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The Future of NFT Art: Creating Unique, Automated Digital Assets with SVG

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Abstract: ***Non-fungible tokens (NFTs) have transformed digital ownership by using blockchain technology to authenticate unique digital assets, enabling artists to monetize directly. This paper introduces an automated method to create 1,000 NFTs using scalable vector graphics (SVG) and image generation techniques, significantly enhancing production efficiency and scalability. We illustrate this through a sumo-themed NFT collection, which is programmatically generated and converted to JPEG for broader platform compatibility. Hosted on the Polygon blockchain, known for its low transaction costs and high efficiency, this method proves ideal for expansive NFT projects and can be scaled up to meet increasing demand. This study offers insights into the scalability and technical execution of automated NFT creation, providing a valuable resource for artists and developers in the digital art sector.***

Keywords*:* Non-Fungible Tokens (NFT), Algorithms, Blockchain, Digital Art, Scalability, Cloud, Java, SVG.

1. Introduction

Non-fungible tokens (NFTs) have revolutionized the landscape of digital ownership by leveraging blockchain technology to guarantee the uniqueness and authenticity of each digital asset [1]. Unlike cryptocurrencies such as Bitcoin or Ethereum, which are fungible and can be exchanged for one another, each NFT is distinct and represents a specific item, piece of art, or digital property [2]. This fundamental difference has transformed the way digital art and other media are valued, bought, and sold, introducing a new paradigm where digital files can have scarcity and exclusivity [3].

The rise of NFTs has empowered artists and creators by providing a direct pathway to monetize their digital content. Traditional art markets often involve intermediaries, but NFTs allow creators to connect directly with buyers, eliminating many of the barriers that have historically limited the distribution and profitability of digital art [4]. Additionally, NFTs can include embedded smart contracts that enable creators to receive royalties from secondary sales. This feature ensures that artists continue to benefit financially as their works appreciate in value and change hands in the market.

Generative art has emerged as a significant trend within the NFT space. This technique uses algorithms to create art, generating unique and varied outputs from a predefined set of rules and parameters [5]. Generative art is particularly well-suited for NFTs because it can efficiently produce a large volume of unique artwork while maintaining a high degree of originality. Artists and developers can harness these algorithms to explore new creative possibilities and produce diverse and cohesive collections.

Despite the promise of NFTs, their widespread adoption has been hindered by the high transaction fees associated with blockchain technologies like Ethereum. These fees, known as "gas fees," can be prohibitively expensive, particularly during periods of high network congestion [6]. To address this issue, our work utilizes the Polygon blockchain [7], a layer-2 solution that operates on top of Ethereum. Polygon [7] significantly reduces transaction costs and increases processing speed while maintaining compatibility with Ethereum's ecosystem. This approach lowers the barriers to entry for creators and collectors, making NFTs more accessible and affordable [8].

This paper introduces a scalable, automated method for creating NFTs using scalable vector graphics (SVG) and advanced image generation techniques. By leveraging automation, we aim to democratize access to NFT creation, enabling artists and developers to produce and market their digital artworks more efficiently [9]. Our methodology streamlines the NFT creation process by integrating cloud storage, automated image generation, and blockchain technology, allowing for the rapid production of high-quality digital assets.

Through the case study of a sumo-themed NFT collection named Warrior Town [10], we demonstrate the practical application of our method. This collection showcases how our approach can be adapted for large-scale projects and varied artistic endeavors. By combining artistic creativity with cutting-edge technology, we not only simplify the technical processes involved in NFT production but also open new avenues for digital creativity and ownership [11].

2. Literature Review

Generative art, which employs algorithms and autonomous systems to produce complex and distinct artworks, is increasingly capturing the interest of the digital art

community. This innovative approach harnesses computational power to create artworks that are not only unique but also scalable in their design, making it particularly suitable for digital media [12]. Its applications are diverse, spanning from music, where it facilitates algorithmic compositions that can adapt and evolve, to graphic design, where it is used to generate intricate patterns and dynamic interactive installations. In fashion, generative art is pushing boundaries by creating one-of-a-kind textile patterns, thereby personalizing and enriching consumer experiences.

Despite its growing popularity, the application of generative art in producing large-scale Non-Fungible Tokens (NFTs) still needs to be explored. This paper seeks to bridge this gap by exploring how generative art can be utilized to create a high volume of unique NFTs efficiently. Integrating generative art into NFT production not only enhances the uniqueness of each digital asset but also significantly streamlines the creation process [13].

Utilizing the Polygon [7] blockchain further enriches this process by offering substantial advantages for NFT transactions [14]. Compared to Ethereum, Polygon [7] provides lower transaction fees (gas fees) and quicker transaction speeds, making NFT creation and sales more accessible and economically feasible for artists and developers. Moreover, Polygon's [7] compatibility with Ethereum ensures seamless interoperability and flexibility for NFT creators, which is crucial for broader adoption and integration into existing digital ecosystems.

By combining generative art with the Polygon [7] blockchain, this paper introduces a novel methodology that leverages both the creative potential of generative algorithms and the technical efficiencies of modern blockchain technology. This synergy not only enables the mass production of unique digital assets but also contributes significantly to the evolution of the NFT market. This approach not only democratizes the art creation process, allowing more artists to participate in the NFT space but also enhances the value of NFTs as each piece is guaranteed to be unique, thereby appealing to collectors and investors within the digital art market.

3. Methodology

1) Preparations of SVGS

The design process begins with creating various parts of a sumo body, including the head, torso, arms, and legs. Each part is meticulously crafted using Adobe Illustrator [15] to ensure high-quality and visually appealing elements. The design includes different expressions for the head, various postures for the arms, distinct shapes for the torso, and diverse stances for the legs [16].

Additionally, accessories such as belts, weapons, and background elements are designed to give each sumo wrestler unique characteristics. Once all parts and accessories are designed, they are exported as scalable vector graphics (SVG) files. This format is chosen for its ability to retain high resolution and allow for easy manipulation [17].

These SVG files are then meticulously organized into distinct traits, such as head shapes, arm positions, and leg stances, ensuring a systematic and efficient approach to generating the final NFTs. Each trait category contains multiple variations, enabling the creation of a vast array of unique sumo wrestlers by combining different traits [18].

2) Automation Process

a) Upload Layers to Cloud Storage

The creation of scalable vector graphics (SVG) for Non-fungible tokens (NFTs) start with a meticulous process of organizing and storing various design components. Artists and designers carefully craft individual SVG layers that represent different parts of the artwork, such as the head, torso, arms, legs, and accessories. These layers are uploaded to a cloud storage service like Amazon S3 [19], which plays a crucial role in the NFT creation pipeline [20].

Amazon S3 [19] (Simple Storage Service) provides a scalable, high-speed, web-based cloud storage solution with robust security features to protect uploaded files against unauthorized access and data breaches. This service ensures that all SVG layers are securely stored and managed in a centralized repository, allowing for easy access and retrieval. This setup is especially beneficial for projects involving multiple designers or teams working remotely, as it supports collaborative efforts by enabling simultaneous access to the latest versions of each design component.

By storing SVG layers in Amazon S3 [19], the overall efficiency of the NFT creation process is enhanced. SVG files are vector-based, meaning they can be dynamically scaled and manipulated without losing quality, making them ideal for detailed artistic projects like NFTs. The cloud storage acts as a reliable foundation, streamlining the subsequent steps of the creation process, such as the programmatic combination of layers to form unique digital assets. Each SVG file can be programmatically retrieved from the cloud, combined in various ways to create distinctive designs, and then converted into final images or animations ready for minting as NFTs.

This method not only preserves the SVG layers at their highest quality but also significantly speeds up the production cycle by automating the retrieval and assembly of artwork components. Cloud storage like Amazon S3 [19] plays a pivotal role in both securing and enabling the efficient creation of NFTs, allowing artists and developers to focus more on creativity and less on logistics [21].

b) SVC Creation Service

The SVG creation service is a key component of the NFT creation process, designed to pick layers from the S3 [19] storage and programmatically combine them to create unique images. This service is initiated through a custom script that automates the combination process, ensuring that each combination of traits is unique and aesthetically pleasing. The script follows a set of predefined rules and logic to carefully manage color schemes, layer order, and transparency, achieving a harmonious final design.

The service iteratively selects one layer from each trait category, such as backgrounds, characters, and accessories, and overlays them to create a cohesive image. This automation allows for the generation of many distinct images,

each with its unique combination of traits. The service can generate thousands of images, each representing a potential NFT, by dynamically combining different SVG parts.

Simultaneously, the script creates initial metadata for each image. This metadata is stored in JSON files and includes detailed information about the traits used in each image, such as color codes, trait names, rarity levels, and any special features. This metadata is crucial for cataloging the images and for integrating them into NFT marketplaces, where such detailed information enhances the value and appeal of each NFT to potential collectors.

Pseudocode:

```
// Initialize Components for NFTs
components = {
    "head": [...], "shoulder": [...], "tummy": [...],
    "weapons": [...], "skin_color": [...],
    "background": [...], "accessories": [...]
}

// NFT generation process
nft_id = 1

// Iterate over all possible combinations of head, shoulder, tummy, etc.
// Loop over each component trait category to create unique NFT combinations
for each head in components["head"]
    for each shoulder in components["shoulder"]
        for each tummy in components["tummy"]
            for each weapon in components["weapons"]
                for each skin in components["skin_color"]
                    for each background in components["background"]
                        for each accessory in components["accessories"]:

                            // Create NFT object with selected traits
                            nft = {
                                "head": head, "shoulder": shoulder,
                                "tummy": tummy, "weapon": weapon,
                                "skin_color": skin, "background": background,
                                "accessory": accessory
                            }

                            // Store the NFT in the SQL Database
                            db.store({"id": nft_id, "nft_data": nft})

                            // Store traits of NFT in MongoDB for quick querying
                            mongo_collection.insert_one({
                                "nft_id": nft_id,
                                "traits": nft
                            })

                            // Increment the NFT ID for the next unique combination
                            nft_id += 1
```

c) Invoke FFMPEG for Image Conversion

The image creation service employs FFmpeg [22], a powerful multimedia framework, to convert the generated SVG images into JPEG format. FFmpeg [22] is capable of decoding, encoding, transcoding, muxing, demixing, streaming, filtering, and playing almost any multimedia file, making it an ideal tool for this conversion process. A script is written to automate the conversion, processing batches of SVG files into high-quality JPEG images.

This conversion step ensures compatibility and proper display across various platforms. JPEG is a widely supported image format, making it suitable for showcasing NFTs on different devices and marketplaces. Using FFmpeg [22] ensures that the conversion is efficient and maintains the integrity of the original designs.

d) Store Images in Metadata in Cloud Storage

Once the JPEG images and their corresponding metadata are created, they are stored back in the S3 [19] storage. This step ensures that all files are securely stored and accessible for further processing. The S3 [19] storage acts as a centralized hub where all the necessary components of the NFT are kept, providing a seamless flow for subsequent steps.

The S3 [19] storage setup includes triggers that automatically initiate the next service in the pipeline whenever a new entry is made. This automation facilitates a continuous and efficient workflow, ensuring that each step in the NFT creation process is executed promptly and accurately.

e) Upload to IPFS Service

A specialized service is set up to monitor the S3 [19] storage for new entries. When new images and metadata are detected, this service uploads the images to the InterPlanetary File System (IPFS) [23]. IPFS is a peer-to-peer hypermedia protocol designed to make the web faster, safer, and more open. It provides a decentralized method of storing and sharing files, offering a permanent and tamper-proof address for each image through a unique IPFS hash.

Uploading images to IPFS ensures that they are stored decentralized, making them resistant to censorship and data loss [24]. The use of IPFS also enhances the security and permanence of the NFT assets, as they are distributed across a global network of nodes rather than being reliant on a single centralized server.

f) Create and Update Metadata

Once the images are uploaded to IPFS, the service creates or updates the metadata to include the IPFS hashes. This metadata includes details such as the NFT's name, description, and traits, as well as the IPFS hash linking to the image. The metadata is formatted as JSON files, which are compatible with NFT standards such as ERC-721 and ERC-1155, ensuring interoperability across different blockchain platforms.

The inclusion of IPFS hashes in the metadata provides a secure and permanent link to the image, ensuring that the NFT remains accessible and verifiable on the blockchain. This step is crucial for maintaining the integrity and authenticity of the NFT, as it provides a transparent and immutable record of its associated digital assets [25].

g) Store Unique Names

To further enhance each NFT's uniqueness, a database is prepared with a list of unique names for the sumo wrestlers. This database is essential for ensuring that each NFT has a distinctive and culturally relevant name, adding to its uniqueness and appeal. The names are pre-compiled and stored in a database management system, which is accessible during the minting process. The use of a dedicated database for storing unique names ensures that no two NFTs share the same name, maintaining the individuality of each digital asset. This step adds an additional layer of personalization and cultural significance to the NFTs, making them more attractive to collectors.

h) Assign Unique Names

Each NFT is assigned a unique name retrieved from the database during the metadata update process. A script fetches the name and includes it in the metadata, ensuring that every

NFT has a distinct and culturally relevant name. This step is integrated into the automation process, allowing for seamless assignment and management of unique names. The assignment of unique names not only enhances the individuality of each NFT but also contributes to its narrative and story, making it more engaging for collectors and enthusiasts.

i) QR Code Integration

The integration of QR codes into the SVG files is a strategic enhancement in the NFT creation process. QR codes serve multiple purposes: they allow users to easily access other platforms where the NFTs can be used and uniquely identify each NFT. The QR code generation process utilizes the Google ZXing library [26] to create QR codes with specified background colors and target URLs, seamlessly integrated into the SVG files.

This integration provides a straightforward method for linking additional digital content or platforms to the NFTs and strengthens the digital assets' security and traceability. By scanning the QR code, users can quickly verify the authenticity of the NFT and access relevant information or platforms, enhancing the overall user experience and value proposition of the NFTs.

Furthermore, the incorporation of QR codes adds a layer of interactivity and connectivity to the NFTs. It enables creators to dynamically link the NFT to evolving digital ecosystems, such as websites, social media platforms, or virtual environments, ensuring that the NFTs remain relevant and engaging over time. This dynamic capability allows for continuous updates or expansions to the content associated with each NFT, offering a richer and more immersive experience for the end-user.

j) MINT NFTS

The final step in the automation process is the minting of NFTs using a blockchain platform's smart contract, such as Polygon. The minting process involves creating tokens on the blockchain and linking them to the metadata JSON files, thereby solidifying their existence as unique digital assets. This critical step is meticulously carried out using sophisticated blockchain development tools and libraries, ensuring that each NFT is unique and verifiable on the blockchain.

The minting process not only guarantees the originality and ownership of digital assets but also includes setting up royalties and other smart contract features that benefit the creator. These features provide ongoing revenue streams from secondary sales and offer additional control over how the NFTs are used or transferred, thereby enhancing the value offered to the original creator. This mechanism fosters a sustainable economic model for artists and developers in the NFT space, promoting a fair and continuous benefit from their creative works.

k) Directory Structure

The directory structure of the SVG parts and the generated outputs is organized into categories based on the type of parts such as Bronze, Gold, and Silver. Each category contains layers like Back_Weapon, Background, and Clothing. Furthermore, the folder structure is organized into three primary categories—bronze, Gold, and Silver—reflecting the sumo NFTs' varying price points and versatility.

For example:

a) Bronze:
- Back_Weapon: Stick.svg
- Background: Sun.svg
- Clothing: Bronze Mawashi.svg

b) Gold:
- Back_Weapon: Diamond Spear.svg
- Background: Sea.svg
- Clothing: Gold Kesho Mawashi.svg

c) Silver:
- Back_Weapon:Double Sided Axe.svg
- Background: Mountain desert.svg
- Clothing: Silver Mawashi.svg

Figure 1: Automated NFT Creation System Architecture

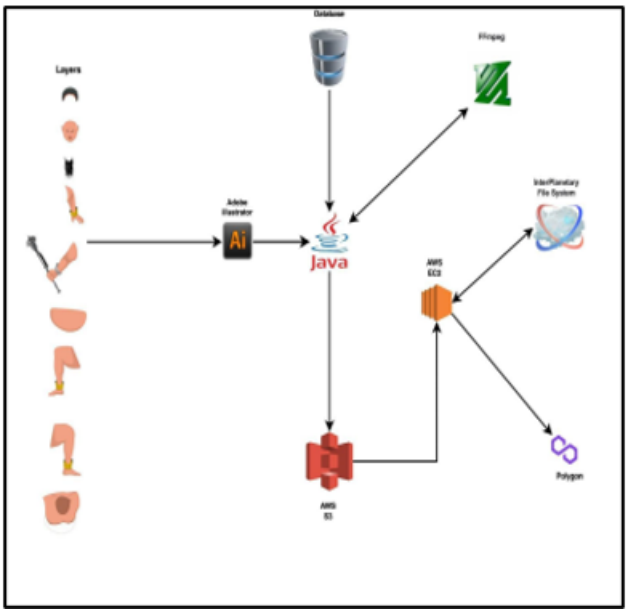

Figure 2: Examples of Sumo-themed NFT

4. Evaluation Methods and Originality

In evaluating the effectiveness and originality of the automated NFT creation process introduced in this paper,

several key criteria were used. First, we measured the scalability of the system by analyzing the ease with which it could generate 1,000 unique NFTs [10]. This was achieved through the automated combination of various layers of SVG components, allowing the production of a large volume of NFTs with distinct traits and characteristics. For each NFT generated, the corresponding traits and characteristics were recorded in the database to ensure that no duplicate NFTs could be produced with the same combination of attributes. This mechanism guarantees the uniqueness of each NFT in the collection. The ability to seamlessly scale by adding new traits and layers further validated the flexibility of the system.

Another aspect of evaluation was the performance of the image conversion process, specifically the integration of FFmpeg for converting SVG images to JPEG format. The accuracy, speed, and preservation of design integrity during the conversion process were critical metrics. The system's ability to efficiently handle batch conversions without compromising the quality of the final images ensured that the NFTs were ready for widespread use on various platforms.

The originality of this approach lies in its use of automation to streamline the traditionally labor-intensive process of NFT creation. By utilizing cloud storage, programmatic layer combination, and blockchain technology, the method significantly reduces the time and effort required to produce high-quality NFTs. Additionally, incorporating unique Japanese names and QR codes into the NFTs adds layers of personalization and interactivity, enhancing both the cultural significance and the functionality of the digital assets.

Finally, the use of the Polygon blockchain, known for its lower transaction fees and faster processing speeds, added a practical advantage to the overall approach, making it more accessible and cost-effective for creators and collectors alike. The originality of this project stems from its holistic integration of generative art, blockchain technology, and automation, which collectively democratizes the NFT creation process and sets a new standard for large-scale digital art production. It is scalable across all dimensions, including backgrounds and various aspects of the human body components. So, it has endless possibilities with infinite traits.

5. Use Case

1) NFTs with QR Code

a) Digital art and collectibles

Enhanced Provenance and Interactivity: Integrating QR codes into NFTs allows collectors to scan the code and access additional information about the artwork, such as the artist's biography, creation process, or personal message from the artist. This enhances the digital collectible's provenance and interactivity.

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

b) Event Tickets

Secure and Verifiable Tickets: NFTs with embedded QR codes can be used as secure and verifiable event tickets. The QR code can be scanned at the event entrance to verify the ticket's authenticity and validity.

Access to Exclusive Areas: Event organizers can grant access to exclusive areas or VIP sections by scanning the QR code on the NFT ticket.

Souvenirs and Memorabilia: After the event, the NFT ticket can serve as a digital souvenir or collectible, with additional content such as event highlights, attendee badges, or personalized messages from performers.

c) Gaming and Virtual Worlds

In-Game Items: NFTs with QR codes can represent in-game items or assets. Scanning the QR code can unlock special abilities, power-ups, or exclusive in-game content.

Cross-Platform Integration: QR codes can enable the transfer of in-game items between different games or virtual worlds. Scanning the code can link the item to a new game, allowing players to use their assets across multiple platforms [29].

Augmented Reality (AR) Experiences: QR codes on NFTs can trigger augmented reality experiences, bringing the digital asset to life in the real world. Scanning the code can display 3D models, animations, or interactive elements.

d) Real Estate and Property Ownership

Virtual Tours: Real estate NFTs with QR codes can provide potential buyers with virtual tours of the property. Scanning the code can access 360-degree views, walkthrough videos, or interactive floor plans.

Property Documentation: QR codes can link to important property documents such as ownership deeds, legal agreements, or maintenance records. This provides a secure and easily accessible way to manage property documentation.

Rental and Leasing Agreements: QR codes on NFTs can represent rental or leasing agreements, allowing tenants to scan the code and access their lease details, payment history, or renewal options.

2) Scalability and Ease of Use

a) Scalability by Adding Layers

Exponential Growth: The system is designed to be scalable by introducing new layers or additional traits. Each new layer exponentially increases the number of unique NFTs that can be generated. For example, adding a new accessory or background element can create thousands of new combinations, ensuring the collection remains diverse and extensive.

Flexible Design: The modular design of the SVG parts and metadata allows for easy addition of new traits. Artists and developers can continuously expand the collection by designing new layers and updating the metadata.

b) Ease of Use

User-Friendly Interfaces: User-friendly interfaces and automated services streamline the process of creating, managing, and minting NFTs [7]. This reduces the technical barriers for artists and collectors, making it easier for them to participate in the NFT [7] ecosystem.

Automation and Integration: Automated services handle the conversion, storage, and minting processes, ensuring efficiency and accuracy. Integration with cloud storage, IPFS, and blockchain platforms simplifies the workflow and enhances the user experiences.

6. Conclusion

This paper provides a comprehensive approach to creating and automating the generation of a large number of NFTs using SVG files. The methodology and implementation details outlined offer valuable insights for artists and developers looking to streamline their NFT creation processes. The automated process not only generates the SVG images but also prepares the necessary JSON metadata files, ensuring each NFT is unique and well-documented. Additionally, the conversion to JPEG format using FFmpeg [22] enhances compatibility and accessibility across various platforms. The assignment of unique Japanese names further personalizes each NFT, adding cultural significance and increasing their appeal to collectors. The use of the Polygon [7] blockchain for selling NFTs provides a cost-effective and efficient platform, reducing transaction fees and increasing accessibility for both creators and collectors. The scalability of the process allows for easy expansion by introducing new layers, making it possible to create any number of unique NFTs.

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