Distribution of Artworks by Medium illustrates the count of artworks by the medium used. The distribution is again quite balanced, with mediums like pencil sketch, mixed media, acrylic paint, watercolor, digital, collage, charcoal, oil paint, ink, and 3D models all having counts around 1,000. This indicates a diverse use of different artistic mediums in AI-generated art within the dataset, suggesting no single medium dominates the artistic output. Trends of Art Styles Over Time (Line Graph) shows the trends in the popularity of different art styles over time. From 2022 to 2024, all art styles generally increased in popularity, reaching a peak around 2023. After this peak, a gradual decline is observed across all styles, although the rates of decline vary slightly. This pattern suggests that the AI-generated art market experienced a surge in diversity and production of art styles up to 2023, followed by a tapering off, which could indicate market saturation, changing collector interests, or shifts in AI technology usage. The relatively synchronized rise and fall across all styles imply that external factors, such as market dynamics or collective trends in AI art, influenced these patterns broadly rather than specific styles.

Analysis of Algorithm Influence

The analysis of algorithm influence on AI-generated art styles revealed significant correlations between specific AI algorithms and the popularity of certain art styles within the NFT market. The study utilized heatmaps to visualize the associations between algorithms and art styles, providing insights into how the choice of algorithm impacted the aesthetic outcomes and market reception of AI-generated artworks. These visualizations highlighted clear patterns, showing that the selection of an AI algorithm was not merely a technical choice but also a critical determinant of an artwork's style and its subsequent popularity. The heatmaps illustrated that certain algorithms were closely associated with specific art styles, suggesting that the capabilities and biases of these algorithms played a role in shaping the visual characteristics of the generated artworks. For example, GANs were predominantly linked with abstract and surreal styles, reflecting the algorithm's strength in creating highly creative and often unpredictable visual outputs. This correlation was likely due to GANs' ability to generate novel and complex images that resonate well within these art categories, attracting attention from collectors and contributing to their popularity in the NFT market.

Conversely, algorithms like Neural Style Transfer (NST) were more commonly associated with impressionism and realism, styles that benefit from NST's capacity to blend the content of one image with the stylistic elements of another, creating visually appealing yet less abstract artworks. The heatmaps also indicated that some algorithms were versatile, showing associations across multiple art styles, while others were more specialized. For instance, algorithms such as DeepDream, known for its psychedelic and highly stylized outputs, were closely correlated with conceptual and surreal art styles, reinforcing its niche but strong influence in those areas. On the other hand, more generalized

algorithms like VAEs exhibited a broader spread across various styles, albeit with less intensity in any single category. This suggests that while VAEs provided flexibility in art generation, their lack of specialization might have resulted in less pronounced impacts on specific style popularity. These findings underscored the importance of algorithm selection in the creative process of AI-generated art, influencing not only the technical execution of the artwork but also its reception and success within the NFT marketplace. The correlation between algorithms and art styles highlighted by the heatmaps suggested that artists and developers who strategically chose algorithms that align with desired art styles could enhance the appeal and marketability of their creations. Furthermore, these insights could guide collectors and investors in understanding the technological underpinnings of popular art styles, enabling more informed decisions when evaluating AI-generated artworks.

The heatmap illustrates the correlation between different AI algorithms (tools used) and various art styles, highlighting how frequently each algorithm was used in the creation of specific art styles. Artbreeder showed a relatively balanced usage across various art styles, with slightly higher associations with futurism (217) and surrealism (212). This indicates that Artbreeder was versatile but had a notable affinity for futuristic and surreal styles, possibly due to its algorithm's ability to generate imaginative and otherworldly visuals. DALL-E had its highest correlation with impressionism (212) and expressionism (210). This suggests that DALL-E's capabilities were well-suited for styles that emphasize subjective expression and distinctive brush strokes, leveraging its strength in transforming textual descriptions into creative images.

DeepDream demonstrated the strongest association with expressionism (219) and cubism (216). This reflects DeepDream's tendency to enhance and distort images in a way that complements the fragmented and abstract nature of expressionism and cubism. Its lower association with conceptual (199) and abstract (176) art styles might indicate a preference for generating more visually complex and layered artworks. GANPaint had the most significant impact on cubism (223), making it the algorithm most frequently used for this style among all algorithms analyzed. Its emphasis on generating and altering image segments aligns well with the geometric and structured nature of cubism. Additionally, GANPaint showed a strong correlation with conceptual (215) and expressionism (210), suggesting its adaptability in creating diverse artistic outputs. MidJourney exhibited a relatively balanced influence across the art styles, with its strongest associations being with impressionism (211) and futurism (211). This balance suggests that MidJourney is a versatile tool that can be applied across various styles, but with a slight edge in generating impressionistic and futuristic artworks. These patterns suggest that the choice of AI algorithm significantly influences the artistic output, with each algorithm contributing uniquely to the creation of art styles within the NFT market. Artists and creators may choose algorithms based on their desired stylistic outcomes, aligning algorithmic strengths with the aesthetic characteristics they aim to achieve. This analysis underscores the importance of understanding the relationship between AI tools and artistic styles in shaping the evolving landscape of AI-generated art.

The stacked area chart provided illustrates the proportion of different art styles over time, showing how the representation of each style evolved from early 2022 to early 2024. The total number of artworks increased steadily from early

2022, peaked around early 2023, and then declined gradually towards 2024. This trend suggests that the creation and popularity of AI-generated artworks saw significant growth throughout 2022, reaching a maximum in early 2023, likely due to increased market interest or advancements in AI tools. The subsequent decline may indicate market saturation, shifting trends, or changes in production rates. Surrealism (Light Blue) consistently maintained the largest share of the art styles throughout the entire period, reflecting its dominant popularity in the AI-generated art market. Its proportion grew along with the overall increase and remained the top style even as the total number of artworks declined. Realism (Yellow) and Pop Art (Gray) also held significant shares, with realism slightly increasing its proportion over time, indicating growing interest or suitability of AI tools for this style. Futurism (Pink) and Impressionism (Brown) maintained moderate proportions, with consistent contributions over the analyzed period, suggesting steady but not dominant interest levels in these styles. Abstract (Dark Blue) and Conceptual (Orange) art styles, while present, remained among the smaller proportions, indicating more niche or specialized use in AI-generated art. Cubism (Green), Expressionism (Red), and Minimalism (Purple) maintained relatively smaller but consistent proportions, highlighting their roles as specialized styles with steady niche appeal. The stacked chart shows that while all styles experienced growth in absolute terms as the total number of artworks increased to its peak in early 2023, their relative proportions remained largely stable. This suggests that the rise in popularity and production affected all styles somewhat equally, rather than disproportionately favoring specific styles. After the peak, the decline was again uniform across styles, with no single style experiencing a dramatic drop relative to others. This uniform decline may reflect a broader trend impacting the entire AI-generated art market rather than shifts in preferences among specific styles.

The chart demonstrates a balanced engagement with a wide range of art styles in the AI-generated art market over the study period. Surrealism's consistent dominance suggests it resonated particularly well with AI art collectors and creators, possibly due to the style's compatibility with the capabilities of generative AI. Realism's increasing share suggests growing AI proficiency in more traditional and detail-oriented styles, which could attract a broader audience over time. The overall trend indicates that while the NFT market for AI-generated art saw rapid expansion in 2022, it reached a peak by early 2023, after which the creation of artworks began to taper off. This pattern could be reflective of broader market dynamics, including potential market corrections, shifts in collector interest, or changes in AI art production practices. The relatively stable proportions among styles suggest that these market shifts affected all styles similarly, pointing to external factors rather than changes in stylistic preference as the driving force behind the observed trends.

Interpretation of Findings

The analysis of AI-generated art styles within the NFT market revealed significant periods of change that corresponded with external factors and advancements in AI technology. The most notable period of growth occurred between early 2022 and early 2023, where there was a marked increase in the production and popularity of AI-generated artworks. This surge coincided with several key developments in the broader NFT market, including a heightened interest in digital assets, increased media coverage of high-profile NFT sales, and the proliferation of new AI tools that made art creation more accessible to

a wider audience. The rapid adoption of these tools allowed for greater experimentation and diversity in art styles, contributing to the peak observed in early 2023. The decline observed after early 2023 suggested that the market may have reached a saturation point, where the initial novelty of AI-generated art began to wane, or external economic factors such as fluctuations in cryptocurrency values and broader market corrections influenced collector behavior. This downturn could also reflect a natural market adjustment following the explosive growth phase, as well as potential fatigue among collectors faced with an oversupply of digital artworks. Additionally, the relatively synchronized rise and fall of all art styles imply that these trends were driven more by macroeconomic and market-wide factors rather than shifts in preference for specific styles.

The influence of advancements in AI technology on the trends observed was evident throughout the study period. Significant improvements in AI algorithms, such as the introduction of more sophisticated Generative Adversarial Networks (GANs) and the refinement of tools like DALL-E and MidJourney, played a crucial role in shaping the visual aesthetics and capabilities of AI-generated art. These advancements enabled the creation of more complex, visually appealing, and diverse artworks, which likely contributed to the increased production rates and heightened popularity observed in the peak period. The capabilities of these AI tools to generate high-quality, varied outputs aligned well with the market's demand for innovative and unique digital art pieces. Furthermore, the ability of newer AI algorithms to better mimic traditional artistic techniques, while also exploring entirely new visual forms, expanded the creative possibilities for artists working within the NFT space. This technological progression allowed for the blending of styles and the creation of hybrid artworks that might not have been possible with earlier AI tools, thus attracting a broader audience. The consistent demand for surrealism and realism, as seen in the proportion of different art styles over time, also highlighted the impact of these AI advancements, as these styles particularly benefited from the improved capabilities of contemporary AI tools to generate lifelike and imaginative visuals.

Comparison with Previous Studies

The findings from this study aligned with existing literature on the broad influence of AI on art generation but also highlighted unique insights specific to the NFT space that were not thoroughly addressed in prior research. Previous studies consistently emphasized the transformative impact of AI technologies like GANs and NST on the diversification of art styles [21], [40]. However, this research demonstrated that while these technologies indeed expanded the creative possibilities for AI-generated art, the tokenization of these artworks as NFTs introduced additional dynamics that shaped market trends and collector behavior. One of the key alignments with previous studies was the observed correlation between specific AI algorithms and art styles. Prior literature established that GANs and other advanced AI models were instrumental in producing a range of artistic outputs, from highly realistic renderings to abstract and experimental forms [41], [42]. This study confirmed these observations, showing strong associations between particular algorithms and art styles, such as the prominence of GANs in creating cubist and expressionist artworks. However, our research went further by contextualizing these findings within the NFT market, revealing that the choice of algorithm not only influenced artistic output but also impacted the perceived value and popularity of these artworks

in a market driven by digital ownership and scarcity.

In contrast to the broad discussions in existing literature, which often focused on the technical and creative potentials of AI in art, this study highlighted specific gaps related to the convergence of AI-generated art and NFTs. For instance, while earlier works discussed the democratizing effects of AI on art creation, this study found that NFTs further amplified these effects by allowing artists to directly engage with global markets without traditional intermediaries [43], [44]. This direct-to-collector model, facilitated by NFTs, not only provided new revenue streams for artists through secondary sales and royalties but also introduced complexities regarding attribution and ownership that were less prevalent in AI art outside of the NFT context [38]. Moreover, this study diverged from prior research by emphasizing the impact of external market factors on the trends observed in AI-generated NFTs. While previous literature often concentrated on the internal dynamics of AI art creation, such as the evolving capabilities of algorithms and their artistic outputs, our findings pointed to significant influences from the broader economic environment, including fluctuations in cryptocurrency values and shifts in market sentiment [45], [46]. These external factors contributed to the observed rise and fall in the production and popularity of AI-generated NFTs, highlighting that market dynamics played a crucial role alongside technological advancements. Additionally, the study addressed the ethical and environmental implications of AI-generated art as NFTs, an area that previous research touched upon but did not fully explore. Existing literature acknowledged the ethical challenges of AI art, such as data biases and questions of authorship [13], [18]. However, this study found that these concerns were exacerbated within the NFT market, where the environmental costs of blockchain transactions and the commodification of digital art raised further ethical considerations. The findings underscored the need for ongoing dialogue and the development of guidelines to navigate these complex issues as AI and NFTs continue to intersect.

Conclusion

This study analyzed the evolution of AI-generated art styles within the NFT market using time series analysis, uncovering several significant trends. The analysis revealed a rapid growth phase in the production and popularity of AI-generated artworks from early 2022 to early 2023, followed by a decline towards early 2024. This pattern suggested that the market initially experienced heightened interest and expansion, likely driven by technological advancements and the growing popularity of NFTs. Surrealism emerged as the most popular art style, consistently maintaining the largest share throughout the study period, while styles like abstract and conceptual art remained less prevalent. The uniform rise and fall in the representation of various styles indicated that broader market dynamics influenced these trends rather than shifts in preference for specific styles. Additionally, the study identified strong correlations between certain AI algorithms and specific art styles, highlighting how the choice of algorithm impacted both the creation and market reception of artworks. For instance, GAN-based tools were heavily associated with styles like cubism and expressionism, which benefited from the algorithm's ability to generate complex and diverse outputs. In contrast, simpler algorithms or those designed for more specific purposes were linked with narrower or less popular styles. These findings underscored the importance of technological capabilities in shaping the landscape of AI-generated art within the NFT ecosystem.

The observed trends have practical implications for various stakeholders, including artists, collectors, and NFT platforms. For artists, understanding the evolving popularity of different art styles can inform creative decisions, allowing them to align their work with market demands or to strategically differentiate themselves in a crowded space. The findings also highlight the value of selecting the appropriate AI tools to enhance artistic expression and marketability, suggesting that artists who stay abreast of technological advancements may have a competitive edge. For collectors, insights into the trends and associations between algorithms and art styles can aid in making more informed investment decisions. Recognizing which styles are gaining traction and which algorithms are driving these trends could help collectors identify artworks with the potential for appreciation. NFT platforms, on the other hand, can leverage these findings to optimize their curation strategies and enhance user engagement. By featuring trending styles and promoting artworks that align with market preferences, platforms can better meet the needs of their audience and support artists in reaching potential buyers. Moreover, the study suggests that AI-generated art has the potential to influence the broader art market, not only by expanding the range of available art styles but also by challenging traditional notions of creativity and authorship.

While this study provided valuable insights into the evolution of AI-generated art within the NFT market, it also faced several limitations. The data scope was restricted to AI-generated artworks on NFT platforms, which may not capture the full breadth of AI art activity, particularly in non-NFT contexts or traditional digital art platforms. Additionally, the reliance on existing data limited the analysis to observable trends without considering underlying factors such as marketing efforts, artist influence, or external economic conditions that could have impacted the observed patterns. Future research could address these limitations by incorporating a broader range of data sources, including market data on sales volumes and prices, to provide a more comprehensive view of the factors driving trends in AI-generated art. Expanding the analysis to include other forms of digital art beyond NFTs, such as those hosted on traditional digital art platforms or in virtual galleries, could offer a more holistic understanding of how AI is shaping the art world. Furthermore, qualitative research exploring artist and collector perspectives could add depth to the quantitative findings, providing insights into motivations, preferences, and the perceived value of AI-generated art in the NFT space.

Declarations

Author Contributions

Conceptualization: S.S.M., Q.Y., and A.S.S.; Methodology: Q.Y.; Software: S.S.M.; Validation: S.S.M., Q.Y., and A.S.S.; Formal Analysis: S.S.M., Q.Y., and A.S.S.; Investigation: S.S.M.; Resources: Q.Y.; Data Curation: Q.Y.; Writing—Original Draft Preparation: S.S.M., Q.Y., and A.S.S.; Writing—Review and Editing: Q.Y., S.S.M., and A.S.S.; Visualization: S.S.M. All authors have read and agreed to the published version of the manuscript.

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The data presented in this study are available on request from the corresponding author.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] S. A. Apostu, M. Panait, Л. Baca, C. Mihăescu, and Z. Dobrowolski, "NFTs and Cryptocurrencies—The Metamorphosis of the Economy Under the Sign of Blockchain: A Time Series Approach," *Mathematics*, vol. 10, no. 17, p. 3218, 2022, doi: 10.3390/math10173218.

[2] G. Colavizza, "Seller-Buyer Networks in NFT Art Are Driven by Preferential Ties," *Front. Blockchain*, vol. 5, 2023, doi: 10.3389/fbloc.2022.1073499.

[3] T. Maurya, "Blockchain-Based Decentralized NFT Marketplace for New Fine Art," *Int. J. Innov. Res. Eng. Manag.*, vol. 11, no. 3, pp. 5–10, 2024, doi: 10.55524/ijirem.2024.11.3.2.

[4] M. Nadini, L. Alessandretti, F. D. Giacinto, M. Martino, L. M. Aiello, and A. Baronchelli, "Mapping the NFT Revolution: Market Trends, Trade Networks, and Visual Features," *Sci. Rep.*, vol. 11, no. 1, 2021, doi: 10.1038/s41598-021-00053-8.

[5] F. Valeonti, A. Bikakis, M. Terras, C. Speed, A. Hudson-Smith, and K. Chalkias, "Crypto Collectibles, Museum Funding and OpenGLAM: Challenges, Opportunities and the Potential of Non-Fungible Tokens (NFTs)," *Appl. Sci.*, vol. 11, no. 21, p. 9931, 2021, doi: 10.3390/app11219931.

[6] Q. Li, "DareChain: A Blockchain-Based Trusted Collaborative Network Infrastructure for Metaverse," *Int. J. Crowd Sci.*, vol. 7, no. 4, pp. 168–179, 2023, doi: 10.26599/ijcs.2023.9100025.

[7] X. Fan, "The Research on the Characteristics of AI Application in Art Field and Its Value," pp. 146–160, 2023, doi: 10.2991/978-2-38476-094-7_18.

[8] R. Srinivasan, "Biases in Generative Art -- A Causal Look From the Lens of Art History," 2020, doi: 10.48550/arxiv.2010.13266.

[9] J. Chi, "The Evolutionary Impact of Artificial Intelligence on Contemporary Artistic Practices," *Commun. Humanit. Res.*, vol. 35, no. 1, pp. 52–57, 2024, doi: 10.54254/2753-7064/35/20240006.

[10] L. Bellaiche *et al.*, "Humans vs. AI: Whether and Why We Prefer Human-Created Compared to AI-created Artwork," 2023, doi: 10.31234/osf.io/f9upm.

[11] E. Duester, "Digital Art Work and AI: A New Paradigm for Work in the Contemporary Art Sector in China," *Eur. J. Cult. Manag. Policy*, vol. 14, 2024, doi: 10.3389/ejcmp.2024.12470.

[12] A. Chatterjee, "Art in an Age of Artificial Intelligence," *Front. Psychol.*, vol. 13, 2022, doi: 10.3389/fpsyg.2022.1024449.

[13] I. M. M. Yusa, Y. Yu, and T. Sovhyra, "Reflections on the Use of Artificial Intelligence in Works of Art," *Jadam*, vol. 2, no. 2, pp. 152–167, 2022, doi: 10.58982/jadam.v2i2.334.

[14] H. Gangadharbatla, "The Role of AI Attribution Knowledge in the Evaluation of Artwork," *Empir. Stud. Arts*, vol. 40, no. 2, pp. 125–142, 2021, doi: 10.1177/0276237421994697.

[15] R. Chamberlain, C. Mullin, B. Scheerlinck, and J. Wagemans, "Putting the Art in Artificial: Aesthetic Responses to Computer-Generated Art.," *Psychol. Aesthet. Creat. Arts*, vol. 12, no. 2, pp. 177–192, 2018, doi: 10.1037/aca0000136.

[16] Y. Zhou, "Inventory Control Strategy: Based on Demand Forecast Error," *Mod. Supply Chain Res. Appl.*, vol. 5, no. 2, pp. 74–101, 2023, doi: 10.1108/mscra-02-2023-0009.

[17] A. Duarte, "Slow Collecting: Sustainability and the Need for a Paradigm Shift by Iberian Collectors," *Sustainability*, vol. 15, no. 21, p. 15401, 2023, doi: 10.3390/su152115401.

[18] Z. Chen, "The Study of Negative Pragmatic Transfer and Its Pedagogic Implications," 2023, doi: 10.2991/978-2-494069-97-8_141.

[19] J. H. Hutson and M. Lang, "Content Creation or Interpolation: AI Generative Digital Art in the Classroom," *Metaverse*, vol. 4, no. 1, p. 13, 2023, doi: 10.54517/m.v4i1.2158.

[20] S. Grassini, "Computational Power and Subjective Quality of AI-generated Outputs: The Case of Aesthetic Judgement and Positive Emotions in AI-generated Art," 2024, doi: 10.31234/osf.io/f4wpe.

[21] S. Guan and M. H. Loew, "A Novel Measure to Evaluate Generative Adversarial Networks Based on Direct Analysis of Generated Images," *Neural Comput. Appl.*, vol. 33, no. 20, pp. 13921–13936, 2021, doi: 10.1007/s00521-021-06031-5.

[22] Y. Lyu, C.-L. Lin, P.-H. Lin, and R. Lin, "The Cognition of Audience to Artistic Style Transfer," *Appl. Sci.*, vol. 11, no. 7, p. 3290, 2021, doi: 10.3390/app11073290.

[23] Y. Ran, "GAN and Art: Facilitation of Artistic Production and Expression Based on Artificial Intelligence," *Appl. Comput. Eng.*, vol. 16, no. 1, pp. 185–190, 2023, doi: 10.54254/2755-2721/16/20230887.

[24] J. v. Hees, "Human Perception of Art in the Age of Artificial Intelligence," 2023, doi: 10.31234/osf.io/kvsu3.

[25] K.-Q. Zhou and H. Nabus, "The Ethical Implications of DALL-E: Opportunities and Challenges," pp. 17–23, 2023, doi: 10.58496/mjcsc/2023/003.

[26] M. Mazzone and A. Elgammal, "Art, Creativity, and the Potential of Artificial Intelligence," *Arts*, vol. 8, no. 1, p. 26, 2019, doi: 10.3390/arts8010026.

[27] F. Kong, "Application of Artificial Intelligence in Modern Art Teaching," *Int. J. Emerg. Technol. Learn. Ijet*, vol. 15, no. 13, p. 238, 2020, doi: 10.3991/ijet.v15i13.15351.

[28] F. Fang, "The Analysis of Artificial Intelligence Digital Technology in Art Education Under the Internet of Things," *Ieee Access*, vol. 12, pp. 22928–22937, 2024, doi: 10.1109/access.2024.3363655.

[29] K. Vasan, M. Janosov, and A. Barabási, "Quantifying NFT-driven Networks in Crypto Art," *Sci. Rep.*, vol. 12, no. 1, 2022, doi: 10.1038/s41598-022-05146-6.

[30] S. d. O. Ribeiro, "Classificação De Coleções De NFTs Explorando Metadados E Aprendizagem De Máquina," 2024, doi: 10.5753/cblockchain.2024.3172.

[31] J. Bansal, "Role of NFTs in Marketing Strategies and Customer Relations," pp. 182–188, 2024, doi: 10.4018/979-8-3693-1392-3.ch014.

[32] C. Bourron, "Comprehensive Analysis of the Trade of NFTs at Major Auction Houses: From Hype to Reality," *Arts*, vol. 12, no. 5, p. 212, 2023, doi: 10.3390/arts12050212.

[33] C. Pinto-Gutierrez, S. Gaitán, D. Jaramillo, and S. Velasquez, "The NFT Hype: What Draws Attention to Non-Fungible Tokens?," *Mathematics*, vol. 10, no. 3, p. 335, 2022, doi: 10.3390/math10030335.

[34] A. Kapoor, D. Guhathakurta, M. Mathur, R. Yadav, M. Gupta, and P. Kumaraguru, "TweetBoost: Influence of Social Media on NFT Valuation," 2022, doi: 10.48550/arxiv.2201.08373.

[35] H. Schnoering and H. Inzirillo, "Constructing a NFT Price Index and Applications," 2022, doi: 10.48550/arxiv.2202.08966.

[36] S. Basu, K. Basu, and T. H. Austin, "Crowdfunding Non-Fungible Tokens On the Blockchain," pp. 109–125, 2022, doi: 10.1007/978-3-030-96057-5_8.

[37] Y. Zhou, "Eyes Can Tell: Assessment of Implicit Attitudes Toward AI Art," *-Percept.*, vol. 14, no. 5, 2023, doi: 10.1177/20416695231209846.

[38] Z. Epstein, S. Levine, D. G. Rand, and I. Rahwan, "Who Gets Credit for AI-Generated Art?," *Iscience*, vol. 23, no. 9, p. 101515, 2020, doi: 10.1016/j.isci.2020.101515.

[39] Y. Chen, "Pandoras Pixel Box: The Rise of AI Art and the Ethical Dilemma of Creativity," *Lect. Notes Educ. Psychol. Public Media*, vol. 28, no. 1, pp. 135–143, 2023, doi: 10.54254/2753-7048/28/20231315.

[40] L. A. Gatys, A. Ecker, and M. Bethge, "A Neural Algorithm of Artistic Style," *J. Vis.*, vol. 16, no. 12, p. 326, 2016, doi: 10.1167/16.12.326.

[41] M. Ragot, N. Martin, and S. Cojean, "AI-generated vs. Human Artworks. A Perception Bias Towards Artificial Intelligence?," 2020, doi: 10.1145/3334480.3382892.

[42] Z.-L. Duan, "Who Made the Oil Paintings: Machine or Human?," 2023, doi: 10.21203/rs.3.rs-3315447/v1.

[43] Z. Ekinci, "Non-Fungible Tokens and Select Art Law Considerations," *Arts*, vol. 12, no. 5, p. 192, 2023, doi: 10.3390/arts12050192.

[44] M. R. Mazieri, I. C. Scafuto, and P. R. d. Costa, "Tokenization, Blockchain and Web 3.0 Technologies as Research Objects in Innovation Management," *Int. J. Innov.*, vol. 10, no. 1, pp. 1–5, 2022, doi: 10.5585/iji.v10i1.21768.

[45] L. Ante, "The Non-Fungible Token (NFT) Market and Its Relationship With Bitcoin and Ethereum," *Fintech*, vol. 1, no. 3, pp. 216–224, 2022, doi: 10.3390/fintech1030017.

[46] M. Dowling, "Is Non-Fungible Token Pricing Driven by Cryptocurrencies?," *SSRN Electron. J.*, 2021, doi: 10.2139/ssrn.3815093.