Universiteit Leiden
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Data Science & Artificial Intelligence

Bridging the Gap Between the Traditional and the Digital:
Assessing the Authenticity of AI-Generated and Digital Art

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Abstract

This study investigates how the four principal methods of traditional art authentication can be applied to digital and AI-generated artworks. The four methods are provenance research, visual analysis, modus operandi research, and technical analysis. To our knowledge, this has not been done before. Through a series of comparative case studies involving digitally created and AI-generated artworks, each authentication method is applied and evaluated in terms of its applicability, usefulness, and limitations. The results demonstrate that all four methods remain applicable, but their implementation and interpretation require adaptation to account for the absence of physical uniqueness and the changing nature of authorship. There is no significant difference regarding the authenticity assessment of digitally painted and AI-generated art. Provenance research proved particularly valuable, while visual and modus operandi analyses provided important contextual information regarding authorship and production. The visual analysis is very similar to the traditional method, but did not strongly contribute to assessing authenticity. The technical analysis has the ability to be very insightful, but often tends to be limited in its results.

Contents

1 Introduction

1.1 Research Problem and Objective

In 1938 the painting *Supper at Emmaus* (fig. 1), believed to have been painted by Johannes Vermeer in the seventeenth century, sold for 520.000 Dutch guilders. However, this painting turned out to have been painted only a year earlier by the art forger Hans van Meegeren [Bla07].

Figure 1: Han van Meegeren, The Supper at Emmaus, 1936-37, oil on canvas. Rotterdam, Museum Boijmans Van Beuningen

The requirement for proper authentication for artworks has both monetary and societal significance. But today not all artworks are painted in a traditional manner. Artworks can be digitally painted, or even AI-generated. Different artforms are increasingly merging. AI-generated art is becoming more prevalent on the internet and markets, and digital art is increasingly recognized as a legitimate art form. Regarding authenticity, these different types of art tend to be segregated in terms of how they are treated and how authentication processes are conducted.

Today, in the art market and museums, digital art, as well as AI-generated art, is increasingly displayed alongside traditional paintings. In 2018, the auction house Christie's sold the AI-generated portrait *Edmond de Belamy* for 432,500 USD (fig. 2) [Chr18]. But there is still much doubt about the authenticity of AI-generated art and ongoing debate surrounding it [Zyl20]. To establish value, authenticity is important. People want to know that what they buy or what they are looking at is consistent with what they believe about the artwork. This includes who made it, how it was made, where it has been, and what materials were used. Sometimes, especially on a screen, these different methods are indistinguishable. Artistic methods are merging, but authentication methods and motivations remain separate.

Traditional art authentication relies on four main principles: provenance, modus operandi, technical analysis, and visual analysis [Dut03] [LMP22]. However, the interpretation of these concepts changes when the mode of creation changes. Digital art has a different notion of uniqueness

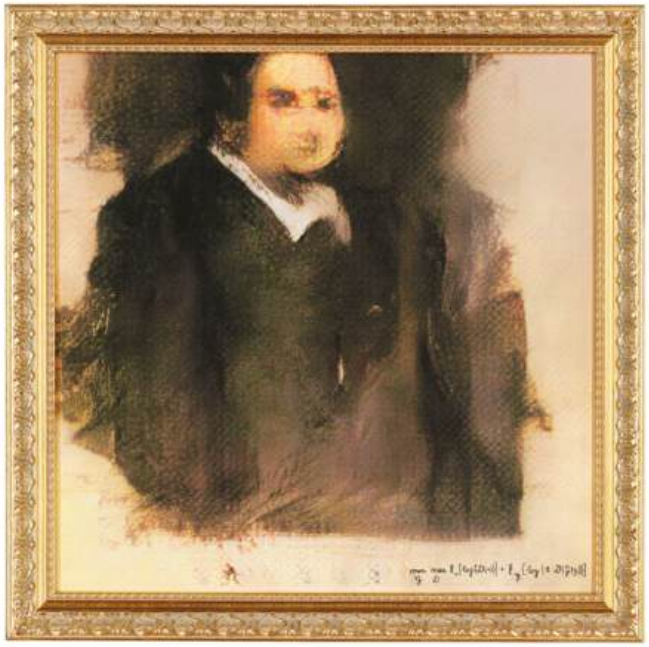

Figure 2: Portrait of Edmond Belamy, 2018, created by GAN [Chr18]

because of its reproducibility, and the technical data is digital. With AI-generated art questions of authorship, creation, and ownership come into question. To fully understand the differences and similarities in authenticity across these forms of art, all methods must be treated within the same analytical framework.

This study attempts to bridge the theoretical and practical gap between traditional, digital, and AI-generated art authentication. This is done by assessing traditional methods with digital and AI-generated works to investigate whether such methods are even applicable to these forms of modern art.

1.2 Research Question

This thesis investigates how the four main principal methods of traditional art authentication can be applied to AI-generated and digital art. These methods include technical analysis, visual analysis, provenance research, and modus operandi research. To our knowledge, limited research has examined whether these principles can be applied comparatively to traditional, digital, and AI-generated artworks for authentication purposes.

Part of this investigation involves comparing the meaning of authenticity, the practical effectiveness of traditional authentication methods when applied to digital and AI-generated art, and identifying additional authentication approaches that may be relevant to these artistic forms.
This study aims to answer the following research question:
How can the traditional methods of assessing authenticity (provenance, modus operandi, technical analysis, and visual analysis) be applied to digital and AI-generated art?

1.3 Thesis Overview

This section, section 1, contains the introduction. Section 2 contains the background. Here, authenticity, AI-generated art, digital art, and authentication methods get discussed. Section 3 contains the methodology. This inludes the provenance, visual analysis, modus operandi, and technical analysis. Section 4 describes the results regarding the case studies. Section 5 is the discussion. Section 6 concludes.

2 Background

2.1 The Meaning of Authenticity in Art

2.1.1 What is Authenticity?

The meaning of authenticity, and the reason it holds value, is part of a broader philosophical debate. In the context of art, authenticity is not solely a property of a physical object, but is strongly dependent on the context in which the work is produced, attributed, and interpreted. Acclaimed traditional artworks such as paintings and drawings often carry attributes such as authorship, intention, provenance, and a sense of uniqueness [Bia25].

Authenticity can therefore be understood as more than a fixed label. It can be considered a social, cultural, and sometimes even political construct. In this sense, authenticity is often non-stationary. The classification of an artwork as authentic may change over time as new information emerges or as interpretations evolve. Lowenthal (1992) argues that many objects displayed in museums were not originally created for such contexts and therefore acquire a different form of authenticity once institutionalized [Low92]. Walter Benjamin similarly argues that the uniqueness of an artwork contributes to its 'aura', which is diminished through mechanical reproduction [Ben69]. However, this notion becomes more complex in cases where artworks are reproducible or where authorship and origin are uncertain. In practice, authenticity is rarely treated as a binary property. Especially in historical works, provenance records may be incomplete, inconsistent, or partially forged. In addition, restoration practices introduce further complexity, as conservation efforts may alter the original material state of an artwork in order to preserve it. This raises the question of whether authenticity refers to the original state of a work or to its preserved form over time.

A further question arises in the context of contemporary and computational art. Does art need to be human-made in order to be considered authentic? This question becomes particularly relevant for generative systems and AI-based image production, where authorship may be distributed between human input, algorithmic processes, and training data.

The meaning of authorship can also be questioned in traditional art. For example, in modern artistic practices such as those of Andy Warhol. His studio, known as The Factory (see fig. 3), employed assistants and industrial production methods challenged conventional notions of artistic authorship and labor. Warhol's Factory employees participated in the physical production of artworks, including the preparation and printing of silkscreen paintings. Nevertheless, these works continued to be considered authentic Warhols because the authorship was attributed to his conceptual direction and artistic vision rather than to the manual execution of every component of the work [Jon91]. As Danto (1997) argues, the status and authenticity of an artwork depend not solely on its physical creation but also on its conceptual meaning and recognition within the art

Figure 3: Ugo Mulas, Andy Warhol, Gerard Malanga and Philip Fagan at the Factory, New York, 1964 [Mul64]

world [Dan97].

In the case of AI-generated artworks, authenticity is often treated differently. Such works do not possess a traditional notion of physical uniqueness or human craftsmanship and therefore challenge established criteria used in art evaluation. Authenticity of AI-generated art is frequently questioned in terms of its origin, authorship, and the role of human intent in its creation [Her18].

Authenticity being an applicable concept for AI-generated art can be questioned due to the art being machine-made. The art is deemed generic and repetitive [MGH19]. From this perspective, AI-generated art is sometimes perceived as lacking originality in the traditional sense of artistic production. On the other hand, it can be argued that the generative process itself is central to the authenticity of AI-generated artworks. Rather than being solely machine produced, these works emerge from a distributed network of human and computational contributions. These include the developers of the model, the organization deploying it, the user writing prompts, and the creators of the data used for training the model. In this sense, authorship and artistic responsibility are fragmented across multiple actors, which complicates traditional notions of a single identifiable creator. Digital art occupies an intermediate position. While it is also infinitely reproducible in principle, it typically retains a clearly identifiable human creator and production process. This distinguishes it from AI-generated outputs, where authorship may be partially or fully delegated to an automated system.

In this thesis, if the authenticity of AI-generated and digital artworks is to be assessed using the same framework as traditional art, then the definition and operationalization of authenticity must also be consistent across all three domains. For the purpose of this study, authenticity will be defined as the extent to which verifiable information is available regarding the origin, authorship, and production history of an artwork.

2.1.2 Why is Authenticity Important?

A psychological study by Newman and Bloom [NB11] investigated why original artworks are valued so dramatically more highly than perfect duplicates. Their work identifies two principal factors termed performance and contagion. Performance refers to the assessment of the artwork as a unique creative act. An original embodies the traces of the artist's hand. This direct connection to the creative process gives the original a quality that no perfect duplicate, no matter how technically identical, can replicate. Contagion refers to the degree of physical contact with the original artist. A psychological value gets attached to objects that have been in physical contact with significant people or events. By this logic, an artwork that has been touched by the artist's own hand carries an intangible but deeply felt connection to that person. A copy produced later, even if created with the artist's explicit permission or guidance, would lack this direct contact with the original creative moment.

Beyond psychology, authenticity is important for art history and cultural criticism [Cho21]. When art historians study an artist's oeuvre, they rely on authenticated works as the foundation for understanding stylistic development, technical evolution, and artistic intention. A single authenticated work can illuminate understanding of dozens of others. Conversely, the presence of skillful forgeries in the historical record creates fundamental problems for interpretation. For example, in the twentieth century, dealer Otto Wacker managed to sell over thirty fake Van Gogh paintings to collectors and institutions [Fei89]. Many were even included in catalogue raisonnés before being exposed as forgeries. These falsely authenticated works corrupted understanding for years.

Furthermore, authenticity has monetary value. The art market operates on the principle that authentic works are fundamentally different in value from even perfectly indistinguishable copies or works by lesser known artists. The value of an artwork is seldom dependent on the visual properties of the work but rather its authenticity and attribution. An authentic work by a canonical artist occupies a unique position in the historical record and cannot be replicated. Its scarcity, combined with the verified connection to the artist, creates genuine economic value independent of aesthetic properties. In the early 2000s, the contemporary art market has grown exponentially, with a 1370% turnover growth rate [Ehr16]. High prices can both attract forgers and cause authentication failures to carry enormous financial consequences [Ade25]. To prevent this, auction houses verify authenticity. The cost of authentication services is substantial, but the alternative exposes the market to integrity risks. Furthermore, collectors may demand discounts on works lacking clear provenance or with contested attributions. Dealers must invest in authentication services before bringing works to market. Insurance becomes more expensive or unavailable for works with authentication concerns.

Authenticity is important for cultural preservation as well. When a museum discovers that a work in its collection is a forgery, the institution faces the decision to deaccession the work, to acknowledge it as a fake, or even to hide the discovery. Each choice carries implications regarding education, public trust, and preservation. Artist reputations are also at stake. When an artist's work is forged extensively, the market becomes flooded with unauthorized copies that dilute the artist's authentic output and distort market understanding of their oeuvre. This affects not only the artist's legacy and reputation but also the economic interests of heirs and collectors.

2.2 AI-Generated art

2.2.1 How AI generates Art

Diffusion models have become the leading architecture for text-to-image generation with models such as DALL-E 3 [Dha21] and Stable Diffusion [RBL+22]. Generation begins with random noise, and the model applies a learned reverse process conditioned on text prompts to create new images. This can be described as two main stages. A forward diffusion process and a reverse denoising process [Sid24]. In the forward process, a fixed Markov chain gradually adds Gaussian noise to training images according to a predefined schedule until the data becomes noise. The reverse process reconstructs images from progressively denoised states as it iteratively predicts and removes this noise. Unlike generative adversarial networks (GANs), which rely on competition between a generator and discriminator, diffusion models are trained with a more stable denoising objective and typically exhibit improved training stability and strong sample quality [Sca24].

Recent advances such as Latent Diffusion Models (LDMs) improve efficiency by performing the diffusion process in a learned latent space produced by an autoencoder rather than directly in pixel space. This enables faster generation while maintaining visual quality [WA25].

2.2.2 AI-Art Detection

Currently, AI authentication methods are used primarily to determine if a work is AI-generated and which model is used. Although AI-detection assesses a part of the authenticity, it does not provide the full picture. Alternative authenticity factors for AI-generated art are often not considered. This is because more information is in most cases simply not required. In this thesis, all aspects for all art forms are considered for the sake of uniformity.

Commercial AI detection systems typically analyze the pixel content of images using machine learning models trained on millions of real versus AI-generated images. The models do not rely solely on EXIF metadata, which may be removed during image editing, compression, or sharing. These systems examine image characteristics including textures, lighting consistency, noise patterns, compression artifacts, and other statistical features present in the pixel data. Detection performance depends on factors such as the image generation model, image quality, and compression level. No current detector achieves perfect reliability [ZCY+23].

A complementary approach focuses on frequency domain analysis. Prior research has shown that some generative models, particularly GAN-based architectures, can introduce detectable artifacts in frequency space that differ from those found in natural images [FES+20].

These artifacts arise because upsampling operations in generative model decoders distort high frequency information. Frequency based detection methods employ techniques such as Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT), and spectral analysis to identify these irregularities. Recent detection methods increasingly combine spatial image features with frequency domain representations to improve robustness and accuracy. For example, SFNet fuses spatial and frequency domain information for forgery detection [QZY+25].

Methods such as pixel-level detection, fingerprint-based detection, and zero-shot detection can be applied as well. Using a ResNet-50 AI-generated image detection model, a score of 80 percent correctness was achieved when detecting AI-generated images using the MC COCOAI dataset. Furthermore, it was 45 percent of the time correct when assigning the model used. This dataset has 96000 data points. The real data points are human-made photographs from the MC COCO dataset

and the synthetic data points include images generated by Stable Diffusion 3, Stable Diffusion 2.1, SDXL, DALL-E, and MidJourney v6 [RIA+26]. This research demonstrates that successful classification can be done, although this example uses photographs, not artworks.

2.3 Digital Art

2.3.1 Digital Authenticity

Digital art and media lack physical uniqueness, which has led to the development of several methods for establishing authenticity in the digital domain. The Coalition for Content Provenance and Authenticity (C2PA) [Gro25] aims to increase transparency in digital media by establishing the origin and edit history of digital content using content credentials. These credentials embed cryptographically signed metadata, referred to as manifests, directly into digital media files. Such manifests record information about the creator and the tools used in production [Coa24]. This enables provenance tracking for digital media and supports claims regarding authorship and origin. Unlike blockchain-based systems, which primarily focus on ownership and transaction history, C2PA emphasizes the provenance of the content itself.

Blockchain is a decentralized and immutable ledger that can be understood as a distributed, append-only data structure maintaining a continuously growing list of records, known as blocks, which are cryptographically linked. Each block contains validated transactions, a timestamp, and a cryptographic hash of the previous block. This structure ensures that any modification to a prior block would invalidate subsequent hashes, making tampering computationally infeasible [ZXD+17] [Sin25]. As a result, data recorded on a blockchain cannot be altered or deleted once confirmed.

In the context of art, blockchain enables the creation of persistent provenance records that document the ownership history of an artwork over time. Transactions such as sales or transfers are cryptographically validated and appended to the chain, forming a transparent chronological record [WE24]. However, this system also preserves incorrect or fraudulent information if it is entered at the point of registration. This is called the oracle problem [Cal20]. Blockchain systems do not store the full digital artwork directly on the chain due to scalability constraints. Instead, they typically store a cryptographic hash of the artwork or its metadata [ZXD+18].

Non-fungible tokens (NFTs) provide a mechanism for establishing ownership and authenticity in digital art. NFTs are unique cryptographic tokens that represent specific digital assets and are implemented on blockchain platforms [WLWC21]. Each NFT contains a unique identifier and is linked with metadata describing the artwork, often including a reference to the digital file itself. NFTs function as certificates of authenticity and ownership, enabling artists to assert authorship and collectors to verify provenance.

2.3.2 Watermarkings and Steganography

Digital watermarking provides another approach to authentication by embedding identifiers directly into digital image data. Visible watermarks are transparent logos or text overlays that identify the artist. Watermarks can also be invisible, for example hidden codes embedded using steganographic techniques. They do not affect the artwork's appearance but can be read by software to verify origin. These techniques support authentication by enabling the detection of copies, unauthorized modifications, and content reuse, thereby contributing to integrity verification at the level of the digital file itself [CWY01] [HWG+24].

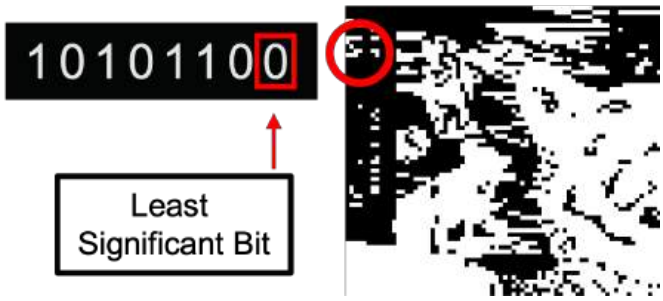

Figure 4: Least Significant Bit (LSB) plane of the upper-left part of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Steganography is the practice of concealing information within another medium in such a way that the existence of the hidden information is difficult to detect. One of the most widely used steganographic techniques is Least Significant Bit (LSB) embedding [SSSS23]. Digital images can be decomposed into bit planes, where each plane consists of the same bit position from every pixel value. For an 8-bit color channel, the first bit plane contains the most significant bits, while the eighth plane contains the least significant bits. Since the least significant bit contributes only minimally to a pixel's overall intensity, modifying it typically produces changes that are invisible to the human eye (see fig. 4). In LSB steganography, the least significant bits of pixel values are replaced with bits from a secret message or hidden image. Because only the lowest order bit is altered, the visual appearance of the carrier image remains largely unchanged while still allowing information to be embedded. Beyond spatial domain techniques such as LSB embedding, steganography can also be performed in transform domains, where information is embedded into frequency coefficients of compressed or multi resolution representations of the image [SS18].

A downside of these techniques is that they are preventative. If an artwork is not connected to, for example, a blockchain or if it is not watermarked, an analysis of these techniques is not very fruitful. Although the absence of authenticity measures can be meaningfully interpreted regarding an artwork or its authenticity.

2.4 Traditional Art Authentication

2.4.1 Current Practice

The Authentication in Art (AiA) foundation is an organization that has developed guidelines for both the authentication process and the academic classification of artworks. This model is primarily based on fine art authentication [dLMM19]. The rules for the authentication process consists of ten points (see Appendix .1). The final five items in the AiA guidelines concern data handling and the practical aspects of the authentication process itself. Although these rules are important, they are less relevant to the scope of this thesis. The first five rules can be grouped into four categories. The first and second items concern provenance research, the third item addresses technical analysis, and the fifth item concerns visual and modus operandi research. However, these guidelines do not specify what these processes entail and lack detailed descriptive attributes. The AiA has also established a classification system for authenticated artworks, which is presented in Appendix .2. These classifications provide a scale of authenticity, allowing the status and nature of an artwork to

be communicated more clearly.

Hephaestus Analytical represents a less traditional approach to art authentication by combining conventional and modern techniques in fine art authentication [Ana23]. The company employs a five step protocol consisting of: (1) provenance research, (2) connoisseurship, (3) chemical analysis, (4) pictology, and (5) blockchain-based security. Connoisseurship is essentially a combination of visual analysis and modus operandi research. In this process, specialists, academics, and art dealers with expertise related to the artist or artwork provide an expert assessment of the piece. Both chemical analysis and pictology can be considered forms of technical analysis. Chemical analysis focuses on scientific testing methods, whereas pictology employs machine learning and artificial intelligence algorithms to support the authentication process.

By generalizing these approaches and making them more broadly applicable, four principal categories of art authentication are identified for use in this thesis: provenance research, visual analysis, modus operandi research, and technical analysis.

2.4.2 Provenance

Provenance refers to the origin of a work, along with the chain of ownership and residences along the way. This differs from provenience, in which the exact spot and context in which an item is found are of importance. This is relevant especially in an archaeological context [PB11]. provenance research tries to obtain as much information as possible to ensure the painting currently in the museum is the same piece as the one which was the art studio hundreds of years ago. This can be accomplished through records, receipts, correspondence, and other types of paperwork. Nowadays, online records and databases are available as research tools, but in fine art, paper trails are indispensable. Provenance research starts with the painting itself. The back of a painting can provide a lot of information. There can be notes, stamps, labels, or other relevant elements. Furthermore, looking at the frame and signature can also provide information [MM23].

Next to using provenance research for authenticity, it is also required for ethical purposes. The International Council of Museums (ICOM) presents a code of ethics that all museums should adhere to. This code regards preservation, cultural, and natural inheritance. Additional topics covered are considering education and legalities. It states museums must ensure that their collections are free from suspicion of illicit trade, looting, or coercion. This means that even when ownership is legally sound, institutions are obligated to assess the ethical conditions under which an artwork changed hands [oM17]. Provenance research for works created or transferred during 1933–1945 is especially important. In this time period, Nazi-looted art entered the international market. Provenance research investigates if this is the case. If so, the item may be returned to the place of origin [FH19].

With digital and AI-generated art, proving provenance becomes difficult as there is no physical object. The point of origin (the provenience) and the creator are more relevant in this case. Blockchain techniques, as discussed in section 2.3.1, can be applied to fine art provenance authentication next to digital art authentication. A physical object gets associated with a digital record on the blockchain. To maintain the connection between the physical and digital domains, additional technologies such as NFC chips, RFID tags, or secure QR codes may be embedded in the artwork or its frame. These hybrid systems aim to provide a continuous and verifiable link between the object and its provenance record, thereby enhancing transparency and reducing the risk of forgery. However, challenges remain in ensuring that the physical-digital link cannot be tampered with or severed, and in establishing legal standards for the recognition of such systems [WE24] [Led25].

2.4.3 Visual Analysis

A visual analysis is a report that can help establish authenticity by comparing the report with other works of the painter and certified literature. For a visual analysis, essentially only a photograph of the work in question would suffice. Compared to the other techniques, this makes visual analysis very resource and cost efficient. The goal is to understand and recognize the choices made by the artist when creating the art piece.

According to the Duke University Thompson Writing Program, a visual analysis starts broadly [Ruc12]. The composition, with elements such as color, texture, size, and space, is analyzed. This helps formulate the main claim. The main claim is a general statement about the artwork, which is supported by a further, and more specific, analysis. Here, you consider elements such as color, shape, texture, and material. Claims of these aspects are made to support the main claim. These observations should be organized in logical order. For a visual analysis, there are terms and vocabulary which are used to give a proper and clear description. When reporting the analysis, statements from the artist and experts and historical context can be taken into account [85423].

To use visual analysis for authenticity verification, overlapping patterns of visual components typical for an artist get studied. One way of doing this is by comparing the painting to other works from around the same time. Painters often have certain defining characteristics in their visual choices. Descriptions of the painting in correspondence and other documentation can give clues about visual aspects, which can be useful in the analysis.

Part of the visual analysis is a signature analysis. If a signature is found, it can help identify or verify the painter, if it is not already known. This signature can be compared to other signatures from paintings of the same artist. In some cases, there are assigned databases to cross-reference the authenticity of a signature. Signature analysis is a controversial method, as it can easily get forged or added later [Koz17]. But when the artist is not clear, it can be useful.

2.4.4 Modus Operandi

Modus operandi translates to 'mode of operation'. It considers the process, techniques, and the artist's way of working. Methodologies are analyzed, and the tools used and their results should be consistent with those methodologies. Tools would include brushes, paints, and canvas.

The creative process and the artist's decision making are also included in the modus operandi. For example, looking at the underlying sketches can tell you about potential characteristic changes. A search for other sketches related to the painting can be performed. More information about the modus operandi can be obtained by researching correspondence, journals, and sketchbooks. Questions about spontaneity and experimentation should also be asked. This will show if red flags should be raised when there are changes in approach.

Further, the beliefs, philosophy and inspirations of an artist are important. The experiences of an artist known from literature can be represented in artworks. Other paintings with similar themes can expose patterns in the working of the artist.

Research into the daily life and circumstances of an artist can reveal additional information. For example, the financial situation of an artist can give insight into the materials used and the themes within the works. How often an artist paints and motivations to do so, like inspiration of commissions, give information about the artist and paintings and give information about how rare the existing works are [Tou24].

For modus operandi research, connoisseurs often give their opinion. When trying to prove that a certain work belongs to an artist, the work in question is compared to other works which have established authenticity. The methods of other artists of the art type or time period may also be relevant. If a work is forged on another date, inconsistencies can appear [Opp90].

2.4.5 Technical Analysis

A technical analysis can be very costly, as well as rewarding. There are many techniques that are useful for different instances. These different methods can be categorized into three main groups: scientific and laboratory techniques, imaging techniques, and digital techniques.

Scientific and laboratory techniques are often invasive and are used only in specific circumstances when a sample can be taken. In some cases, it may even be preferred [Tit02]. In traditional art, microscopic examination of elements such as pigments or binders can result in information about, for example, the time period the work emerged from. It allows for a closer examination of elements in a painting which are not as clear with other techniques. The cross-section of a part of a painting can provide a lot of information about the layers and method used of a painting. For example, specific paints were only made available in a specific time. Titanium white became available at the beginning of the 20th century [vAv+18], so if it were to be detected in a work said to be before that date, it is likely a forgery. It is important to note that this type of information can be deduced using imaging techniques as well. Other scientific and laboratory techniques include carbon-14 dating and lead isotope analysis. Carbon-14 dating measures the decay of radioactive carbon-14 absorbed by materials such as wood, bone, fiber, or other organic materials. Generally, it has a high accuracy. An example for the use of carbon-14 dating in art is with contemporary paintings between 1963 and 1965. Because of the increase of C14 in the atmosphere due to nuclear bomb testing, carbon-14 dating opened the door for exploitation (figure 5). Because of this, the modern high C-14 levels could be mistaken for antiquity [FCM+13] [FMM+14].

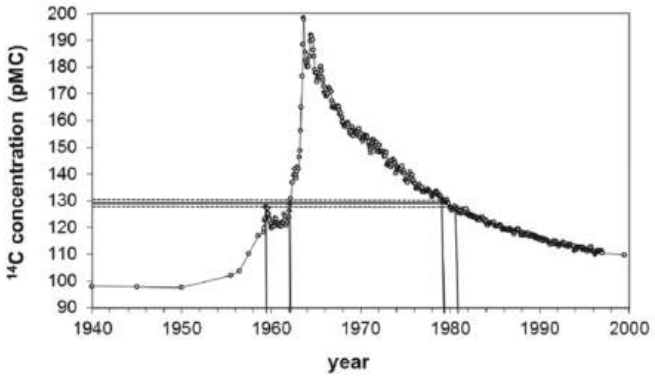

Figure 5: Calibration of the measured C14 concentration 1940-2000 [FMM+14]

Imaging techniques include, but are not limited to, X-ray fluorescence, X-ray radiography, reflectance imaging spectroscopy, infrared reflectance and ultraviolet fluorescence. All these techniques are non-invasive.

X-ray radiography (XRR) allows the viewer to essentially see through the painting. Elements such as the canvas frame and nails are visible (fig. 6 b.). Furthermore, hidden layers can be revealed non-destructively. This is because as the photons pass through the painting, they are

absorbed differently by the atoms depending on the material [RKDCA13]. X-ray fluorescence (XRF) determines the elemental composition. It maps chemical elements, revealing inorganic pigments and materials (fig. 6 c.). Both XRR and XRF use x-rays, but only XRF measures the characteristic energies admitted from specific elements [SMT03]. Another method to reveal (faded) colors within a painting is reflectance imaging spectroscopy (RIS). With this technique, the wavelength of colors is measured outside of the boundaries of visible light. The absorption and reflection rates for these wavelengths can be represented in a graph which, in turn, can be paired to a specific pigment [DZT+09] (fig. 6 d.). When using ultraviolet fluorescence (UVF), the UV rays get absorbed by the varnish or other materials present in the outer layers (fig. 6 a.). This can illuminate restorations, aging, and even materials used [VP05]. Non-invasively observing the sketch or underpainting is possible with infrared reflectography (fig. 6 e.). The radiation passes through the paint layers until it gets absorbed. Most underdrawings were made using carbon black, which is very absorbent of infrared radiation.

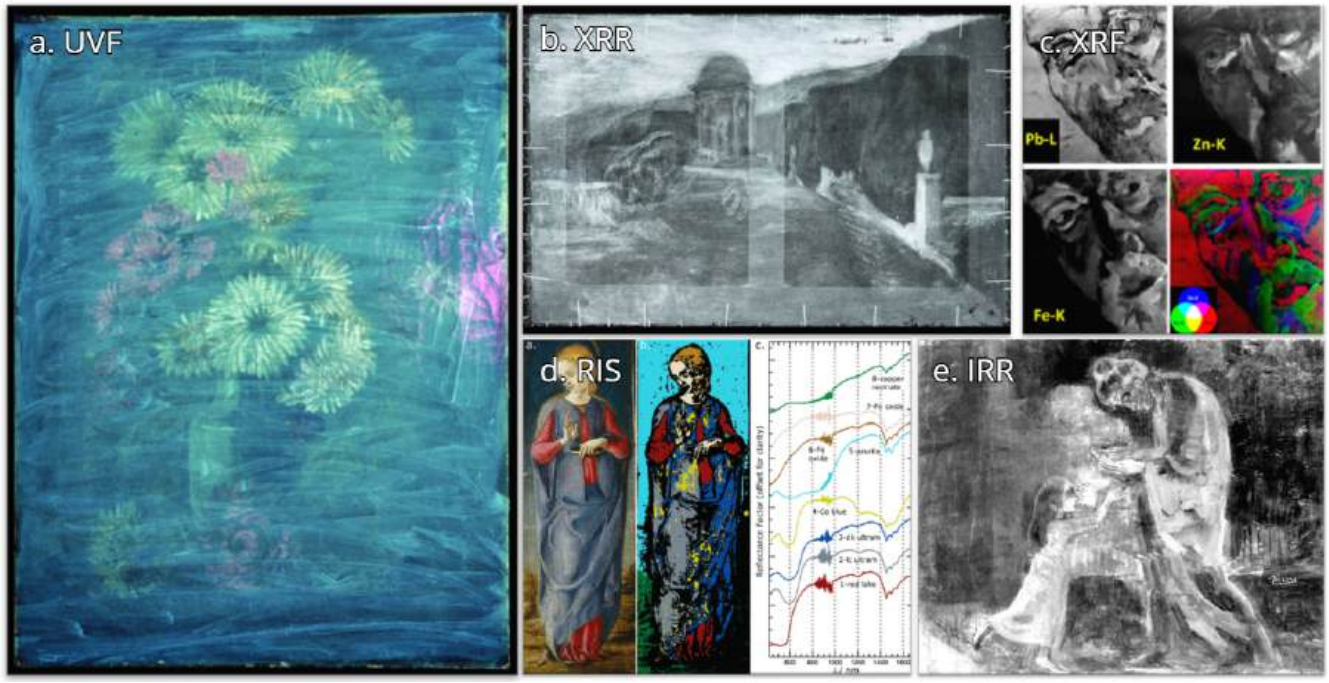

Figure 6: a. Still life with flowers (20th century), Ireland. Ultraviolet fluorescence [Liz11]. b. Pablo Picasso, La Miséreuse accroupie (The Crouching Woman) (1902). X-ray radiography [PDB+20]. c. Painting from a private collection, Rio de Janeiro, Brazil. X-ray fluorescence [PFO+21]. d. Cosmè Tura, The Virgin Annunciate (c. 1470/1480). Reflectance imaging spectroscopy [CDP16]. e. Pablo Picasso, La Soupe (1902–03). Infrared reflectance imaging [Cas18].

Digital analysis techniques are continuously evolving. Computational and AI-based methods for fine art authentication often treat the problem as a statistical learning task. The goal is to determine whether a painting fits the learned pattern of authentic works of an artist. Because confirmed forgeries are rare and datasets are usually small, many approaches rely on one class or anomaly detection methods rather than standard classification. These models learn what 'authentic' looks like and flag anything that deviates too strongly from that pattern. Early methods used

handcrafted features to describe artistic style in measurable terms. For example, they analyze brushstroke structure, texture patterns, and local image properties using tools such as wavelet transforms, Gabor filters, and local binary patterns. These techniques attempt to capture consistent stylistic habits that may be unique to an artist [JHB+08] [ELK+18].

More recent approaches use deep learning, which automatically learns features from large sets of images. Convolutional neural networks (CNNs) and transformer models can capture both fine details and broader compositional patterns. Instead of directly classifying a painting, many systems use metric learning methods such as Siamese networks, which learn to measure similarity between artworks [CLG19]. Other methods use autoencoders or similar models that try to reconstruct authentic paintings. If a painting cannot be reconstructed well, it is considered unusual or potentially inauthentic. More advanced systems combine multiple types of data and learning methods to improve reliability. Despite these advances, AI methods are still used mainly as support tools, since artistic style changes over time and many historical works were produced collaboratively in workshops [GEB16].

3 Methodology

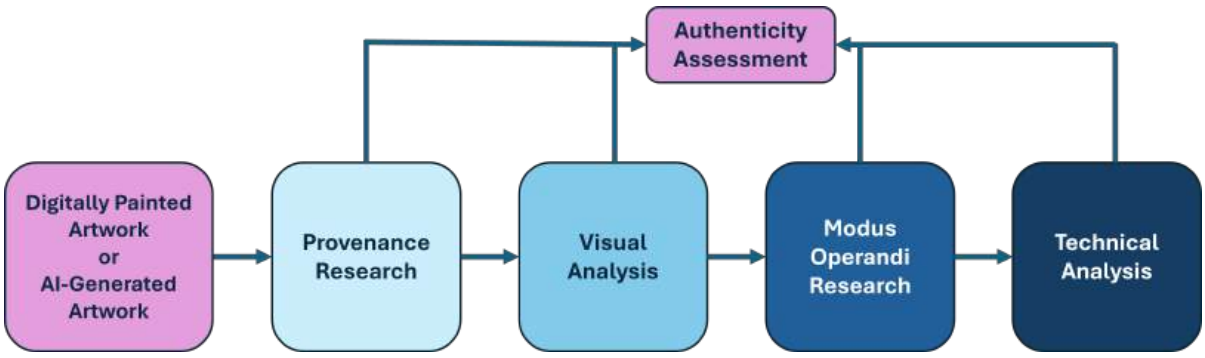

Figure 7: Pipeline of the methodology. For both an AI-generated and digitally painted image the four assessment methods get applied subsequently. The results of each technique get combined in the authenticity assessment of each work.

The traditional techniques (technical analysis, visual analysis, provenance research and modus operandi research) in the context of digital and AI-generated are reimagined and examined in a series of three comparative case studies. Each case study consists of a digital artwork and an AI-generated artwork.

The aforementioned traditional authentication methods are applied in series to the pairs of digitally painted and AI-generated art. The, when appropriate, changed manner of application for each method is described in sections 3.2, 3.1, 3.3 and 3.4. After the case studies, for each method is established if the application is possible, useful, and if, or how, it should be revised to fit the art type. The combined gathered information results in how a traditional method can be applied to a non-traditional artwork. These four techniques build upon each other. This makes the order of conduct relevant. The first technique is provenance research. This gives a good frame of reference and initial sources to use for the other methods. With provenance research, information about origin and ownership is revealed. The findings can be used as reference for the visual analysis.

Information from both the visual analysis and the provenance is used to establish the modus operandi. The modus operandi looks into the artist, platform, artwork and tools. Lastly, a technical analysis is conducted. This method is less restrained by other techniques. It is appropriate for the technical analysis to be conducted last, as this is often the case for traditional art. Prior information helps interpret the data. Using the four techniques, the authenticity of each individual artwork gets assessed using the rubric (fig. 13). For an overview of the methodology, see fig. 7.

3.1 Provenance

As stated in section 2.4.2, provenance research tries to create a chain of ownership. This chain starts at the creator and ends up at the current owner and position of the work. For digital or AI-generated art, this is difficult as the artwork does not have material uniqueness. Digital access to an artwork does not entail ownership. Ownership remains with the creator or the person to whom ownership is transferred (as a gift or purchase). With small cases, there is rarely documentation about ownership. An exception is when there is a blockchain like with NFTs (see section 2.3.1).

This makes the first step of provenance research to check if the image is linked to a blockchain. Tools like Etherscan or Solana Explorer can provide this information, but a token ID or address is needed. Because in these case studies this is not available, metadata will be checked first. If there is nothing pointing towards a blockchain, the reverse image NFT finder Nyckel is used [Nyc22].

The second part of the provenance research is regular reverse image search using Google image Search, TinEye and Yandex [Yan10] [Tin08] [Goo01]. A list is created of all found postings of the artwork. They get dated, the uploader gets noted, and the work gets categorized by if the posting is made by the creator or if it is a repost. The earliest known upload is noted as the original posting, which establishes provenance and is used for the modus operandi research.

The following outputs are considered:

- Blockchain assessment
- Artist assessment
- Original posting platform assessment
- Accessibility and reposting assessment

3.2 Visual Analysis

The visual analysis is conducted on the visual image of the artwork. This is in a similar fashion as for traditional artworks, described in section 2.4.3. The finished product is a report where first, a general analysis is described which leads to the main claim. In this general analysis, elements like color, texture, size, and space get described. Further detailed claims are made to support the main claim.

Because images can be AI-generated, semantic coherence is considered. This includes anatomical plausibility, scene logic, repeating patterns and object permanence.

If in the provenance research other paintings from the same collection or artist are discovered, they are compared to the contested artwork. Differences and similarities are documented. Signatures and watermarks are looked for and compared if applicable.

The following outputs are considered:

- A visual analysis report with main claim
- Semantic coherence assessment
- comparison to relevant works

3.3 Modus Operandi

The modus operandi looks into the making of the work, as described in section 2.4.4. First, information provided by the provenance research about the artist and origin jump starts an investigation into possible documentation and information about the modus operandi. Artist behavior will be considered. This includes posting rhythms and behaviors. Other aspects of the modus operandi are an assessment of the platform, an assessment of the tools and techniques and an investigation into the background of the artwork itself.

This is subsequently compared to the visual analysis to see if it corresponds. A closer inspection will be taken into techniques and tools visible in the painting itself.

The following outputs are considered:

- Behavioral profile of the artist
- Posting platform assessment
- Background of the artwork
- Tools and technique assessment

3.4 Technical Analysis

The technical analysis will focus on digital techniques, as scientific and imaging techniques (as described in section 2.4.5) are not possible for these art forms.

For potential (invisible) watermarks, the artwork is run through watermark detection software. The software used are JoyCaption, Gemini, and Nyckel. JoyCaption watermark detection uses classification model OWLv2, which results in a boolean, and a YOLO based model that draws bounding boxes around all detected watermarks [Fan25]. Googles AI Gemini is used because of the integrated SynthID checker, which is Gemini's watermarking tool [Dee24] [Goond]. When images are generated using Gemini, a digital watermark is embedded in the image which is detectable for Gemini. If the image gets flagged, it is clear that the image is generated using Gemini. Lastly, Nyckels AI-Based watermark checker is used which gives a confidence threshold [Nycnd] about the presence of a watermark.

Steganography detection techniques, such as investigations of RGB or LSB data, are used to extract as much data as possible from the image itself. This detects potential hidden messages or files if present. The tool used is Apri'Solve [Zee26]. With Apri'Solve, the image gets decomposed for all color and bit planes. This goes for red, blue, green, superimposed and color remapping. They get checked because alternative images can be hidden in these planes. Further more, it uses zsteg, steghide, outguess, binwalk, foremost and strings. Zsteg extracts hidden data from PNG's and BMP's. It uses various techniques including LSB and zlib-compressed data [Cybnd]. Steghide can be used when there is data embedded with Steghide. This works for JPEG, BMP, WAV and AU

files. Often a password is needed, but this is not always the case [Pro03]. Outguess, like Steghide, works only when a file is encoded using Outguess. It embeds data by modifying JPEG coefficients in a statistically controlled way and often requires a password [RBCnd]. If needed for further extraction, BocenTriq OutGuess extractor will be used [Boxnd]. Binwalk detects embedded files inside of other files. It scans for known file signatures and offsets. Foremost is a file carving utility that scans an image file as raw data, searching for known file signatures (headers and footers) to recover embedded files and extracts it. It supports numerous file types, including JPEG, PNG, PDF, MP3, and ZIP. Strings extracts human readable ASCII/UTF-8 text sequences from a file's raw bytes. It can result in plaintext hidden data like appended messages, flags or URLs being visible. It can include metadata or artifacts like usernames, file paths or tool markers and it can give hints about other encryption tools used.

Various EXIF (Exchangable Image File Format) metadata tools are used to provide further information about an image. This includes information about softwares, copyrights, and the author. If an image is compressed, or went through a specific pipeline, it can be visible within this data. Multiple extraction services get cross referenced and used. These services are the Windows Properties Viewer, Aperisolve [Zee26], Shutterstock Image EXIF viewer [Shund], Metadata2go [Qaand], and Jimpl [Jimnd].

Several AI detection softwares are used. These models do not give reliable results, but they are considered, although not conclusively. The models used are SightEngine [Signd], Hive Moderation [Hivnd], and ZeroGPT [Zernd].

- Watermark assessment
- Steganography assessment
- Extracted EXIF metadata
- AI detection

3.5 Artwork Authenticity Assessment

The Authentication in Art Organization [dLMM19] classifies the of authenticity for the object of research according to their classification list, as established in section 2.4.1.

Using this model, however, it is hard to classify AI-generated work, as it is unclear if the model is a tool, collaborator, or artist. So, a rubric is used to score each artwork considering aspects of the works authenticity based on the assessment methods, see Appendix .3. Following the rubric, each work gets a rating between zero and ten.

3.6 Method Assessment

Each method gets assessed to see if the if the application is possible, useful and if it is correctly revised to fit the art type or if it should be revised further. The results of the case studies and the authenticity classification rubric are used in consideration.

3.7 Art Selection

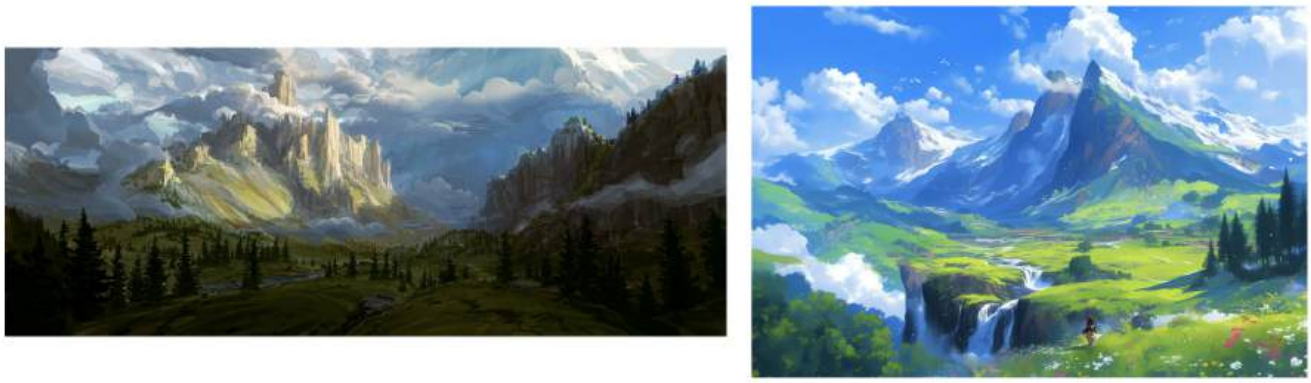

Figure 8: Artworks for case study 1: (left) Landscape, Philipp A. Urlich (2020), digitally painted [Url20]. (right) Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Figure 9: Artworks for case study 2: (left) Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24]. (right) Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Figure 10: Artworks for case study 3: (left) 6 Corgis, Nadiapixel (2022), digitally painted [Pix22]. (right) Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

For each of the three case studies, two artworks, one AI-generated and one digitally painted, have been hand selected from different websites (ArtStation, Instagram, Shedevrum, PixilArt, and Magnific). Digital paintings are selected and AI-generated paintings are chosen to match them. The order is regarding the fast amount of AI-generated works available, in comparison to the amount of digital paintings which is considerably less. In the search for an artwork, tags and labels are looked at to classify them as AI-generated or digitally painted. In advance, no intensive research is done to see if the label is correct, as that is part of the case study.

All three pairs have a different main genre. The genres are a landscape (fig. 8), an abstract work (fig. 9), and pixel art (fig. 10). All images are selected considering they are available in digital format suitable for analysis and they have diversity in style, format, and source platform. When selecting a corresponding AI-generated artwork, several criteria are considered. Both paintings should have a similar composition, style, size, quality, and subject.

Because of this selection method, images are selected with knowledge about their origin and creation prior to experimentation. This is not further investigated before the case study is conducted.

The artworks are downloaded as provided on the initial website. This includes the format.

4 Results

The case studies from which the results are concluded are available in Appendixes .4, .5, and .6.

The authenticity scores presented in this section do not represent definitive proof of authenticity or inauthenticity. Instead, they reflect the extent to which the available evidence supports authenticity claims according to the developed assessment rubric.

4.1 Classifications

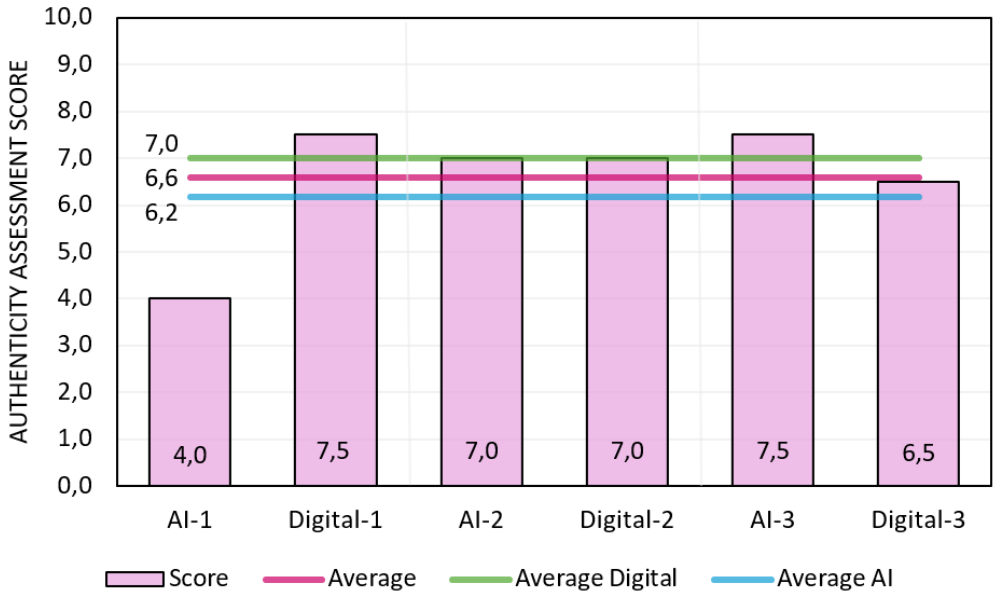

Figure 11: Scores of all six artworks of the three case studies using the rubric (fig. 13).

The artworks score on a scale from 1 to 10 using the authenticity assessment rubric (see fig. 13). The six artworks investigated in the case studies obtain scores ranging from 4.0 to 7.5, with a mean authenticity score of 6.6 (see fig. 4). Across the three case studies, the digital artworks achieve a mean score of 7.0, whereas the AI-generated artworks achieve a mean score of 6.2.

In all three case studies, the AI-generated artwork receives a score that is equal to or lower than that of the corresponding digital artwork. When all artworks are considered collectively, the digital artworks obtain a slightly higher authenticity score than AI-generated artworks.

A paired-samples t-test, however, reveals that this difference is not statistically significant. The results found are $t(2) = -0.61$ and $p = .60$. Consequently, there is insufficient evidence to conclude that the performance of the AI and Digital approaches differ significantly. The observed difference should be interpreted with caution, as the very small sample size ($n = 3$) substantially limits the statistical power of the analysis and prevents reliable generalization of the findings.

4.2 Provenance Research

For both digital and AI-generated artworks, provenance research focuses on obtaining as much information as possible regarding the origin, ownership, and dissemination of an artwork.

The provenance research consists of two components. First, each artwork is investigated to determine whether it is associated with a blockchain. None of the examined artworks show evidence of blockchain association. Second, the digital footprint of each image is investigated using reverse image search techniques. Reverse image search does not always provide complete results, particularly for lesser known or recently published works. This limitation is observed for the AI-generated artwork in case study 1 (Appendix .4) and the digital artwork in case study 3 (Appendix .6). To maximize the amount of obtained information, multiple reverse image search engines are employed.

When no results are found using these engines, the file name of the image is searched on the internet, which leads to sources in the case of these artworks.

The provenance research results in timelines of the identified postings for each artwork. This includes information regarding original uploaders, publication dates, platforms, and subsequent repostings by either the artist or third parties. In case studies 1 and 2, the digital artworks exhibit a larger online presence than the AI-generated artworks, including both original posts and repostings. This pattern is not observed in case study 3, where the digital artwork can not be located through reverse image search techniques.

Overall, provenance research provides substantial information regarding the origin and dissemination of the artworks and serves as an important foundation for the other authentication methods. These findings suggest that this interpretation of provenance research is both feasible and useful for the authentication of digital and AI-generated artworks. Future research could investigate alternative methods in addition to reverse image search techniques to obtain a broader range of results.

4.3 Visual Analysis

The visual analysis differs only minimally from traditional approaches to art authentication. By analyzing an artwork and comparing it with other works by the same artist or within the same collection, it is possible to assess stylistic consistency and thematic coherence. When such similarities are present, they may provide supporting evidence regarding an artwork's origin and authorship.

Using the sources identified during the provenance research, artworks by the same artist and from similar time periods are selected for comparison. The digital artists investigated in this study generally exhibited stronger thematic consistency and more clearly identifiable artistic styles than the creators of the AI-generated artworks, whose portfolios are often more diverse in terms of style, genre, and subject matter. However, individual collections of AI-generated works occasionally display a greater degree of consistency.

The examination of semantic coherence occasionally provides information regarding whether an artwork exhibits characteristics commonly associated with AI-generated imagery and aids in identifying stylistic characteristics of individual creators. Nevertheless, this component of the investigation provides only limited additional evidence regarding the authenticity of the artworks.

The findings indicate that visual analysis remains both feasible and useful for digital and AI-generated artworks. Although visual analysis alone cannot establish authenticity, it contributes contextual information when combined with provenance research and technical evidence. No substantial modifications to the method appear necessary, as it successfully provides a deeper understanding of the artwork itself.

4.4 Modus Operandi

The modus operandi research focuses on the artist, the original publication platform, the history of the artwork, and the tools and techniques used during its creation. The sources identified in the provenance research serve as a starting point for investigating these aspects.

This method provides a deeper understanding of both the artwork and the artist. It yields valuable contextual information regarding authenticity. The availability of verifiable information concerning the artist, production process, and publication history may strengthen confidence in

an artwork's authenticity assessment. This information allows the artworks to be placed within a broader context.

The digital artists included in this study generally have a larger and more verifiable online presence than the creators of the AI-generated artworks. Information regarding their education, artistic development, professional activities, social media accounts, and previous works is often publicly available and can be cross-referenced across multiple sources. This results in a more comprehensive understanding of the artists and their creative processes. However, the AI-generated artworks often provide additional information in the form of generation prompts and information about the image generation platform that had been used. These details offer insight into the creation process and could partially compensate for the lack of information regarding the creator.

The availability of verifiable information concerning the artist, production process, and publication history may strengthen confidence in an artwork's authenticity assessment. However, the amount of available information varies considerably between case studies. The findings suggest that modus operandi research remains both feasible and useful. Furthermore, the effectiveness of modus operandi research is highly dependent on the quantity and quality of publicly accessible information and on the results obtained during provenance research.

4.5 Technical Analysis

The technical analysis consists of four components: metadata assessment, watermark assessment, steganography assessment, and AI detection. These methods provide substantial information regarding the technical characteristics of the images, although not all of this information is directly relevant to authenticity assessment. Nonetheless, it contributes to a more comprehensive understanding of the artworks themselves.

A watermark is correctly detected in the AI-generated image of case study 2 (Appendix .5). Although this watermark provides additional supporting information, it does not yield new information regarding the artworks provenance or authorship.

No significant steganographic abnormalities are detected. The decompositions of the artworks make artifacts occasionally more apparent, which can point to an artwork being AI-generated. An example is case study 3 (Appendix .6). Both artworks in this case study are created in a pixel art style. The digitally painted image exhibits consistency in color and texture across individual pixels, whereas the AI-generated image displays visible artifacts and inconsistencies in texture (see fig. 12).

EXIF metadata occasionally shows a lot about the consistency and origin of the image, but it can also be quite bare, suggesting that it might be stripped. The absence of metadata may itself be meaningful, as it can indicate that metadata has been removed during processing or distribution. The quality of the image is shown in metadata, which can be used to better classify the image. In several cases, such as the AI-generated artwork of case study 3 (Appendix .6) and digital artwork of case study 2 (Appendix .5), the EXIF metadata provides insight into the processing through which the image has passed.

The AI-detection methods are generally correct, but not very reliable. Although all AI-generated images are correctly classified, only one of the digitally painted images is unanimously correctly classified (see table 1).

The technical analysis is not guaranteed to provide a lot of concrete information regarding the artwork. Nevertheless, it is still useful as the data can still be interpreted and conclusions can be

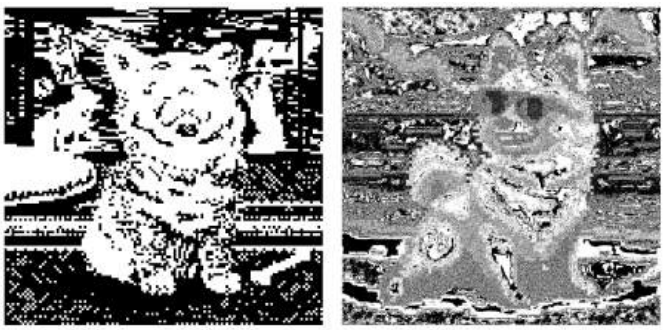

Figure 12: First bit plane of the red color channel for (left) 6 Corgis, Nadiapixel (2022), digitally painted [Pix22] and (right) Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Type	SightEngine	HiveModeration	ZeroGPT
AI-1	FAKE	FAKE	FAKE
Digital-1	REAL	REAL	REAL
AI-2	FAKE	FAKE	FAKE
Digital-2	FAKE	FAKE	FAKE
AI-3	FAKE	FAKE	FAKE
Digital-3	FAKE	REAL	REAL

Table 1: Results of various AI-detection engines considering the artworks of all case studies

drawn from potential absences of the data. The technical analysis is additionally useful as it is not dependent on prior sources and information regarding the painting. The method is feasible, but may benefit from the use of more advanced tools, interpretation methods, and extraction techniques.

5 Discussion

The authentication methods provenance research, visual analysis, modus operandi research, and technical analysis can be applied to digital and AI-generated artworks. The results indicate that all four methods remain applicable, but their implementation and interpretation require adaptation to the characteristics of digital, and AI-generated art. The case studies demonstrate no significant difference between the AI-generated and digitally painted artworks.

One of the most significant findings is that provenance research remains the strongest foundation for authentication across all three forms of art. In traditional art, provenance focuses on ownership history and physical movement of an object. In digital and AI-generated art, provenance instead becomes a reconstruction of the artwork's digital footprint. Reverse image searches, post histories, and blockchain records can collectively establish a chain of origin.

The visual analysis proves equally applicable to digital and AI-generated works as it is to traditional art. The method requires few modifications and successfully provides insight into stylistic consistency, thematic coherence, and relationships between artworks produced by the same creator. However, visual analysis alone cannot establish authenticity. Similar visual characteristics can be

imitated, especially by generative AI systems capable of reproducing artistic styles. Consequently, visual analysis is most effective when combined with provenance and technical evidence.

Modus operandi research also remains relevant. Information regarding artist behavior, publication habits, preferred platforms, and production methods provide valuable context for evaluating authenticity. Generally, there is more information found regarding the artist in the case of digital art, but the tools and creation methods are more clear for AI-generated art.

The technical analysis produces mixed results. Metadata, watermark detection, and steganographic analysis occasionally provides useful information about image origin and production methods. However, metadata is often limited or absent and no significant watermark or steganographic evidence is identified in the selected case studies. AI-detection tools similarly produce results that are difficult to interpret conclusively. While the technical analysis remains valuable, it can not be used stand alone to assess authenticity.

Several limitations should be acknowledged. First, the study examines a relatively small number of case studies. A larger dataset would allow stronger generalizations and comparisons between different artistic genres and platforms. The differences observed between digital and AI-generated artworks should be interpreted cautiously. Although digital artworks achieve slightly higher authenticity scores on average, this difference was not statistically significant within the present sample. The limited number of case studies and the exploratory nature of the research prevent broad generalizations regarding the relative authenticity of digital and AI-generated artworks. Second, many of the technical tools used are freely available online services with varying levels of transparency and reliability. More advanced software may produce different results. Finally, because the selected artworks were already known to be digital or AI-generated before analysis, the study focused on authentication rather than identification of unknown works. If the nature of the artworks were to be completely unknown, results may differ.

Future research could expand the number of case studies and investigate additional authentication techniques. Further work could also explore how concepts such as authorship and authenticity should be interpreted in increasingly AI-assisted creative processes.

6 Conclusion

This thesis investigates how the four principal methods of traditional art authentication can be applied to digital and AI-generated artworks. These methods include provenance research, visual analysis, modus operandi research, and technical analysis. To our knowledge, this has not been done before.

Currently, for AI-generated art and digital art authentication methods such as AI-detection or Non-fungible tokens (NFTs) are used. Although these current methods for authenticating AI-generated or digitally painted art are useful and provide valuable information, it does not necessarily provide a full picture. When using these methods the traditional techniques tend to get lost. To better understand the similarities and differences between traditional art, digital art, and AI-generated art, the traditional methods are applied to the non-traditional art forms. Thus, in this thesis, authenticity gets defined by the extent to which an artwork's origin, authorship, and production history can be verified.

The results demonstrate that all four methods remain applicable to digital and AI-generated art, although each requires adaptation to account for the absence of physical uniqueness and

the changing nature of authorship. In a series of case studies, a substantial amount of verifiable information was obtained for both digital and AI-generated artworks. Provenance research proves particularly valuable, as digital footprints, platform histories, and creator information can provide a verifiable record of origin. Visual analysis and modus operandi research remain useful for establishing stylistic consistency and understanding the creative process behind a work. Technical analysis can provide supporting evidence through metadata extraction, watermark detection, and steganographic examination.

To properly assess the authenticity of an artwork, no method alone will suffice. Similarly to traditional art, the combination of these techniques, with an accompanying interpretation, results in a better understanding of the authenticity of an artwork. Alternative modern authentication practices still hold their value to obtain the required information. As digital and AI-generated artworks become more prevalent within museums, galleries, and online marketplaces, authentication practices will need to continue evolving alongside the technologies used to create and distribute art. Still, modern developments do not make traditional techniques less valuable and insightful.

In this thesis is determined that, although changes have to be made to the traditional methods, they remain applicable and important in the digital age. The focus must shift from the examination of physical characteristics to the examination of information. Rather than verifying the authenticity of a unique physical object, authentication increasingly concerns the verification of origin, authorship, and production history through digital evidence. This shows that, despite being created centuries apart, traditional art, digital art, and AI-generated art share fundamental similarities regarding their authentication assessment.

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7 Appendix

.1 Universal Rules for the Authentication Process

1. *Only the creator/creators was/were present at the moment of making the art object in question*
2. *The origin of an art object (fake, copy or genuine) is always bound to a moment in time*
3. *Essential to the process is a comprehensive scientific examination of a work's materials, techniques and history. This examination should always be conducted by a multidisciplinary research team*
4. *Research surrounding an art object is always defined in relation to the object itself. This definition always includes, but is not limited to, the study of the object's art historical attributes, artists' materials, and artists' techniques*
5. *Research questions are based on deductive and inductive reasoning*
6. *Round-robin fact checking is fundamental to building robust protocols*
7. *The disclosure of research and analysis methods are a fundamental tenet of the scientific method (and a pre-requisite for all peer-reviewed scientific publications), and transparency in data collection and analysis parameters are essential components of an effective and widely accepted authentication*
8. *The conclusions of research teams should be overwhelmingly based on objective findings, and not on subjective opinions*
9. *All findings must be presented, discussed and evaluated*
10. *Scientific findings can be overturned with the advent of newer and more sophisticated imaging and analysis technologies. Good science is transparent and accessible, and as such is always open to this progress and correction*

.2 Universal Rules for Authentication Classification

1. *The painting, signed or not, is made in its entirety by the author. It is comparable to an autograph.*
2. *The painting and (one or more) variant(s), signed or not, are made in its entirety by the author with fellow artist(s), and assistant(s) from the same workshop. It is comparable to an autograph.*
3. *The painting is completed with assistance of a workshop. The workshop assistance integrated the painting using the style and technique of the Master.*
4. *The painting is a design (with a possible under-drawing) by the Master but the paint layer is finished by (known or unknown) assistants or students.*
5. *The painting is the result of cooperation between two or more artists from different workshops. Each responsible for a part of the execution.*
6. *An unfinished painting, for whatever reason, was completed by a different painter.*
7. *The painting is a replica by the artist of the original painting.*
8. *The painting is a workshop replica, made under the supervision of the Master, possibly with his participation.*
9. *The painting belongs to one of the above categories but has been (partly) ruined due to poor conservation treatment and/or storage conditions.*
10. *The work is (industrially) produced in a series.*
11. *The painting is a more or less true copy of the original.*
12. *The painting is a copy made as a study-copy.*
13. *The painting is in the style of another painter.*
14. *The painting is authentic, but misleading or fraudulent additions have been made.*
15. *The painting has undergone serious alterations through human intervention.*
16. *The object is an industrially made reproduction, which after treatment is made to look like a painting.*
17. *The painting is a complete forgery, made using only modern materials.*
18. *The painting is a complete forgery, crafted exclusively from aged materials.*

.3 Rubric for Authentication Assessment

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation software or drawing	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 13: Authenticity assessment rubric

.4 Case Study 1

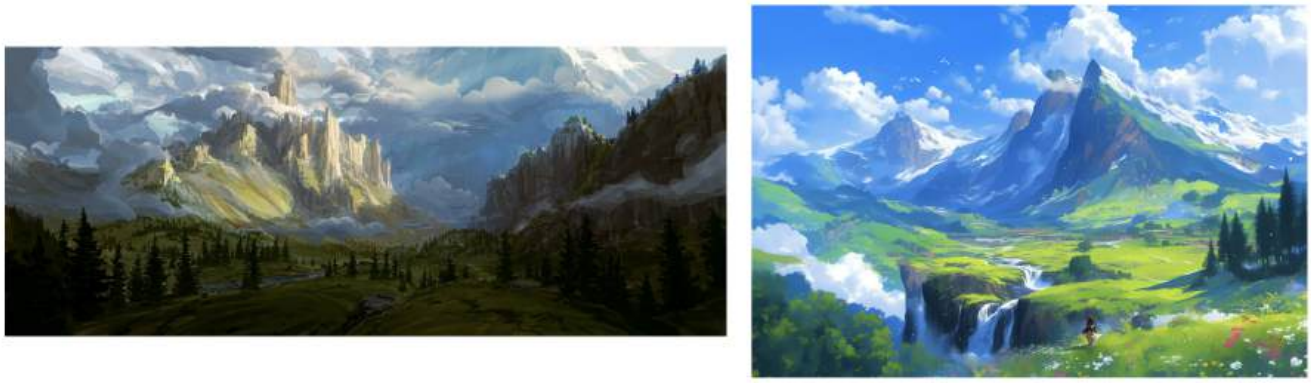

Figure 14: Artworks for case study 1: (left) Landscape, Philipp A. Urlich (2020), digitally painted [Url20]. (right) Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Provenance

Blockchain

Using the reverse NFT finder Nyckel, no results came up regarding the two images. See figure 15.

Reverse Image Search

The reverse image searching engines used are Yandex AI, TinEye and Google Images. Unique, working sites found are in table 2 and 3.

Pictures are notated as a repost when there is no direct affiliation with the creator. Otherwise, they are noted as unclear. If there is a direct link to the artist, they are noted as original.

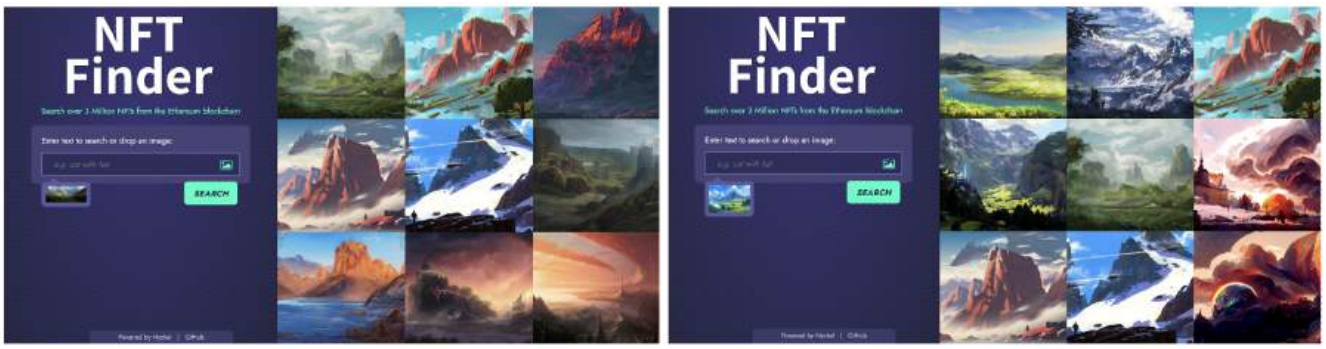

Figure 15: (left) Results from NFT checker Nyckel on (left) Landscape, Philipp A. Urlich (2020), digitally painted [Url20] and (right) Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Table 2: Postings of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

Source	**Link**	**Date**	**Notes**	**Reposting**
Yandex	https://pl.pinterest.com/pin/landscape-by-philipp-a-urlich--268597565268529067/?utm_medium=organic	15 May 2022	Poster: Erin Costello	Repost
Yandex	https://in.pinterest.com/pin/911556780803160346/	27 Sep 2022	Poster: alihanadilbek594	Repost
Yandex and Google Images	https://reactor.cc/post/4459921	10 Aug 2020	Alternative: https://joyreactor.cc/post/4459921	Repost
Yandex and Google Images	https://wallhere.com/en/wallpaper/1997283	19 March 2021	Multiple language versions of same site.	Repost
Yandex and Google Images	https://urlich.art/projects/48Nvw8?album_id=1270226	10 Aug 2020	Also on mirror sites.	Original
Yandex	https://www.wallpaperflare.com/artwork-digital-art-landscape-clouds-trees-rocks-philipp-a-ulrich-wallpaper-ycnfq	Unknown	Collection: https://www.wallpaperflare.com/search?wallpaper=Philipp+A.+Ulrich	Unknown, Repost

Source	Link	Date	Notes	Reposting
Yandex	https://www.sotwe.com/07MMF	Unknown	Banner image, unrelated.	Repost
Yandex	https://wallhaven.cc/w/mdx6gk	2021	External mirror source.	Unknown, Repost
Google Images	https://www.pinterest.com/pin/444237950749245369/	10 Aug 2020	Poster: cole_pham	Repost
Google Images	https://www.wallpaperflare.com/landscape-mountains-valley-trees-grass-clouds-wallpaper-ytfkc	Unknown		Unknown, Repost
Google Images	https://rare-gallery.com/423716-artwork-digital-art-landscape-clouds-trees-rocks-philipp.html	Unknown	Alternative: https://wallpapercrafter.com/1111802-artwork-digital-art-landscape-clouds-trees-rocks-philipp.html	Unknown, Repost
Google Images	https://www.artstation.com/artwork/48Nvw8	9 Aug 2020	Timestamp available.	Original
Google Images	https://www.reddit.com/r/ImaginaryLandscapes/comments/1oyplfb/landscape_by_philipp_a_urlich/	16 Nov 2025		Repost
Google Images	https://danbooru.donmai.us/posts/11171297	16 Apr 2026		Repost
Google Images	https://www.iwakuroleplay.com/threads/where-the-wanderers-go.213394/	30 Mar 2026	Supportive imaging.	Repost
TinEye	https://imgur.com/1C8XSTD	14 Oct 2023		Repost
	https://www.instagram.com/p/CDs3ic1jc_a/	10 Aug 2020		Original

Regarding AI-generated artwork (fig. 14 (right)), no exact match is found using TinEye, Google Images and Yandex. Although, there were many similar ones. To find the source of the artwork, the file name (makikoshop-artwork-1.jpg) is used as point of investigation. Searching for MakikoShop on Google, resulted in the source websites.

Table 3: Postings of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Source	Link	Date	Notes	Reposting
File name search	https://www.artstation.com/artwork/98k5kq	21 Dec 2024		Original
File name search	https://makikoshop.artstation.com/projects/98k5kq	21 Dec 2024	Hosted by ArtStation.	Original
File name search	https://www.redbubble.com/i/poster/Majestic-Mountain-Valley-with-Waterfalls-by-MakikoShop/167308349/flk2	Unknown	Artwork available on different products (36+).	Original

Conclusion

From this research, it can be concluded that the digital artwork was originally posted by the Swiss artist Philipp A. Urlich, also known as *Somartist*. The artwork was first posted on the 9th of August 2020 on ArtStation, on Urlich's personal account. The artwork was also later posted on his personal website, urlich.art (hosted by ArtStation) and on his personal Instagram account. In recent years, the artwork has been reposted by other accounts on several websites, including wallpaper downloading sites. The artwork is not connected to a blockchain and is not an NFT.

The AI-generated artwork could not be found with reverse image tools. This is likely due to the image not being well spread. When reverse image searches were performed, many very similar images were shown, indicating that the work lacks uniqueness, which may make it hard to find (see figure 16). After searching the file name on Google, multiple websites where the work is posted were found. These websites are mainly shops where you can buy several products with the artwork printed on them. The work is uploaded by an account named MakikoShop based in Brisbane, Australia. The artwork was originally posted on 21 December 2024. There are no known repostings.

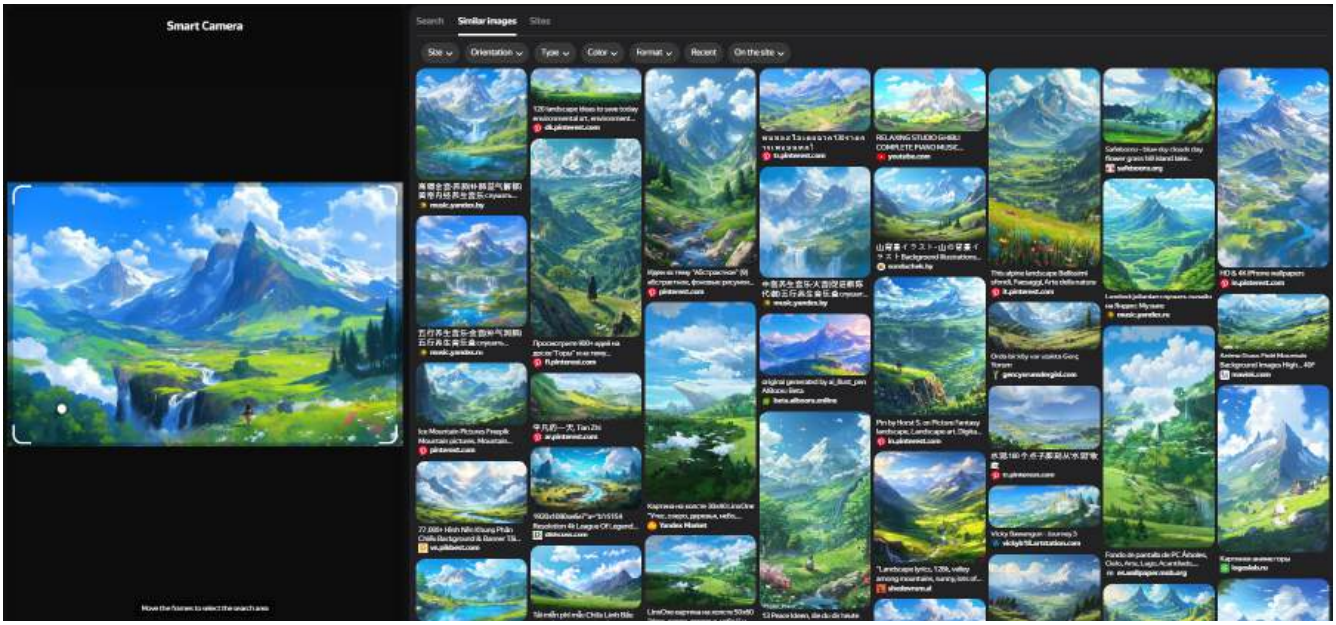

Figure 16: Results of reverse image search engine Yandex regarding Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Visual Analysis

Report Digital Artwork

General. The digital artwork (fig. 14 (left)) shows a valley landscape emersed in shadows. In the center of the artwork is a small creek surrounded by grass and trees. Mountains are visible in the background and sides of the frame. There is a big and nearly visible mountain lurking in the background. In the top half, many clouds are visible. A round, unblended digital brush is used. The brushstrokes are visible and unrefined. They are lightly see-through, giving the illusion of colors blending, even though no blending tools are used (see fig. 56). There does not appear to be a signature.

Main Claim. The leftmost mountain is the main focus of the painting.

Support. This main claim is supported by the lighting used. Sunlight shines through the uppermost part of the frame down to the side of the mountain, making that section of the painting brighter, drawing the eye in. Here, there are more and smaller brushstrokes, making it more detailed than the rest of the work.

Comparison Digital Artwork

It is very common for Philipp Urlich to make mountain landscapes. Some artworks, especially the newer ones, show more detailed and blended brushstrokes. But there are many works, especially

Figure 17: Upper-middle area of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

those from around the same time period, that show the same technique applied with similar themes. Furthermore, the trees made with this method appear very similar (see fig. 18).

Figure 18: (left) Mountain Valley, Philipp A. Urlich (2022) [Url22], (middle) Mountain Side, Philipp A. Urlich (2023) [Url23], (right) On a journey, Philipp A. Urlich (2021), [Url21].

Report AI-Generated Artwork

General. AI-generated artwork (fig. 14 (right)) shows a cliffside landscape with mountains in the background. The farthest mountains appear to be snowy. The foreground shows a human-like character facing towards the mountain. To the left of the character, there is a waterfall with the water disappearing into treetops. The creek attached to the waterfall disappears into the background. At the foot of the mountain there is something that appears to be a village, but this is not clearly visible (fig. 19). Based on the shadows, the lighting appears to come from the top right corner. The brushstrokes are textured and sporadic, with the paint strokes randomly placed without clear intention. There does not appear to be a signature.

Main Claim. The character at the bottom of the painting is the subject.

Figure 19: Center area of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Support. There is a color contrast between the character at the bottom and the rest of the painting. In comparison to the vibrant greens and blues of the painting, the figure is colored with brown and beige, making it stand out. The details and brushstrokes used to make the character are significantly different from the rest of the painting. This makes it visually stand out, even though the figure is quite small.

Comparison AI-Generated Artwork

The artworks uploaded by MakikoShop are thematically broad. There are many nature-based artworks of a similar style (see fig. 20 (middle)), but also very different works centering around portraits in a cartoon, or abstract style (see fig. 20 (left) and fig. 20 (right)). These works are very different compared to the AI-generated artwork by MakikoShop in question. The artworks in the collection that have a similar theme use the same type of brushstrokes with sporadic elements.

Figure 20: (left) Breaking Point, MakikoShop (2025) [Mak25b], (middle) Golden Fields at Sunset, MakikoShop (2025) [Mak25c], (right) Be You, Be Cool, MakikoShop (2025) [Mak25a]

Semantic Coherence

The digital artwork in question has quite simplistic elements. The trees, mountains and the creek are semantically well placed within the painting. The placement of the mountain in the background

is less logical. It blends in with the clouds, making it barely visible. The size makes the viewer question the scale. Compared to the trees, the highlighted mountain is already very large, which would make the bigger mountain all the way in the background astronomical in size.

The AI-generated artwork in question has a lot of elements, making it difficult to focus on one specific part of the painting. The placement of the waterfall is highly unrealistic, making the painting feel fantastical. Semantically, the bending of the foreground and the middleground is slightly off, making the depth hard to grasp. The small patch of pine trees does not make sense if you consider the other trees and the coloring. It does not have a strong sense of intention.

Conclusion

Both artworks match with the portfolio of the artist as appears on ArtStation, but the digitally painted artwork does more so. The digital artwork (fig. 14 (left)) has many similarities to other artworks of Philipp A. Urlich. The AI-generated artwork (fig. 14 (right)) is similar to some works by MakikoShop, whose portfolio is much more diverse.

Semantically, there are more different elements in the AI-generated artwork by MakikoShop than in the digital artwork by Philipp A. Urlich. Considering how these elements are placed, the digitally painted artwork gives a better sense of coherence, although not perfect.

Modus Operandi

Artist Profile of Digital Artwork

Philip A. Urlich is a digital artist based in Schaffhausen, Switzerland. He has worked as an environment concept artist at multiple companies, including game studios. He has an art and graphic design degree obtained in Zürich. He has been actively working on his current portfolio since 2019, which as of now contains over 600 works on ArtStation. He describes his work as 'fantastic imaginative and realistic or stylized landscapes' [Urlnda] [Urlndb]. He occasionally streams the creation of his artworks on the platform Twitch [Urlndd]. As of writing this, he has 34.1K followers and 785 posts on Instagram [Urlndc].

Artist Profile of AI-generated Artwork

MakikoShop does not have a lot of personal information available. On ArtStation is stated that they are based in Brisbane, Australia. Skills are noted as Digital Art and AI Art. Furthermore, it states that they do freelance work [Maknda]. At the end of 2024, they joined Redbubble, where they state 'I create vibrant, AI-generated, and artist-refined designs inspired by nature, anime, and modern aesthetics' [Makndc]. Social media is mentioned for behind the scenes content, but there is only a Pinterest page linked with no additional content [Makndb]. All artworks are for sale in different forms. This includes clothes, posters, phone cases, and more.

Platform Profile of Digital Artwork

ArtStation will be considered the original posting platform. It is a platform with the primary purpose for artists to easily create and showcase an online portfolio of their artworks. This includes images, videos, 2D art, 3D art, and more. Other features allow the artist to have a blog, online

store and a personalized website. It is free, but there are tiered subscriptions where you unlock more features with a monthly fee. It was founded in 2014. Videogame and software developer and publisher Epic Games acquired ArtStation in 2021 [Tra26]. The search function allows you to filter artworks based on whether they were created with AI.

Platform Profile of AI-generated Artwork

The AI-generated artwork by MakikoShop has ArtStation as the original posting platform as well. For the profile, see section .4 (Platform Profile of Digital Artwork).

Digital Artwork Profile

Not a lot of information is provided on the digital artwork in question (fig. 14 (left)), except for a small caption reading *Landscape scratching* [Url20]. Some works have a sped-up screen recording of the painting process attached to his website, but this specific painting does not. It does, however, have sketches uploaded on the ArtStation page and on his personal website (see fig. 21). As of writing this, the artwork has almost 900 likes, 1 comment, and 18.6K views on ArtStation.

Figure 21: Sketches of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

AI-generated Artwork Profile

There is no further information available about this specific artwork than stated in section .4 (Tools and Techniques of AI-generated Artwork). As of writing this, the artwork has one like, no comments, and 12 views on ArtStation [Mak25d].

Tools and Techniques of Digital Artwork

In Urlich's biography, he states to work with the softwares Krita, Photoshop, zBrush, Cinema4d, Blender, and UE. The specific software used for the artwork in question is not clearly stated

[Urlndb]. On his website, he states that he uses Krita as painting software for all his digital work. Therefore, it can be assumed that this specific artwork has been made using Krita as well. Further, he states the hardware he uses is a Wacom Intuos Pro M and a Cintiq Pro 24". Both are drawing tablets.

Tools and Techniques of AI-generated Artwork

The software used, as stated on ArtStation, is Midjourney and Photoshop [Maknda]. It is unclear if the artwork is primarily created with the AI image generator Midjourney and later edited by the artist with Photoshop or is purely AI-generated. MakikoShop does state that the artwork is AI-generated and artist-refined, but the precise meaning of this is unclear, as there is no further information about their methodology available.

Conclusion

There is much more information about the artist and creation of the artwork available from Philip A. Urlich than from MakikoShop. Regarding Urlich, it can be concluded that art is his profession and livelihood, which does not appear to be the case for MakikoShop. This could be a reason why Urlich provides more insight and background in comparison to MakikoShop.

Technical Analysis

Metadata Assessment of Digital Artwork

The EXIF metadata of the digital artwork is fairly minimal and generic (table 4). It has little provenance available. There is no artist, copyright, software, dating, or edit history information. All other data is typical for a JPG image.

Table 4: EXIF metadata of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

Original download location*	https://www.artstation.com/artwork/48Nvw8	
Name	philipp-a-urlich-cpncept220.jpg	
File type	JPEG	
MIME type	image/jpeg	Confirms JPEG container type.
Size	881.54 KB (902.694 bytes)	Moderate JPEG compression for the size.
Image dimensions	3000 x 1200 (3.6 megapixels)	Moderate resolution.
Checksum	86578654c097cfb2514 d4592bd5a9b96	Unique file fingerprint. MD5-style hash.
Bits Per Sample	8	Standard 8-bit per channel image depth.

Color Components	3	Three channel color image.
Color Space	Uncalibrated	No ICC profile or tag. Suggests lightweight or stripped export.
Components Configuration	Y, Cb, Cr, -	Standard JPEG color channel layout.
Encoding Process	Baseline DCT, Huffman coding	Standard compatible JPEG encoding.
Exif Byte Order	Little-endian (Intel, II)	Internal EXIF storage format.
Y Cb Cr Positioning	Centered	Standard JPEG chroma positioning.
Y Cb Cr Sub Sampling	YCbCr4:4:4 (1 1)	Full chroma detail retained with 4:4:4.
Metadata size	190 bytes	Very little metadata.
Flashpix Version	0100	EXIF compatibility tag. Image passed through standard EXIF capable software pipeline

*Not available from EXIF metadata

Metadata Assessment of AI-Generated Artwork

The EXIF metadata extracted from the AI-generated artwork (table 5) is even less than that of the digital artwork. Similarly, there is little provenance available. There is no artist, copyright, software, dating, or edit history information. All other data is typical for a JPG image.

Table 5: EXIF metadata of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Original download location*	https://www.artstation.com/artwork/98k5kq	
Name	makikoshop-artwork-1.jpg	
File type	JPEG	
MIME type	image/jpeg	Confirms JPEG container type.
Size	544.38 KB (557440 bytes)	Moderate JPEG compression for the size.
Image dimensions	1920 x 1280 (2.5 megapixels)	Moderate resolution.

Checksum	4f447e65b1496a38cba9e025f7848e9e	Unique file fingerprint. MD5-style hash.
Bits Per Sample	8	Standard 8-bit per channel image depth.
Color Components	3	Three channel color image.
Encoding Process	Baseline DCT, Huffman coding	Standard compatible JPEG encoding.
Y Cb Cr Sub Sampling	YCbCr4:2:0 (2 2)	Standard JPEG compression. Reduces color detail and file size.
Metadata size	18 bytes	Extremely little metadata.
JFIF Version	1.01	Standard JPEG interchange format version.

*Not available from EXIF metadata

Watermark Assessment of Digital Artwork

The conclusion of all the watermark detectors was negative. This includes a signature.

Using JoyCaption Watermark Detection, both the YOLO and the OWLLv2 models detected no watermarks. Gemini, using SynthID, concluded that the image was not made with Google AI. It does not rule out AI tools, but does suggest that, taking into account the file name (philipp-a-urlich-cpncept220.jpg), the digital painting is made by Philipp A. Urlich. Nyckel's watermark checker categorized the artwork as unwatermarked with 72.50 percent confidence.

Watermark Assessment of AI-Generated Artwork

The conclusion of all watermark detectors was negative. This includes a signature.

Using JoyCaption Watermark Detection, the OWLv2 Prediction was 'Not Watermarked'. The YOLO detection model, however, does spot a watermark with 60 percent confidence in the bottom left corner (fig. 22). After inspection, this gets classified as a false positive, which often happens with the model. Gemini, using SynthID, concluded that the image is not made with Google AI, but cannot provide further conclusions. In addition, it says that it did not detect any further visible watermarks and that it does have characteristics of various AI models. Similar to the digital artwork, Nyckel's watermark checker categorized the artwork as unwatermarked with 72.50 percent confidence.

Figure 22: Watermark detection results using YOLO model of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

Steganography assessment of Digital Artwork

Decomposition:

Figures 23, 24, 25, 26, and 27 show the decompositions of the digital artwork. No hidden images are observed.

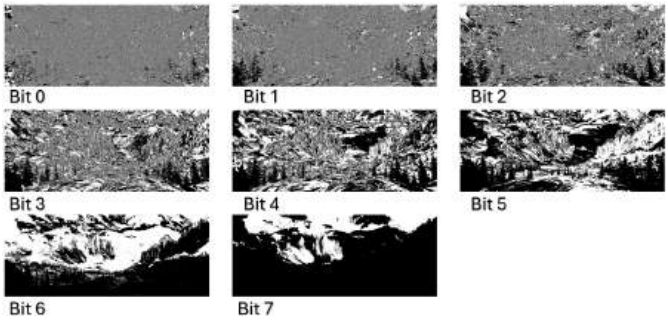

Figure 23: Decomposition of red for all 8 bit planes of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

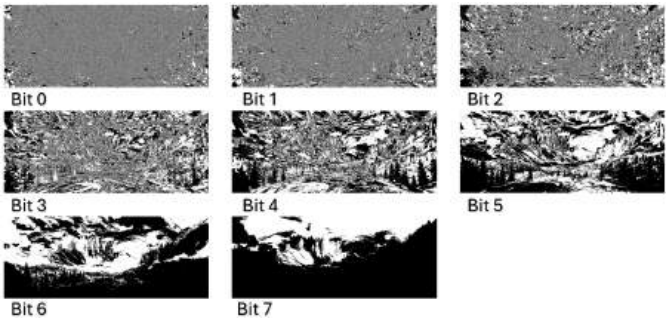

Figure 24: Decomposition of green for all 8 bit planes of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

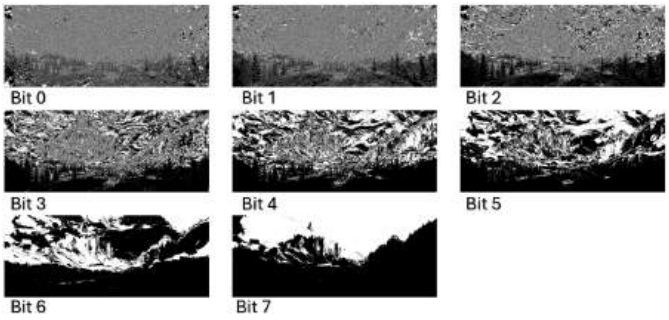

Figure 25: Decomposition of blue for all 8 bit planes of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

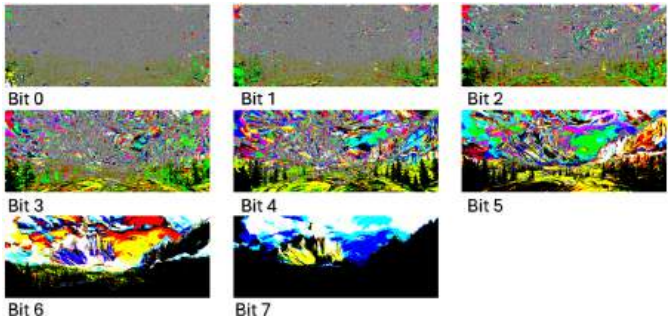

Figure 26: Superimposed decomposition for all 8 bit planes of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

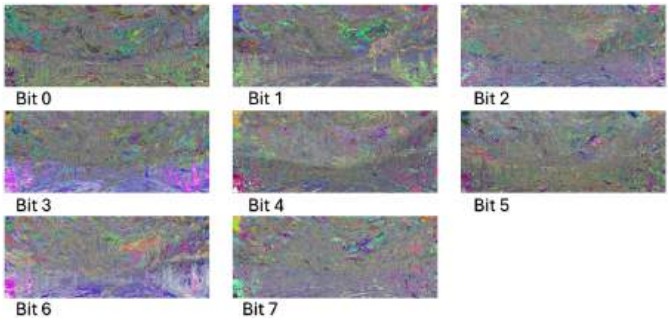

Figure 27: Color remapping decomposition for all 8 bit planes of Landscape, Philipp A. Urlich (2020), digitally painted [Url20].

Zsteg: Because the artwork was available for download only in a JPG format instead of a PNG, Zsteg cannot be used.

Steghide: No extracted data

Outguess: Reading ../86578654c097cfb2514d4592bd5a9b96.jpg.... Extracting usable bits: 977979 bits Steg retrieve: seed: 36291, len: 53752
After looking at the hexdump with Boxentriq, it is most likely that there is no hidden message in the extracted data. It is essentially random noise from the DCT coefficients. The hexdump has no

readable structure, and the signature shows application/octet-stream, which is the generic fallback for unrecognized binary.

Binwalk: No extracted data. Either no utility was found or it is unimplemented.

Foremost: 1 file extracted: ../86578654c097cfb2514d4592bd5a9b96.jpg Length: 881 KB (902694 bytes)

The file extracted by Foremost is the same image as the original artwork. Foremost scans for known file signatures within a file. In this case, it found a JPEG signature inside the file, which was the file itself. No additional files were found. The file name is the same as the checksum as noted in table 4.

Strings: No meaningful strings pulled. It is essentially noise, typical JPEG artifact strings.

Steganography assessment of AI-Generated Artwork

Decomposition:

Figures 41, 42, 43, 44 and 45 show the decompositions of the AI-generated artwork. No hidden images are observed.

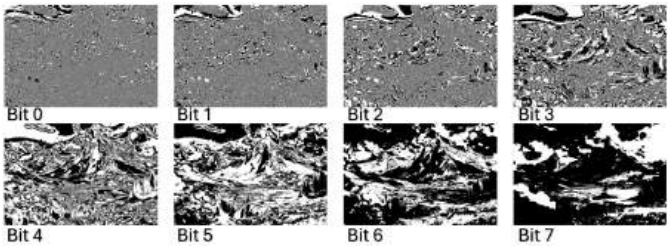

Figure 28: Decomposition of red for all 8 bit planes of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

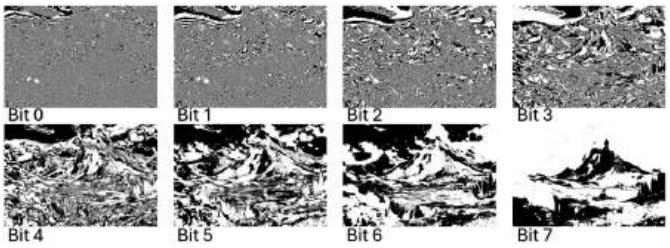

Figure 29: Decomposition of green for all 8 bit planes of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

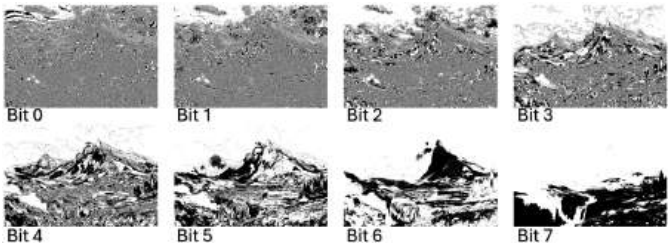

Figure 30: Decomposition of blue for all 8 bit planes of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

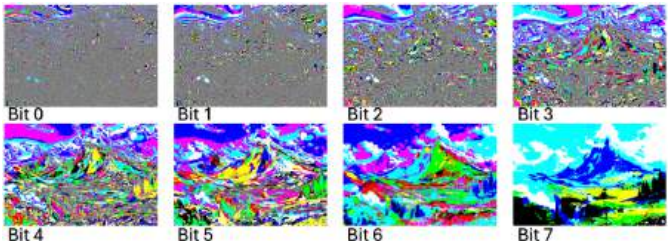

Figure 31: Superimposed decomposition for all 8 bit planes of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

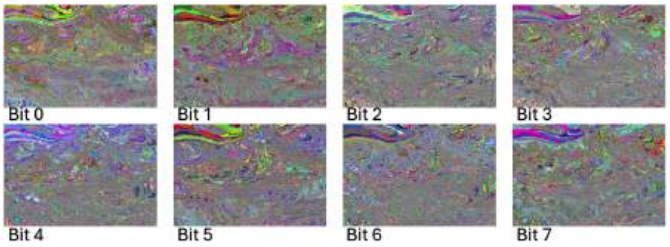

Figure 32: Color remapping decomposition for all 8 bit planes of Majestic Mountain Valley with Waterfalls, Makikoshop (2024), AI-generated [Mak25d].

Zsteg: Because the artwork was available for download only in a JPG format instead of a PNG, Zsteg cannot be used.

Steghide: No extracted data

Outguess:Reading ../4f447e65b1496a38cba9e025f7848e9e.jpg.... Extracting usable bits: 595239 bits Steg retrieve: seed: 23812, len: 53027
The interpretation of the Outguess output is the same as the interpretation mentioned regarding the digital image. There is no hidden message.

Binwalk: No extracted data. Either no utility was found or it is unimplemented.

Foremost: 1 file extracted: File: ../4f447e65b1496a38cba9e025f7848e9e.jpg Length: 544 KB (557440 bytes)
This is the same case as for the digital image. The file extracted by Foremost is the same image as the original artwork. No additional files were found. The file name is the same as the checksum as noted in table 5.

Strings: No meaningful strings pulled. It is essentially noise, typical JPEG artifact strings.

AI Detection Assessment of Digital Artwork

The combined result of the AI image detectors used is that the digital artwork is not AI-generated.

SightEngine: Not likely to be AI-generated or Deepfake. GenAI 3%, Face manipulation 0%.

HiveModeration: This input is not likely to contain AI-generated or deepfake content, 0% likely to be AI-Generated Image, 0% likely to be Deepfake.

ZeroGPT: his image is likely real 68% REAL, AI Likelihood: 32%, Confidence: Low, Classification: Real.

AI Detection Assessment of AI-Generated Artwork

The combined result of the AI image detectors used is that the AI-generated artwork is AI-generated.

SightEngine: Likely AI-generated. GenAI 98%, Face manipulation 0% (kling 44%, MidJourney 23%, Stable Diffusion 11%).

HiveModeration: This input is likely to contain AI-generated or deepfake content, 92.1% likely to be AI-Generated Image, 0% likely to be Deepfake (midjourney: 58.4%, adobefirefly: 29.1%, dalle: 1.5%).

ZeroGPT: This image is likely created by AI 94% FAKE, AI Likelihood: 94%, Confidence: High, Classification: Fake.

Conclusion

Because both images are downloaded from the same website, similarities are unavoidable in how data is handled and presented. This is especially true with steganography and watermark detection.

The EXIF metadata does show some differences. For example, the AI-generated artwork has less data available. The digital artwork includes additional technical tags such as the Flashpix version, YCbCr positioning, and more detailed JPEG structural metadata. It also uses 4:4:4 chroma subsampling, which preserves full color detail and is typically associated with higher quality or deliberately controlled exports. This is often seen in manually created digital artwork workflows. This suggests that the file likely originated from a more feature complete export process that preserved standard EXIF/JPEG metadata blocks.

The EXIF metadata in the AI-generated image is highly stripped. It lacks most EXIF-specific fields, such as byte order, component configuration, and explicit color space metadata. It also uses 4:2:0 chroma subsampling. This is a more aggressive compression method commonly associated with web-optimized or automatically processed images. This indicates that the file likely passed through a recompression or distribution pipeline that removed or did not preserve embedded metadata.

Classification

Digital artwork

The authenticity of the digital artwork is quite clear, scoring an 7.5 on the rubric (see fig. 33). There is a lot of information available about the artist and this artwork, but not a lot within the artwork itself.

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 33: Rubric digital artwork case study 1

AI-generated artwork

There is not a lot of information available, and the information that is available is hard to verify. In the rubric, the AI-generated picture gets a score of 4 (see fig. 34).

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 34: Rubric AI-generated artwork case study 1

.5 Case Study 2

Figure 35: Artworks for case study 2: (left) Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24]. (right) Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Provenance

Blockchain

Using the reverse NFT finder Nyckel, no results came up regarding the two images. See figure 36.

Figure 36: (left) Results from NFT checker Nyckel of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23] and (right) Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

Reverse Image Search

The reverse image searching sources used are Yandex AI, TinEye and Google Images. The unique and working websites which are found of the digital and AI-generated painting are in table 6 and 7.

Pictures are notated as a repost when there is no direct affiliation with the creator. Otherwise, they are noted as unclear. If there is a direct link to the artist, they are noted as original. Yandex and TinEye showed no direct results regarding the digital artwork. An exact match of the AI-generated image was only found with Yandex.

Table 6: Postings of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

Source	Link	Date	Notes	Reposting
Google Images	https://www.instagram.com/p/DFNmtacx5q3/?img_index=4	24 Jan 2025	Poster: lvcidia.xyz	Repost
Google Images	https://thursd.com/articles/alycia-rainaud-of-maalavidaa	19 Nov 2025	Article, alternative language pages.	Repost
Google Images	https://www.instagram.com/p/C7zLF4RsZj-/	4 Jun 2024		Original
Google Images	https://shop.maalavidaa.com/products/belladonna-of-sadness-print	14 Jul 2024		Original

Source	Link	Date	Notes	Reposting
Google Images	https://www.redbubble.com/i/canvas-print/Floral-Watercolor-Mizuno-Logo-Burst-by-Yakupjukid/171479764/5mul	Unknown	Stolen design for sale by Yakupjukid.	Repost

Table 7: Postings of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Source	Link	Date	Notes	Reposting
Yandex	https://shedevrum.ai/en/post/5a26fcb589cc11eeb06f7a2f0d1382ba/?utm_medium=organic&utm_source=yasmartcamera	23 Nov 2023	Alternative languages available.	Original

Conclusion

The digital artwork (fig. 35 (left)) is painted by Alycia Rainaud, also known as 'Maalavidaa'. She is from France and is based in Canada. The artwork was first posted on Instagram on June 4, 2024. She has 192K followers on the platform. The post has about 15K likes. The artwork is titled *Belladonna of Sadness* and is available for sale on Rainauds personal website.

The AI-generated artwork (fig. 35 (right)) is created by the user Rich Caravan and is posted on the website Shedevrum. On this website, AI-generated images can be created using YandexART. Rich Caravan has created 3.1K posts and has 611 subscribers. The artwork in question has four likes.

Visual Analysis

Report Digital Artwork

General. The digital painting is in a vertical format. In the center, it shows a mainly pink and orange flower. It appears to be floating in space, since the background is black with white dots in certain areas. The flower is surrounded by saturated color spills of greens, purples, yellows, pinks, blues, and other colors. The colors merge into each other and from the flower. There are dots and other shapes in and on top the color spill. There is barely any brushwork visible. Colors are intentionally separated, or blend seamlessly into each other.

Main Claim. The flower is floating in space.

Support. The flower, the main subject of the artwork, does not appear to be attached to anything. There is no stem in the painting. This gives the effect that it is floating. Behind the color layer, the background appears to be black, creating a stark contrast. The way the colors flow

gives the image a nebula-like effect, with the flower in the center. This supports the claim that the background is space. The white dots spread through the painting can be classified as stars. Combining these factors makes the flower appear to be floating in space.

Comparison Digital Artwork

Figure 37 shows a snippet of Alycia Rainaud's Instagram page (@maalavidaa) [Rai24] from around the same time that she made the painting in question. Generally, all her artworks have the same characteristic color spill and color blending. Many also appear to have a space-like background and have a central flower theme. The flower in the artwork in question is a bit more defined than the flowers present in other works, but there overall themes match.

Figure 37: Collection of Instagram posts by @maalavidaa [Rai24]

Report AI-Generated Artwork

General. The AI-generated image shows a colorful neon flower on a black background. In the center is a bright flower made out of yellow and white light that radiates outward into streaks of magenta, cyan, blue, orange, and purple. The composition creates the impression of motion and energy, resembling at some places paint or light erupting from a central point.

Main Claim. The central flower is made out of light.

Support. The artwork has an intense glow, radiant colors, and a lack of solid physical texture. The center of the flower shines brightly in yellow and white. This makes it look like it emits light outward rather than reflecting it. The petals are formed by streaks of neons that resemble beams or trails of energy. The soft blending and glowing edges give the flower an almost electric appearance, making it seem as though it is constructed from light.

Comparison AI-Generated Artwork

On Rich Caravans Shedevrum profile, there are over three thousand posts [Carndb]. The posts from just before and after the artwork in question are very similar (see fig. 38). Posts from other moments are vastly different. The posts in figure 39 are posted only a few days before the AI-generated artwork in question. Almost all posts do share the fact that they have one central subject.

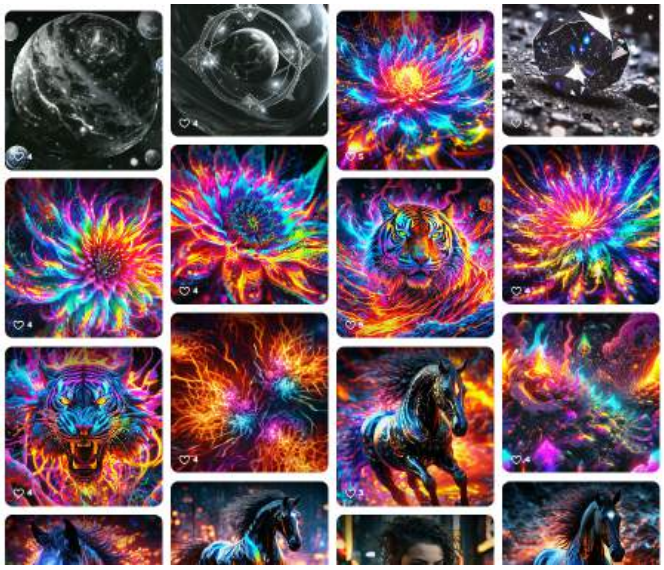

Figure 38: Posts on Shedevrum by Rich Caravan

Semantic Coherence

Both images do not have many elements next to main subject (the flower). Still, there is more material coherence in the digital image. Although different parts of the work show different techniques and textures, it looks intentional. The bottom left shows some more organic round shapes, which contrasts with the flowing colors. These dots do appear slightly in the top right of the work, tying it together. With the AI-generated image, it looks like it tries to resemble light, but if you look closer to the edge of the flower, it behaves like paint. This disrupts the coherence when inspecting the painting closer.

Conclusion

The digital painting (fig. 35 (left)) closely resembles other paintings by Alycia Rainaud. She has a clear art style and her method is very recognizable. The use of a more detailed flower makes this piece unique. Rich Caravan has many different works. Because of the AI-generated nature of the artworks, there is hardly a stylistic overlapping. Most posts do appear to have a central subject. He does have AI-generated artworks on his page, which are very similar to the AI-generated artwork in question (fig. 35 (right)). Both artworks are not completely uniform in what the colors appear to be. With Rainauds artwork, this feels more intentional than with Rich Caravans artwork.

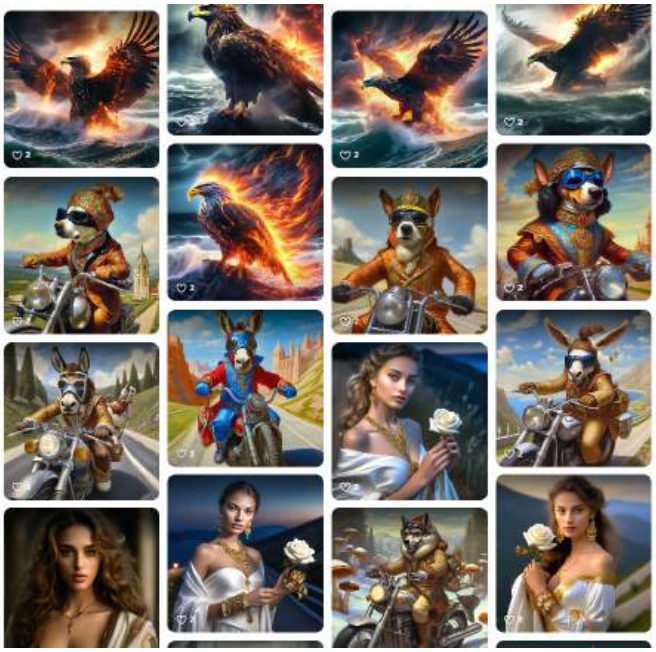

Figure 39: Posts on Shedevrum by Rich Caravan

Modus Operandi

Artist Profile of Digital Artwork

Alycia Rainaud has been creating art using the name Maalavidaa since 2016. She is a French graphic designer and digital artist based in Montreal [Raindd]. On her website, she states that her artwork is inspired by Jungian therapy, color therapy, and meditation. In 2018, she graduated with a masters degree in graphic design in France. Currently, she is the creative director of the Canadian non-profit art gallery *0x Society* [0x nd] and the founder of *Heal The Deal: The Web3 Emotional Support Club* since 2021 [Rainda]. *Heal The Deal* is an NFT-based emotional support community. Alycia Rainaud is involved with crypto and does sell her works occasionally as NFT's online via SuperRare or *Heal The Deal*. On SuperRare, her highest sale price is 66.0K USD [Raindc]. The artwork in question is not part of her NFT collection. her main platform for posting her artworks is Instagram. On Instagram, she has 190K followers and, as of writing this, over two thousand posts. Her first post is from November 12, 2016 [Rai24]. In contrast to her recent posts, her oldest posts are mainly in black and white. She has collaborated with multiple brands, including BMW, Shein and Lush [Raindb]. In addition, she occasionally teaches online classes and sells products regarding her artwork in her webshop.

Artist Profile of AI-generated Artwork

Rich Caravan does not have much information available. On his Shedevrum page, he has 642 subscribers, 4.0K likes and 3.1K posts [Carndb]. Most of the posts do not have any interactions, such as comments or likes. Posting dates range from November 2, 2023 to August 13, 2025. He appears to have another account with the same name and profile picture [(alnd]. This account has 107 subscribers, 4.6K likes, and 580 posts. This account has a more positive like to post ratio.

On this account, posting dates range from October 15, 2023 to November 1, 2023. There is also a TikTok account with username @rich.caravan and the same profile picture [Carnda]. On this account, there are posts ranging from 2023 to today. As of now, he has 47.9K followers and 946.2K likes on TikTok.

Platform Profile of Digital Artwork

The digital artwork was posted on Instagram by the artist Maalavidaa. Instagram is a well known and widely used social media platform that allows artists to share their work, interact with audiences, and establish a public portfolio. The platform records posting dates, user profiles, and captions. Although Instagram does not verify the creation process of uploaded images, it can help establish a timeline of publication and connect artworks to a specific artist account.

Platform Profile of AI-generated Artwork

Shedevrum is an AI-art generator as well as a community platform. The beta version was launched in April 2023 by Yandex, a Russian technology company providing a myriad of internet provided products. On the website, you can generate up to 70 images a day. On the app, there are no restrictions. The platform allows you to generate images and videos. Subsequently, you can share, or post them on the platform itself. When posted, you can gain likes and other users can leave comments or download the post. You can browse AI-generated posts by other users and you can subscribe to them or add them as a friend. Optionally, posts has the used generation prompt included.

Digital Artwork Profile

The painting was posted on Instagram on June 4, 2024 and, as of writing this, has 14.8K likes [Rai24]. It is pinned to the top of her page. The caption reads:

> *All I wanted was to be the flower you'd pick out of the bouquet*

AI-generated Artwork Profile

This image, posted on November 23, 2023, has four likes as of now. It has no comments [Car23]. The prompt used to generate the image is posted alongside the image:

> *flower neon solar explosion of rainbow lava water rainbow matter fog cobwebs ocean detailed drawing fractal , neon lighting 64k surrealism hyperdetalization hyperreal volcanic cracks brightest colors*

Tools and Techniques of Digital Artwork

No documentation for the process used to create *Belladonna of Sadness* is available. In interviews, she has discussed her general method. It starts with physical paint. She uses pour-over techniques using inks and acrylics to create dynamic shapes. These paintings get photographed and further edited using Photoshop, cinema 4D, or Processing to add the colors and details to the painting. In clips, she is also seen using Procreate on an Ipad [Roo22].

Tools and Techniques of AI-generated Artwork

The image is created using AI-image generator YandexART. Because of the date the post was made, it was generated with one of the earlier YandexART models. With more current posts, the model is stated in the post. In this instance, this is not the case. In late 2023, YandexART advertised the use cascade diffusion architecture and to be trained on roughly 330 million image-text pairs [Yan23]. The website instructs you to write a prompt and choose an aspect ratio. After showing you an advertisement, you can edit the image, post it, share it, or download it.

Conclusion

Regarding Maalavidaa's digital artwork, there is not a lot of information available. There is, whoever, a lot of information available about herself. She is a french artist based in Monteal. She creates digital paintings, which start out as traditional paintings, and posts them mainly on Instagram. Occasionally, she sells them as NFT's.

The AI-generated artwork is one of 3K posts by user Rich Caravan on Shedevrum, a Russian AI-generator and community platform. The image is generated in 2023 using their model YandexArt.

Technical Analysis

Metadata Assessment of Digital Artwork

The EXIF metadata regarding the digital artwork (table 8) makes it clear that the image is downloaded from the Thursd article. The metadata shows the editor of the company, the use of Canva, and the advertisement details. The rest of the EXIF metadata is quite standard.

Table 8: EXIF metadata of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

Original download location*	https://thursd.com/articles/alycia-rainaud-of-maalavidaa	
Name	Details-of-a-flower-in-neon-colors.jpg	
File type	JPEG	
MIME type	image/jpeg	Confirms JPEG container type.
Size	336 KB (343911 bytes)	Moderate JPEG compression for the size.
Author	Melissa Maingot Gerstein	The content editor at Thursd, where the image was downloaded.
Creator Tool	Canva (Renderer)	The image was rendered/exported by Canva.
Image dimensions	900 x 1200 (1.1 megapixels)	Moderate resolution.

Checksum	996ec333e52e7af98a16e2052a7e3742	Unique file fingerprint. MD5-style hash.
Bits Per Sample	8	Standard 8-bit per channel image depth.
Color Components	3	Three channel color image.
Color Space	Uncalibrated	No ICC profile or tag. Suggests lightweight or stripped export.
Components Configuration	Y, Cb, Cr, -	Standard JPEG color channel layout.
Encoding Process	Baseline DCT, Huffman coding	Standard compatible JPEG encoding.
Exif Byte Order	Little-endian (Intel, II)	Internal EXIF storage format.
Y Cb Cr Positioning	Centered	Standard JPEG chroma positioning.
Y Cb Cr Sub Sampling	YCbCr4:2:0 (2 2)	Half horizontal and half vertical color resolution with 4:2:0.
Metadata size	3.7 KB	Moderate amount of metadata.
Flashpix Version	0100	EXIF compatibility tag. Image passed through standard EXIF capable software pipeline
Ads Created	2024-10-28	Ad creation date
Ads Ext Id	1	Internal advertising identifier
Ads Fb Id	525265914179580	Likely Facebook advertising ID
Ads Touch Type	2	Advertising workflow parameter

*Not available from EXIF metadata

Metadata Assessment of AI-Generated Artwork

The EXIF metadata for the AI-generated image (table 9) indicates that the image is a fully color managed JPEG that includes an embedded ICC profile. The profile is defined as an sRGB display device profile with a Profile Connection Space of XYZ. The presence of an embedded ICC profile ensures consistent color reproduction across different devices and software environments. The

copyright attribution to "Google Inc. 2016" refers to the standard sRGB color profile distributed by Google. It is widely used in modern imaging pipelines, particularly in web browsers and Android systems. Unlike simpler or stripped metadata commonly found in social media or advertising exports, this image preserves full color management information, suggesting it passed through a modern web or AI image processing pipeline.

Table 9: EXIF metadata of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Original download location*	https://shedevrum.ai/en/post/5a26fcb589cc11eeb06f7a2f0d1382ba/	
Name	5a26fcb589cc11eeb06f7a2f0d1382ba.jpg	
File type	JPEG	
MIME type	image/jpeg	Confirms JPEG container type.
Size	355 KB (363266 bytes)	Moderate JPEG comp- ression for the size.
Image dimensions	1024 x 1024 (1.0 megapixels)	Moderate resolution.
Checksum	0e2e8f5744c93f0cb6fcf4feae626053	Unique file fingerprint. MD5-style hash.
Bits Per Sample	8	Standard 8-bit color depth per channel.
Color Components	3	Three channel color image (RGB).
Color Space Data	RGB	Image uses the RGB color model.
Profile Description	sRGB	Standard color space used for web and digital displays.
Profile Class	Display Device Profile	ICC profile intended for display devices.
Profile Connection Space	XYZ	Standard ICC color-management connection space.
Profile Version	4.3.0	Version of the embedded ICC profile specification.
Profile Copyright	Google Inc. 2016	Embedded color profile distributed by Google.
Profile ID	0	No unique ICC profile identifier assigned.
Primary Platform	Unknown	No specific operating system platform recorded.

Rendering Intent	Media-Relative Colorimetric	Preserves accurate colors relative to the target medium.
Connection Space Illuminant	0.9642 1 0.82491	Reference white point used for color management.
Media White Point	0.9642 1 0.82491	Defines the profile's white point.
Red Matrix Column	0.43607 0.22249 0.01392	Red primary chromaticity coordinates in the ICC profile.
Green Matrix Column	0.38515 0.71687 0.09708	Green primary chromaticity coordinates in the ICC profile.
Blue Matrix Column	0.14307 0.06061 0.71410	Blue primary chromaticity coordinates in the ICC profile.
Red Tone Reproduction Curve	Binary data (40 bytes)	Gamma/tonal response data for the red channel.
Green Tone Reproduction Curve	Binary data (40 bytes)	Gamma/tonal response data for the green channel.
Blue Tone Reproduction Curve	Binary data (40 bytes)	Gamma/tonal response data for the blue channel.
CMM Flags	Not Embedded, Independent	Profile is self contained and not device specific.
Device Attributes	Reflective, Glossy, Positive, Color	Standard ICC profile characteristics.
Encoding Process	Baseline DCT, Huffman coding	Standard compatible JPEG encoding.
Exif Byte Order	Little-endian (Intel, II)	Internal EXIF storage format.
Y Cb Cr Positioning	Centered	Standard JPEG chroma positioning.
Y Cb Cr Sub Sampling	YCbCr4:2:0 (2 2)	Half horizontal and half vertical color resolution with 4:2:0.
Metadata size	492 Bytes	Very little amount of metadata.

*Not available from EXIF metadata

Watermark Assessment of Digital Artwork

The overall conclusion of all watermark checkers was negative. This includes a signature.

Using JoyCaption Watermark Detection, both the YOLO and the OWLLv2 model detect no watermarks. Gemini, using SynthID concluded that the image is not made with Google AI. It does not rule out other AI tools. Nyckel's watermark checker categorized the artwork as unwatermarked with 72.50 percent confidence.

Watermark Assessment of AI-Generated Artwork

The overall conclusion of the watermark checkers, except Synth ID, was positive.

Using JoyCaption Watermark Detection, the OWLv2 Prediction was 'Watermarked'. YOLO Detection notices the watermark in the bottom right corner with 0.95 percent confidence (see fig. 40). Gemini, using SynthID concluded that the image is not made with Google AI. It does not rule out other AI tools. Nyckel's watermark checker categorized the artwork as watermarked with 72.50 percent confidence.

Figure 40: Watermark detection results using YOLO model of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Steganography assessment of Digital Artwork

Decomposition:

Figures 41, 42, 43, 44, and 45 show the decompositions of the digital artwork. No hidden images are observed.

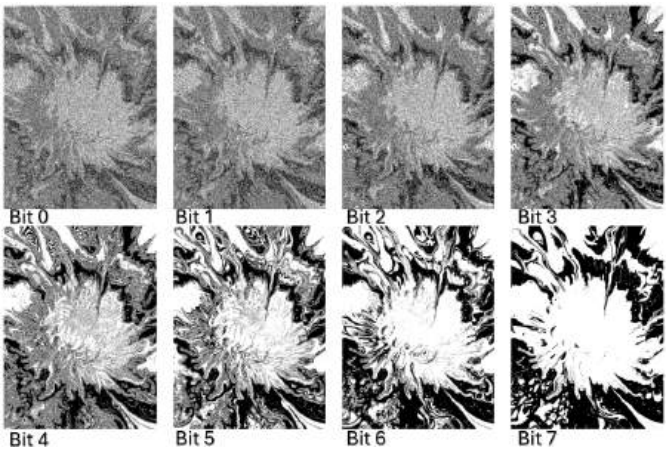

Figure 41: Decomposition of red for all 8 bit planes of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

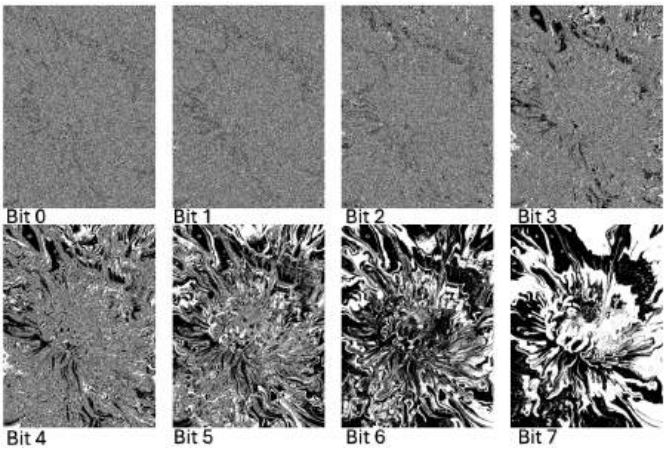

Figure 42: Decomposition of green for all 8 bit planes of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

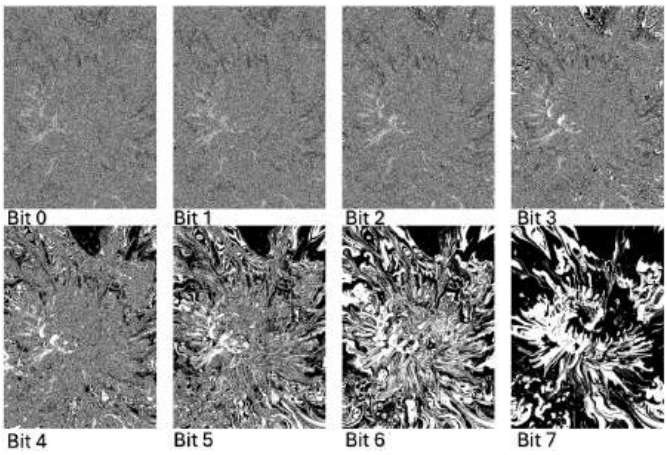

Figure 43: Decomposition of blue for all 8 bit planes of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

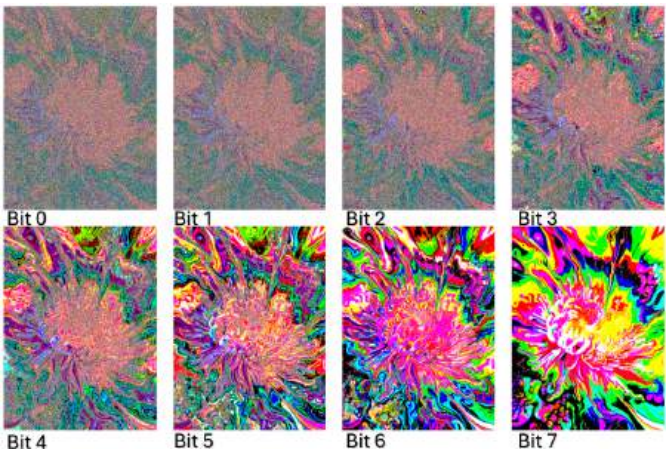

Figure 44: Superimposed decomposition for all 8 bit planes of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

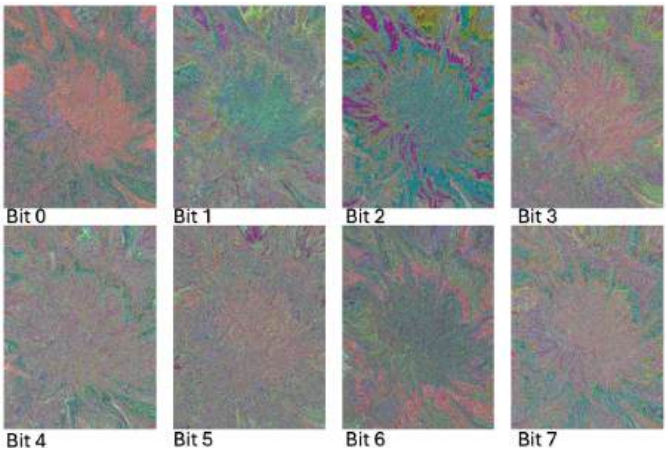

Figure 45: Color remapping decomposition for all 8 bit planes of Belladonna of Sadness, Aycia Rainaud (2024), digitally painted [Rai24].

Zsteg: Because the artwork was available for download only as a JPG instead of a PNG, Zsteg cannot be used.

Steghide: No extracted data

Outguess: Reading ../996ec333e52e7af98a16e2052a7e3742.jpg.... Extracting usable bits: 354590 bits Steg retrieve: seed: 2799, len: 42233
After looking at the hexdump with Boxentriq, it is most likely that there is no hidden message in the extracted data. It is essentially pseudo random noise from the DCT coefficients. The hexdump has no readable structure, and the signature shows application/octet-stream, which is the generic fallback for unrecognized binary.

Binwalk: No extracted data. Either no utility was found or it's unimplemented.

Foremost: Processing: ../996ec333e52e7af98a16e2052a7e3742.jpg—*—
One file was extracted by Foremost. It is the same image as the original artwork. Foremost scans for known file signatures within a file. In this case, it found a JPEG signature inside the file, which was the file itself. No additional files were found. The file name is the same as the checksum as noted in table 8.

Strings: No meaningful strings pulled. It is essentially noise, typical JPEG artifact strings.

Steganography assessment of AI-Generated Artwork

Decomposition:

Figures 46, 47, 48, 49, and 50 show the decompositions of the digital artwork. No hidden images are observed.

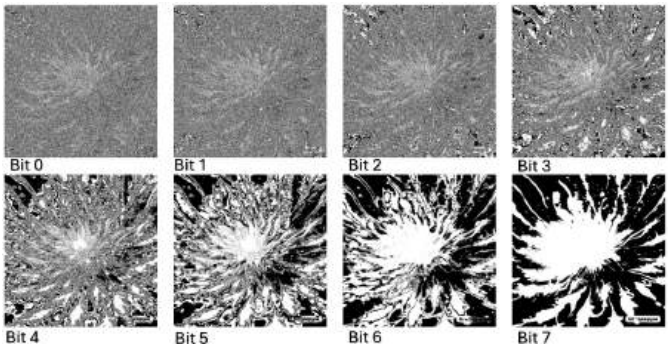

Figure 46: Decomposition of red for all 8 bit planes of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

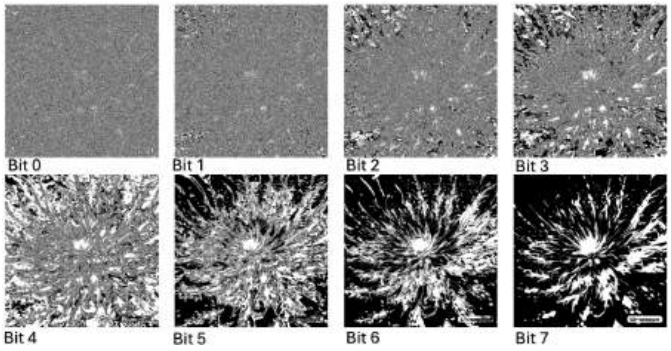

Figure 47: Decomposition of green for all 8 bit planes of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

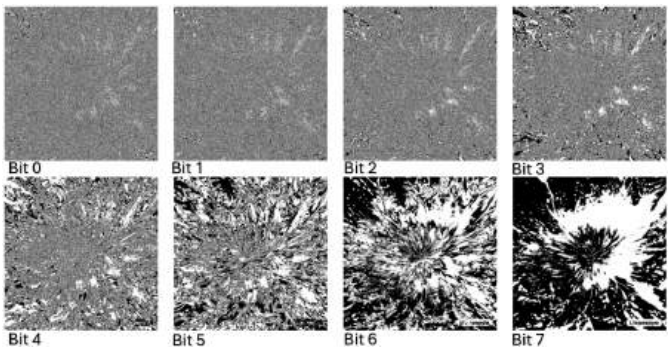

Figure 48: Decomposition of blue for all 8 bit planes of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

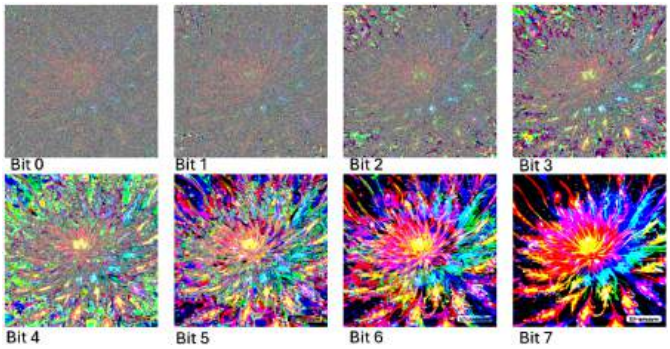

Figure 49: Superimposed decomposition for all 8 bit planes of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

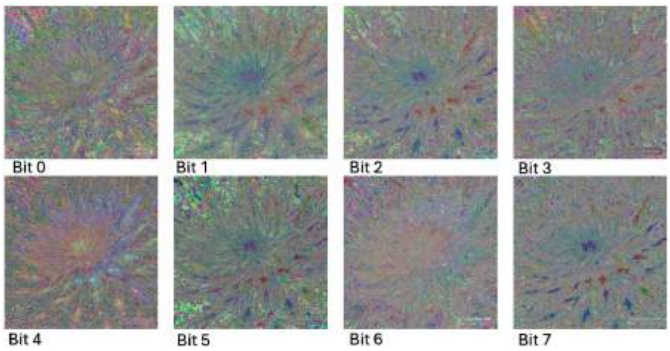

Figure 50: Color remapping decomposition for all 8 bit planes of Flower Neon Solar Explosion(...), Rich Caravan (2023), AI-generated [Car23].

Zsteg: Because the artwork was available for download only as a JPG instead of a PNG, Zsteg cannot be used.

Steghide: No extracted data

Outguess: Reading ../0e2e8f5744c93f0cb6fcf4feae626053.jpg.... Extracting usable bits: 375404 bits Steg retrieve: seed: 14893, len: 6301

After looking at the hexdump with Boxentriq, the same results were observed as with the digital artwork.

Binwalk: No extracted data. Either no utility was found or it's unimplemented.

Foremost: Processing: ../0e2e8f5744c93f0cb6fcf4feae626053.jpg—*—

One file was extracted by Foremost. It is the same image as the original artwork. The file name is the same as the checksum as noted in table 9. This is the same case as the digital artwork.

Strings: No meaningful strings pulled. It is essentially noise, typical JPEG artifact strings.

AI Detection Assessment of Digital Artwork

Interestingly, the combined result of the AI image detectors is that the digital artwork is AI-generated.

SightEngine: Likely AI-generated. GenAI 99%, Face manipulation 0%, 99% Flux diffusion model.

HiveModeration: This input is likely to contain AI-generated or deepfake content, 84.5% likely

to be AI-Generated Image, 0% Likely to be Deepfake. 89.7% Midjourney as generation source.
ZeroGPT: This image is likely created by AI 97% FAKE, AI Likelihood: 97%, Confidence: High, Classification: Fake.

AI Detection Assessment of AI-Generated Artwork

The combined result of the AI image detectors is that the digital artwork is AI-generated.
SightEngine: Likely AI-generated. GenAI 99%, Face manipulation 0%, 42% Kling diffusion model and 34% MidJourney.
HiveModeration: This input is likely to contain AI-generated or deepfake content, 99.8% likely to be AI-Generated Image, 0% Likely to be Deepfake. 66.7% stablediffusion as generation source.
ZeroGPT: This image is likely created by AI 96% FAKE, AI Likelihood: 96%, Confidence: High, Classification: Fake.

Conclusion

The EXIF metadata of the digital artwork highlights the fact that the image is downloaded from a commercial website. The AI-generated artwork has an sRGB color display device profile, ensuring consistent color reproduction. In addition, both images do not provide more information on authenticity. The AI-generated image has a watermark present in the right-bottom corner, which is detectable with software and the naked eye. The watermark is the name of the website, Shedevrum, which gets translated to 'masterpiece' in english. All images downloaded from Shedevrum have this watermark. For both images, all AI detection models were very confident that both images were AI-generated. Although this is (presumably) not the case for the digital painting by Maalavidaa. In both cases, steganographic techniques did not provide additional information.

Classification

Digital artwork

The authenticity of the digital artwork scores a 7 on the rubric (see fig. 51). The artist has a lot of information available, but not a lot regarding this specific artwork.

AI-generated artwork

The AI-generated artwork receives a 7 as well (see fig. 34). This is because, even though there is not a lot of information about the creator, there is a lot of information about how it is created and the platform.

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 51: Rubric digital artwork case study 2

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 52: Rubric AI-generated artwork case study 2

.6 Case Study 3

Figure 53: Artworks for case study 3: (left) 6 Corgis, Nadiapixel (2022), digitally painted [Pix22]. (right) Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Provenance

Blockchain

Using the reverse NFT finder Nyckel, no results came up regarding the two images. See figure 54.

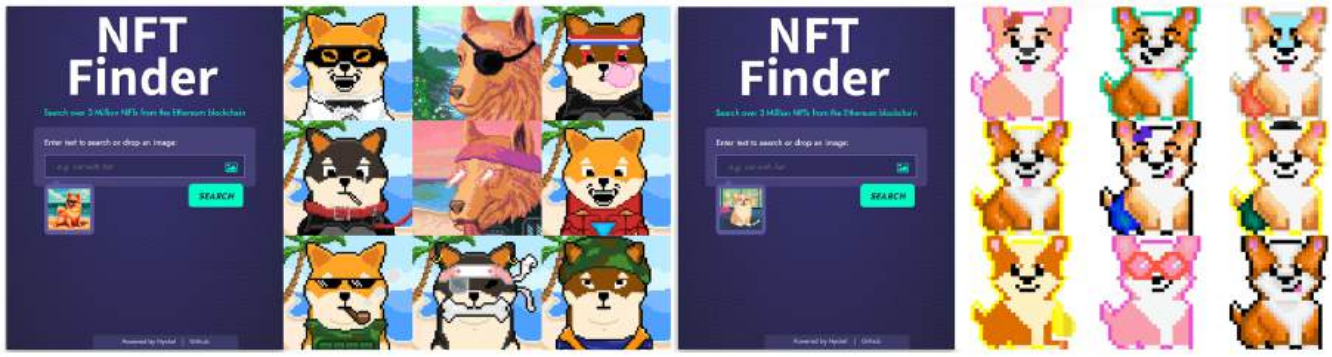

Figure 54: Results from NFT checker Nyckel on (left) Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24] and (right) 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Reverse Image Search

The reverse image searching resources used are Yandex AI, TinEye and Google Images. Unique and working sites found are in table 11 and 10.

Pictures are notated as a repost when there is no direct affiliation with the creator. Otherwise, they are noted as unclear. If there is a direct link to the artist, they are noted as original.

For the digital artwork, no images could be found using reverse image search techniques. The way the original source website was found, was by looking up the file name 'sr2dbcd0242ea7d' on Google.

Table 10: Postings of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Source	Link	Date	Notes	Reposting
File name search	https://www.pixilart.com/art/6-corgis-sr2dbcd0242ea7d	4 June 2022	Poster: @nadiapixel	Original

Table 11: Postings of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24]

Source	Link	Date	Notes	Reposting
TinEye and Yandex and Google Images	https://www.magnific.com/free-ai-image/pixel-art-style-scene-with-adorable-pet-dog_186697860.htm	29 Apr 2024	Poster: Freepik. Noted as AI-generated by Midjourney 6.	Original

Source	Link	Date	Notes	Reposting
Yandex	https://www.pinterest.com/pin/814236807666292054/?utm_medium=organic&utm_source=yasmartcamera	Unknown	Poster: Pat McCarthy	Repost
Yandex and Google Images	https://filmora.wondershare.com/trending-topic/dog-pixel-art.html?utm_medium=organic&utm_source=yasmartcamera	4 Jul 2025	Article by James Hogan.	Repost
Yandex	https://github.com/ecs124?utm_medium=organic&utm_source=yasmartcamera	Unknown	Profile picture of GitHub user ecs124.	Repost
Google Images	https://www.tdfunding.eu/en/for-investors	29 Apr 2026		Repost

Conclusion

The AI-generated image (fig. 53 (right)) has originally been posted by Freepik, now known as Magnific. The original image was found on the website with the same name and was posted on April 29, 2024. Since then, the image has been used on various websites for, for example, articles or profile pictures.

The digital artwork (fig. 53 (left)) could not be found using reverse image searching techniques. This makes it more difficult for the provenance research to find the image reliably, especially for reproducibility. Eventually, the image was found using the file name. But not in all cases would the file name provide results, making this technique unreliable. The image was found to be originally posted on the website Pixilart by Nadiapixel on June 4, 2022.

Visual Analysis

Report Digital Artwork

General. The digital artwork shows a corgi in the foreground, with four more corgis behind glass in the background. The work is pixel art, with a size of 128x128. The dog in the foreground looks at the viewer from a blue carpet. On the right, there is a bone, and on the left there is a magenta pillow. There are glass plains behind the dog, showing a field of grass where four other corgis are playing. There is also a ball on the field.

Main Claim. The image uses a pixel art style and a cheerful composition to create a playful and inviting portrayal of a corgi.

Support. The dog is prominently in the center of the image, immediately drawing the viewer's

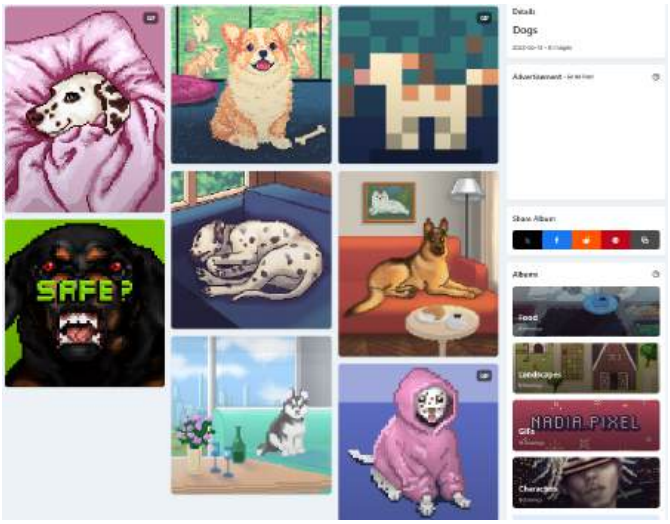

Figure 55: Nadiapixel's dog album on Pixilart [Pixnda]

attention. Its large eyes, open mouth, and upright posture convey excitement and friendliness. The soft pastel color palette, featuring tan fur and green background tones, contributes to a lighthearted mood. Additionally, the corgis in the background and the ball suggest playfulness and energy, reinforcing the image's joyful atmosphere.

Comparison Digital Artwork

All of Nadiapixel's 82 artworks on Pixilart are pixel art, but they are quite diverse. The sizes span from 48x48 to 200x330, for example. The subject of an artwork also changes often. There are portraits, food, landscapes, and horror imagery. She does have an album containing eight dog-centered artworks (see fig. 55).

Report AI-Generated Artwork

General. The AI-generated artwork shows a corgi on a beach. It stands on sand, with a calm ocean in the background and a light blue sky with clouds. The dog itself appears to be happy and is wearing sunglasses. The work itself is created as pixel art. It appears to be about a hundred pixels in height and length. However, this is hard to establish because some pixels differ in size. Overall, the artwork has an orange-yellow and blue color palate with slight pink accents.

Main Claim. The artwork, due to being AI-generated, is not truly pixel art.

Support. The artwork is not truly pixel art because of the details and textures present in the pixels and their inconsistent size. Traditionally, in pixel art, every pixel has the same size and is entirely filled with a color. When taking a closer look, inconsistencies and textures are present in a lot of pixels. The face of the dog is a good example of this (see fig. 56).

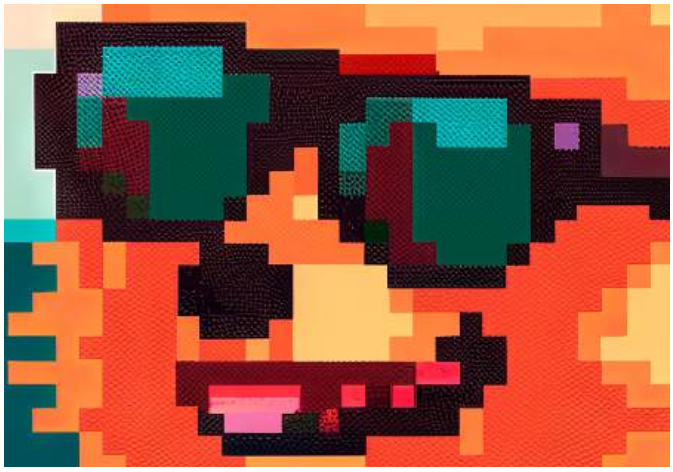

Figure 56: Zoom-in of the dog (center) of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Comparison AI-Generated Artwork

Freepik includes images created and generated by the platform itself. This is a fast amount of images. The AI-generated work in question is part of their *Cats and Dogs in Pixel Art* series, which includes 48 images (fig. 57). The other works in this series appear to have a similar style, as well as similar issues with the generation of the pixels as seen in fig. 56.

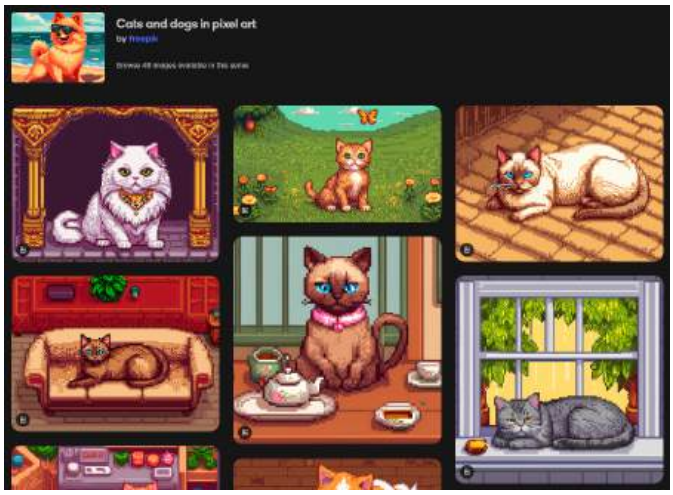

Figure 57: Freepiks series of Cats and Dogs in Pixel Art [Magnd]

Semantic Coherence

Because both images are pixel art and quite small, there are not a lot of elements. This makes both images quite semantically coherent. In the AI-generated image, the sunglasses on the dog are clearly part of the semantics. For the digital artwork, the dog appears to be in a home. The location is less clear, but not incoherent.

Conclusion

Visually, the digital artwork (fig. 53 (left)) is a playful image of a corgi, with multiple corgis playing in the background. Nadiapixel has made more pixel art works with dogs, but does not exclusively do so.

The AI-generated artwork (fig. 53 (right)) shows a corgi with sunglasses on the beach. The image is not strictly pixel art, as the pixel sizes are inconsistent and some of the pixels show textures. The artworks in Freepiks series *Cats and Dogs in Pixel Art* show similar artifacts.

Modus Operandi

Artist Profile of Digital Artwork

Nadiapixel is a pixel artist from Tbilisi, Georgia, as she states on her Behance page [Pixndb]. Further, it says that she graduated from the Saint Petersburg State Academy of Art and Design in 2023 and that she is open for freelance or fulltime jobs. On pixilart, she posts and creates pixel art since 2022. As of writing this, she has 888 followers and an accumulated 31k likes and 241K views [Pixndd]. Next to pixilart, she posts her pixel art on Instagram [Pixnde], where she has 1,3K followers, and Pinterest. She has created asset packs for video games and has done game design for various games available on her Itch.io page [Pixndc].

Next to pixel art, Nadiapixel makes contemporary art using her real name, Nadia Kazakovtseva. From this Behance page can be discovered that she is born in 1999, in St. petersburg and that she has taken part in an exchange program to Berlin [Kaznd].

Nadiapixel had released an NFT collection under the cyberpunk NFT-art group FYRW on the platform Rarible [Rarnd]. The artwork in question is not part of this collection.

Artist Profile of AI-generated Artwork

The creator of the AI-generated image is Freepik, the former website name where the artwork is posted. This is likely a collective of employees of Magnific, creating and generating these images. So, there cannot be an individual linked to the creation of this artwork.

Platform Profile of Digital Artwork

On PixilArt, you can create art, create pixel art, or post artworks. You can interact with users and their art by liking and commenting. New artworks can be found with various themes. The website was created by Bryan Ware in 2018. As a user, you can choose to directly upload art from your device, or create it within the app.

Platform Profile of AI-generated Artwork

The platform where the image was originally posted is Magnific, formerly known as Freepik, founded in 2023. It is an AI-powered image generation and stock image platform. Users can generate, edit and download images, videos, 3D models, and sounds. Furthermore, it offers courses to help users use the website to its full potential.

Digital Artwork Profile

The artwork in question has, as of writing this, 9,2K views, 700 likes, and 46 comments [Pix22]. The artwork is named *6 corgis* and has the following description:

> *Would u come to a place like this?? #challenge #dogs*

Curiously, the artwork itself only shows five corgis. The image size is 128x128 pixels and uses 157 colors. It has been edited eight times and is labeled as cloud .pixil.

AI-generated Artwork Profile

The artwork was posted on April 29, 2024 [Fre24]. It is named *Pixel art style scene with adorable pet dog*. It's dimensions are 4096x4096 and its license is free.

Tools and Techniques of Digital Artwork

Because the artwork notes it has been edited eight times and has been labeled as cloud .pixil, it is concluded that the artwork was created with PixilArt using the pixel art creation tool. This appears to be the case with most works by Nadiapixel. However, some of her works are labeled as created with the application Aseprite.

Tools and Techniques of AI-generated Artwork

The information panel of the artwork states that it was created using Midjourney 6 [Fre24].

Conclusion

The digital artwork was created by Nadia Kazakovtseva, also known as Nadiapixel, a pixel artist with a documented artistic background and presence across multiple creative platforms. The artwork was produced using pixel art software and was shared on PixilArt, a platform where art can be created and shared. In contrast, the AI-generated artwork was created using Midjourney 6 and published on Magnific, an AI-focused platform that enables users to generate and edit visual content with artificial intelligence.

Technical Analysis

Metadata Assessment of Digital Artwork

The EXIF metadata regarding the digital artwork is available in table 12. Because the image is a PNG, PNGchecker was used in Aperi'Solve. This shows that the image is 98.8% compressed. This coincides with the amount of EXIF metadata available, which is very little.

Table 12: EXIF metadata of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Original download location*	https://www.pixilart.com/art/6-corgis-sr2dbcd0242ea7d	
Name	sr2dbcd0242ea7d.png	
File type	PNG	
MIME type	image/png	Confirms PNG container type.
Size	62.2 KB (63733 bytes)	Small size.
Image dimensions	1152 x 1152 (1.3 megapixels)	Moderate resolution.
Checksum	8ee27d83ee50b69b9fa015954057e0be	Unique file fingerprint. MD5-style hash.
Bit Depth	8	Standard 8-bit per channel image depth.
Compression	Deflate/Inflate	PNG uses the deflate compression algorithm. It is lossless, meaning no image quality is lost.
Color Type	RGB with Alpha	The image contains Red, Green, Blue color channels plus an Alpha channel for transparency.
Filter	Adaptive	Before compression, PNG applies filters to image rows to make compression more efficient. Adaptive means the encoder automatically selected the most effective filter for each row.
Interlace	Noninterlaced	The image is stored sequentially from top to bottom.

*Not available from EXIF metadata

Metadata Assessment of AI-Generated Artwork

The EXIF metadata for the AI-generated image (table 13) is far more extensive. Notably, the metadata contains a Digital Source Type field set to trainedAlgorithmicMedia, indicating that the image was generated using an AI-based system. Additional metadata records show that the image was processed using Adobe Photoshop and Topaz Photo AI, converted from PNG to JPEG format, and saved multiple times within a short time period. The creation date is even more clear now,

corroborating it being made in April of 2024 and specifying the date to the 4th, instead of the posting date (the 29th).

Table 13: Metadata of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Attribute	**Value**	**Interpretation**
Original download location*	https://www.magnific.com/free-ai-image/pixel-art-style-scene-with-adorable-pet-dog$_1$86697860.*htm*	
Name	pixel-art-style-scene-with-adorable-pet-dog.jpg	
File Type	JPEG	
MIME Type	image/jpeg	Confirms the file is stored in the JPEG image format.
File Size	6.46 MB (6,772,067 bytes)	Relatively large file size, consistent with a high-resolution image.
Image Dimensions	4096 × 4096 pixels (16.8 megapixels)	High resolution square image suitable for detailed viewing and editing.
Checksum	a479d0640ec641ec2c90eab96e2eaebe	Unique MD5-style hash that can be used to verify file integrity and identify identical copies.
Color Mode	RGB, 8 bits per channel	Standard color representation.
Compression	Baseline DCT, Huffman coding	Standard compatible JPEG encoding.
Resolution	240 × 240 dpi	Print resolution metadata indicating intended display or printing quality.
Editing Software	Adobe Photoshop 25.6 (Windows)	Editing and export using Adobe Photoshop.
Additional Processing Software	Topaz Photo AI 2.3.2 (Windows)	The image underwent AI-assisted enhancement or upscaling during processing.

Digital Source Type	trainedAlgorithmicMedia: http://cv.iptc.org/newscodes/digitalsource-type/trainedAlgorithmicMedia	IPTC metadata explicitly identifies the image as content generated using a trained algorithm (AI-generated).
Digital Image GUID	ce759957-bc4a-465a-b8e2-c426b0524867	Unique identifier assigned to this image instance within the metadata.
Embedded Thumbnail	Present (approximately 9 KB)	A small preview image is stored within the file for quick display.
Device Attributes	Reflective, Glossy, Positive, Color	ICC profile attributes describing the intended display characteristics of the image rather than the actual image content.
History Action	["saved", "converted", "saved", "saved"]	Records a sequence of editing operations performed on the image during its life cycle.
History Parameters	from image/png to image/jpeg	The original image was converted from PNG format to JPEG format during processing.
History Software Agent	Adobe Photoshop 25.6; Topaz Photo AI 2.3.2; Adobe Photoshop 25.6	Documents the software applications used to edit, enhance, and export the image.
History Timestamp	2024-04-04 03:00:43 to 03:17:13 (+07:00)	Provides a timeline showing that multiple editing operations occurred within approximately 17 minutes.
History Instance IDs	Multiple XMP instance identifiers present	Several editing sessions or processing stages were recorded in the XMP metadata.
ICC Profile Name	Adobe RGB (1998)	Professional color profile embedded in the image to ensure consistent color reproduction across devices.

Primary Platform	Apple Computer Inc.	The platform associated with the embedded ICC profile, so the color profile origin.
Profile CMM Type	Adobe Systems Inc.	Adobe's Color Management Module is used for color profile processing.
Profile Class	Display Device Profile	The embedded ICC profile is intended for display device color management.
Profile Connection Space	XYZ	Standard ICC color reference space used for color conversion between devices and profiles.
Profile Copyright	Copyright 1999 Adobe Systems Incorporated	Copyright information associated with the embedded Adobe RGB color profile.
Profile Creation Date	1999-06-03	Creation date of the ICC color profile itself.
XMP Toolkit	Adobe XMP Core 9.1	Identifies the metadata framework used to store and manage XMP metadata within the image file.
YCbCr Subsampling	YCbCr 4:4:4	No chroma subsampling was applied. Full color information is preserved.

*Not available from EXIF metadata

Watermark Assessment of Digital Artwork

The overall conclusion of all watermark checkers was negative. This includes a signature. Using JoyCaption Watermark Detection, both the YOLO and the OWLLv2 model detect no watermarks. Gemini, using SynthID concluded that the image is not made with Google AI. It does not rule out other AI tools. Nyckel's watermark checker categorized the artwork as unwatermarked with 70.00 percent confidence.

Watermark Assessment of AI-Generated Artwork

The overall conclusion of all watermark checkers was negative. This includes a signature. Using JoyCaption Watermark Detection, the OWLv2 Prediction was 'Not Watermarked'. YOLO Detections falsely notices five watermarks with differentiating confidence intervals (see fig. 58). Gemini, using SynthID concluded that the image is not made with Google AI. It does not rule out other AI

tools. Nyckel's watermark checker categorized the artwork as unwatermarked with 70.00 percent confidence.

Figure 58: Watermark detection results using YOLO model of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Steganography assessment of Digital Artwork

Decomposition:

Figures 59, 60, 61, 62, and 63 show the decompositions of the digital artwork. No hidden images are observed.

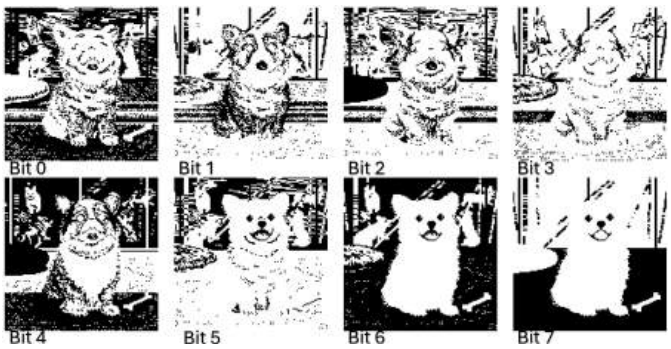

Figure 59: Decomposition of red for all 8 bit planes of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

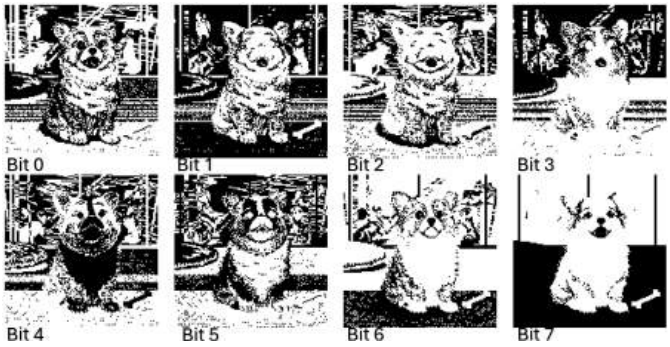

Figure 60: Decomposition of green for all 8 bit planes of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

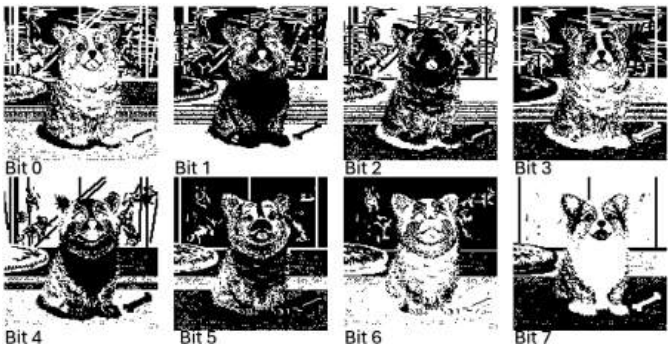

Figure 61: Decomposition of blue for all 8 bit planes of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Figure 62: Superimposed decomposition for all 8 bit planes of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

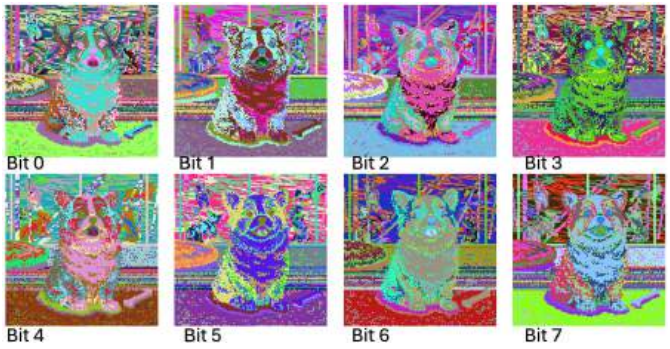

Figure 63: Color remapping decomposition for all 8 bit planes of 6 Corgis, Nadiapixel (2022), digitally painted [Pix22].

Zsteg: Most of the Zsteg results are negative or just low information patterns, meaning most bit planes do not contain usable hidden data.

The only meaningful signal is a structured text block found in b2,abgr,msb,xy, which shows repeated characters (C, ;, /, o) and is likely an embedded or encoded payload rather than random noise. This, however, is not clear. A few other detections (like "VISX image file" and "AVR firmware") appear, but these are likely heuristic false positives from zsteg rather than confirmed embedded files.

Steghide: The file format of the file is not supported (JPEG or BMP only).

Outguess: Unknown data type of ../8ee27d83ee50b69b9fa015954057e0be.png

Binwalk: WARNING: One or more files failed to extract: either no utility was found or it's unimplemented

Foremost: Processing: ../8ee27d83ee50b69b9fa015954057e0be.png—*—
One file was extracted by Foremost. It is the same image as the original artwork. Foremost scans for known file signatures within a file. In this case, it found a JPEG signature inside the file, which was the file itself. No additional files were found. The file name is the same as the checksum as noted in table 12.

Strings: No meaningful strings pulled. It is essentially noise, typical PNG artifact strings.

Steganography assessment of AI-Generated Artwork

Decomposition:

Figures 64, 65, 66, 67, and 68 show the decompositions of the AI-generated artwork. No hidden images are observed. Artifacts within the pixels, however, are very clear.

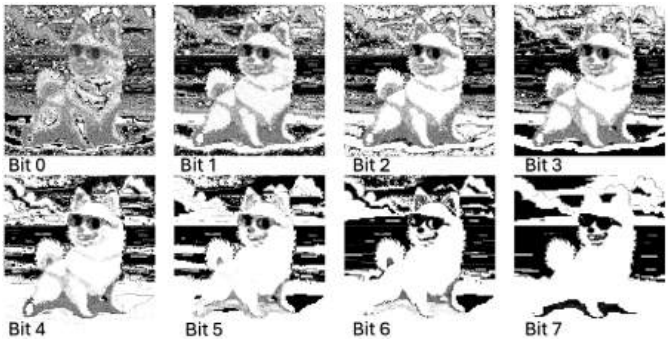

Figure 64: Decomposition of red for all 8 bit planes of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

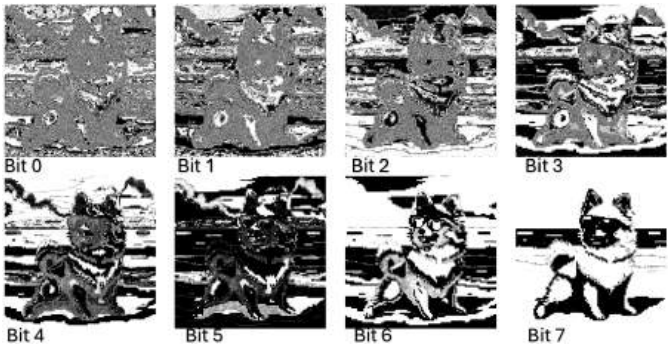

Figure 65: Decomposition of green for all 8 bit planes of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

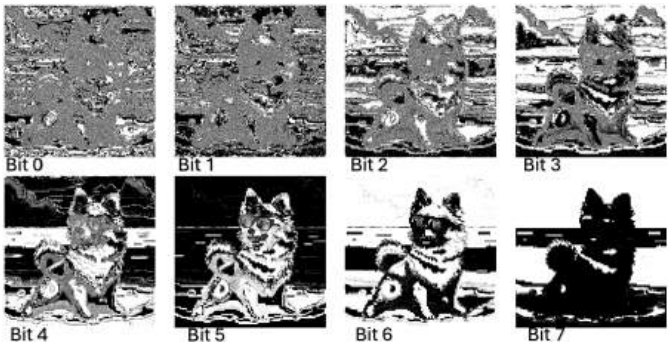

Figure 66: Decomposition of blue for all 8 bit planes of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

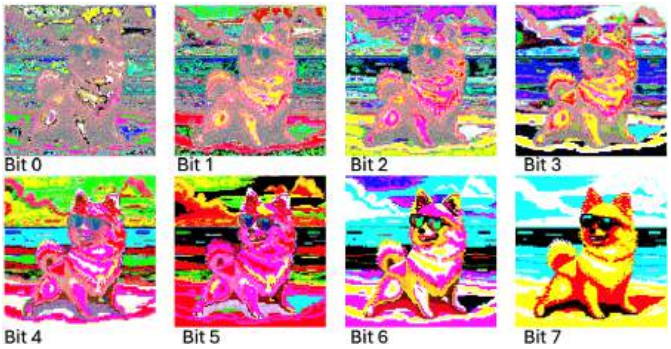

Figure 67: Superimposed decomposition for all 8 bit planes of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

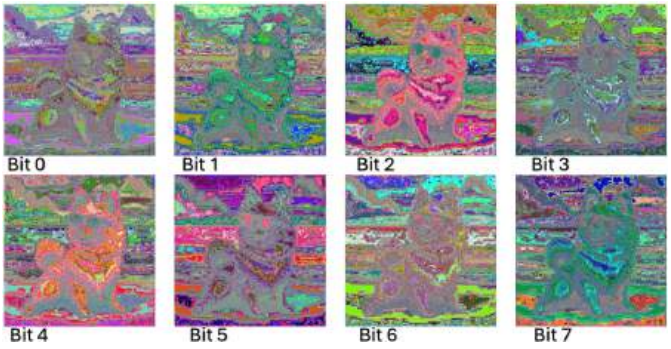

Figure 68: Color remapping decomposition for all 8 bit planes of Pixel Art Style Scene with Adorable Pet Dog, Freepik (2024), AI-generated [Fre24].

Zsteg: Because the artwork was available for download only as a JPG instead of a PNG, Zsteg cannot be used.

Steghide: No extracted data

Outguess: Reading ../b5860f075bd73c6a028ff2e63b047c03.jpg.... Extracting usable bits: 871152 bits Steg retrieve: seed: 45506, len: 63946
After looking at the hexdump with Boxentriq, it is most likely that there is no hidden message in the extracted data. It is essentially pseudo random noise from the DCT coefficients. The hexdump has no readable structure, and the signature shows application/octet-stream, which is the generic fallback for unrecognized binary.

Binwalk: No extracted data. Either no utility was found or it's unimplemented.

Foremost: Processing: ../b5860f075bd73c6a028ff2e63b047c03.jpg—*—
One file was extracted by Foremost. It is the same image as the original artwork. Foremost scans for known file signatures within a file. In this case, it found a JPEG signature inside the file, which was the file itself. No additional files were found. The file name is the same as the checksum as noted in table 13.

Strings: No meaningful strings pulled. It is essentially noise, typical JPEG artifact strings.

AI Detection Assessment of Digital Artwork

All software have a vastly different conclusion regarding the nature of the digitally painted image.
SightEngine: Likely AI-generated. GenAI 99%, Face manipulation 0%, Recraft 39%, MidJourney 22%, GPT 16%.
HiveModeration: This input is not likely to contain AI-generated or deepfake content. 0.8% Likely to be AI-Generated Image. 0% Likely to be Deepfake.
ZeroGPT: This image is likely digitally edited 79% REAL. Digitally Edited Likelihood: 21%. Confidence: Low. Classification: Digitally Edited.

AI Detection Assessment of AI-Generated Artwork

The combined result of the AI image detectors is that the digital artwork is AI-generated.
SightEngine: Likely AI-generated. GenAI 99%, Face manipulation 0%, MidJourney 33%, Flux 14%, Recraft 14%.
HiveModeration: This input is likely to contain AI-generated or deepfake content, 99.5% likely to be AI-Generated Image, 0% Likely to be Deepfake. 4o: 71.9% likely as generation source and midjourney: 12.5%.
ZeroGPT: This image is likely created by AI 99% FAKE, AI Likelihood: 99%, Confidence: High, Classification: Fake.

Conclusion

The digital artwork (fig. 53 (left)) shows little EXIF metadata, due to compression and there is no watermark. In the steganography assessment, Zsteg showed mainly negative or low information patterns. The decomposition channels clearly show the uniform nature of the pixels, which contrasts with the decompositions of the AI-generated image. Here, the artifacts within the pixels become abundantly clear. AI detection models were inconclusive regarding the digital artwork. It got classified as AI-generated, not AI-generated, and digitally edited by separate models.

The EXIF metadata available for the AI-generated artwork (fig. 53 (right)) is more extensive. It shows information about the creation of the artwork, histories, software used, and time stamps. The work is not watermarked, but because of the artifacts present in the pixels, they were falsely identified. All AI detection models labeled the work correctly as AI-generated.

Classification

Digital artwork

The authenticity of the digital artwork scores 6.5 on the rubric (see fig. 69). There is enough information available, but not an extensive amount. Regarding the technical analysis, there was very little information found.

AI-generated artwork

The AI-generated artwork receives a 7.5 on the rubric (see fig. 70). Although the specific artist is unnamed, the tools, platform, and metadata is well established.

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 69: Rubric digital artwork case study 3

Type	Points: 0	Points: 0.5	Points: 1
Provenance			
Artist assessment	The artist is unclear.	The artist is named, but without clear sense of identity (i.e. only stagename available.	The artist, and their identity is clear and verifiable.
Platform assessment	The original posting plaform is unclear.	There are posting platforms found, but the validity, or originality is unclear	The original posting platform is clear and verifiable.
Visual Analysis			
Visual report	The visual report does not coincide with other related works, or there are not any available.	It is unclear if the visual report coincides with related works.	The visual report coincides with other related works.
Modus Operandi			
Artist Behaviour	There is no information available about the artists behaviour or it does not line up with the artwork.	There is insufficient information available about the artists behaviour and/or it barely lines up with the artwork.	There is sufficient information available about the artists behaviour and it lines up with the artwork.
Platform Credibility	The posting platform is not credible.It has art available with questionable authenticity. And/or There is not a lot of information available.	The posting platform had limited credibility. And/or the information is not verifiable.	The posting platform well-established and credible with verifiable and trustworthy information.
Background Artwork	There is no information available about the background of the artwork or it does not coincide.	The background available provides limited information or does not coincide.	The background available of the artwork is clear and verifiable.
Tools and techniques (i.e. image generation- or drawing software)	The tools and techniques used are unclear.	The tools and techniques used are partly covered or unclear.	The tools and techniques used are clear and coincide with the painting.
Technical Analyis			
Metadata	There is no useful metadata available or it does not coincide with the artwork or artist.	There is some useful metadata available but is does not provide a lot of extra information.	There is much metadata available which provides coinciding information about the artwork.
Watermarkings	The watermark available corresponds with another artist or another tool than mentioned.	There is no watermark available.	There is a watermark available corresponding with the artist or tools.
Steganography	There is steganographic information available rendering the artwork as inauthentic.	There is no steganographic information available of note, but nothing points to the work being inauthentic.	There is steganographic information available which provides information about the painting.

Figure 70: Rubric AI-generated artwork case study 3