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IMPLEMENTATION OF ETHEREUM SMART CONTRACTS FOR AI-GENERATED ARTWORK NFT CREATION AND VERIFICATION

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ABSTRACT

Objective: This study aims to develop and implement a decentralized application (DApp) that integrates Generative Artificial Intelligence (AI) and Ethereum blockchain technology to create, verify, and manage AI-generated digital artworks through Non-Fungible Tokens (NFTs). This research addresses the challenges of digital ownership, authenticity verification, and provenance tracking of AI-generated content.

Research Design & Methods: This research applies a Research and Development (R&D) approach by designing and developing an AI-generated NFT marketplace system.

Findings: The results show that the developed system successfully integrates AI creation and blockchain-based asset management. Smart contracts successfully performed NFT minting, ownership recording, and transaction management with a 100% success rate across all functional test scenarios. The system also enables transparent verification of digital ownership and provenance through Token IDs, blockchain transactions, and IPFS-based metadata containing native AI commands.

Implications: This research shows that combining Generative AI and blockchain can provide a more transparent, secure, and verified ecosystem for managing digital creative assets.

Contribution & Value Added: This study provides a hybrid AI-blockchain framework by combining creative genealogy through AI-commanded metadata, extending the functionality of NFTs beyond certification of ownership to documenting the provenance and creation process of AI-generated artworks.

Keywords: Generative AI, Blockchain, NFT, Smart Contract, Ethereum.

JEL codes: O33, O32
Article type: research paper

INTRODUCTION

The development of artificial intelligence (AI) technology in recent years has experienced very rapid growth, especially in the field of Generative Artificial Intelligence (GenAI) which is capable of producing various forms of digital content automatically. This technology has brought about major changes in the modern creative industry because it allows computer systems to produce visual works such as digital images, illustrations, character designs, and even works of art that have a high degree of similarity to the results of human creativity. This development is supported by advances in deep learning methods and neural network-based generative models that are able to understand data patterns and generate new content based on user input (prompts).

Several generative AI technologies, such as Stable Diffusion, DALL-E, and Midjourney, have introduced a new approach to digital art creation through text-to-image generation. With this technology, users simply provide a text description (text prompt), and the AI system then translates the instructions into a visual representation in the form of a digital image. This capability provides a huge opportunity for the creative industry because the process of producing works becomes faster, more flexible, and can be done by users without having to have advanced design skills.

However, the development of Generative AI also presents new challenges, particularly regarding the originality, ownership, and copyright protection of digital works. The ease of producing and distributing AI-based works has given rise to questions about who can be considered the original creator of a work, when the work was first created, and how to prove legal ownership of the digital asset (Musyarofah and Prasetyo, 2024). In contrast to physical works which have a tangible form, digital works have the characteristic of being easily copied, modified and distributed without reducing their original quality.

The issue of digital ownership becomes even more complex in the conventional internet (Web2) environment, where digital files can be perfectly replicated without leaving any visible traces of changes. A digital image published over the internet can easily be downloaded, copied, or reused by others without strong authentication mechanisms (Komalavalli et al., 2025; Musyarofah and Prasetyo, 2024). In addition, additional information in digital files such as metadata or work identity information can be changed or deleted, making it difficult to prove original ownership (Komalavalli et al., 2025).

In the context of AI-based artwork, this issue can arise when someone takes another user's AI-generated image, modifies it, and then claims it as their own for commercial purposes. This situation demonstrates the need for a mechanism that can securely and transparently record the history of creation, ownership, and transfer of digital assets. Therefore, technology is needed that is capable of providing digital evidence that is not easily manipulated to support the protection of creative assets in the digital era.

One technology that has significant potential to solve these problems is Blockchain. Blockchain is a distributed ledger technology that allows for transparent, secure, and immutable transaction recording once the data is stored on the network (Rino et al., 2025). Initially, blockchain was developed by Nakamoto as a supporting technology for cryptocurrency, but now its application has expanded to various fields such as digital identity, health, supply chains, and even digital certification systems (Rino et al., 2025).

Blockchain's key characteristics of decentralization, transparency, and the ability to verify data without relying on third parties make it a suitable technology for digital asset management. Every transaction within a blockchain network must go through a validation mechanism agreed upon by the network, reducing the risk of manipulation or fraudulent activity on stored data (Rino et al., 2025). In its implementation, blockchain technology is often combined with Non-Fungible Tokens (NFTs) as a mechanism for representing digital asset ownership. NFTs are unique, blockchain-based tokens with distinct identities and cryptographic codes, allowing each asset to be digitally distinguished and verified (Wang et al., 2021). Through NFT, a digital artwork can have a certificate of ownership that is permanently recorded on the blockchain network, thus providing authentic proof of the owner and transaction history of the asset.

In addition to NFTs, smart contract technology is a crucial component of the blockchain ecosystem because it enables automated transaction processes based on pre-programmed rules. Smart contracts are programs that run on a blockchain network and serve as a digital agreement mechanism between two or more parties without the need for a third-party intermediary. According to Szabo, 1996, the concept of smart contracts is designed to create a trustworthy transaction mechanism through program code that is capable of executing contract decisions automatically and transparently (Azmi et al., 2023).

Smart contracts on the Ethereum network enable developers to create decentralized applications (DApps) with publicly verifiable transaction rules. Previous research demonstrating the implementation of smart contracts in Ethereum-based NFT transactions demonstrated that this technology can improve transparency, security, and transaction efficiency because ownership validation is performed directly by the blockchain system without relying on third parties (Rino et al., 2025).

Based on these issues, this research proposes the implementation of an NFT-based AI Generated Artwork system supported by Ethereum smart contracts. The developed system integrates AI Image Generator technology to generate digital artwork, IPFS (InterPlanetary File System) as a digital asset storage medium, and Solidity smart contracts based on the ERC-721 standard to regulate the minting process, transactions, and verification of NFT ownership.

The novelty of this research lies in the integration of Generative AI and the Ethereum blockchain into a single, integrated system flow. Unlike previous research that focused on NFT image transactions, this study adds the aspect of recording the creative process in the form of AI prompts as part of the digital metadata. This metadata is stored via IPFS and associated with an ERC-721 ID Token on the blockchain, serving not only as proof of asset ownership but also as documentation of the creation history of AI-based digital works.

Based on the problems outlined, this research focuses on the design and implementation of a decentralized application (DApp) that integrates Generative Artificial Intelligence (AI) technology with the Ethereum blockchain in managing NFT-based digital artwork. This research aims to develop an NFT marketplace system capable of producing AI-Generated Artwork, performing minting, transactions, and automatically transferring ownership of digital assets through the implementation of Solidity smart contracts based on the ERC-721 standard. Furthermore, this research proposes a mechanism for verifying the authenticity and ownership of digital works through

decentralized metadata storage using the InterPlanetary File System (IPFS) connected to a blockchain network. The main contribution of this research lies in the integration of AI-based creative processes with blockchain technology, specifically through recording AI prompts as part of NFT metadata to establish digital provenance, or the history of the origins of digital works. With this approach, the developed system is expected to provide solutions to the problems of authentication, plagiarism, and protection of digital artwork ownership rights in the era of Generative AI development.

LITERATURE REVIEW

Artificial Intelligence Generative

Generative Artificial Intelligence (AI) is a branch of artificial intelligence that generates new content such as text, images, audio, and video based on patterns learned from previous data. Unlike conventional AI, which focuses on analysis and prediction, Generative AI uses machine learning and deep learning methods to generate new output based on user input (prompts) (Grover et al., 2024; Paul and Anuradha, 2024; Taşabat, 2025).

Generative AI models such as Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and Transformers are widely used in the digital content creation process because they are capable of producing synthetic data with a high degree of similarity to the original data (Hanycz and Antiperovitch, 2025; Whatmough, 2025). In this research, Generative AI is utilized to generate digital artwork (AI Generated Artwork), which is then combined with blockchain technology to support the authentication and ownership of digital assets. Despite its significant capabilities in the creative process, Generative AI still faces challenges such as data bias, copyright issues, and validating the authenticity of the generated content (Karthik et al., 2025; Paul and Anuradha, 2024).

Blockchain

Blockchain is a distributed database technology (Distributed Ledger Technology/DLT) that enables secure recording and storage of transactions on a computer network without the need for a central authority (Kouraogo and Orhanou, 2025). Blockchain has the main characteristics of decentralization, transparency, security, and immutability, thus reducing the risk of manipulation and increasing trust in digital data exchange (Aghili, 2024; Teeluck et al., 2021). The blockchain mechanism is supported by several main components, such as a distributed ledger to store data on multiple nodes, cryptographic technology to maintain transaction integrity, a consensus mechanism for data validation, and smart contracts that enable automatic execution of transaction rules based on program code (Aghili, 2024; Kouraogo and Orhanou, 2025). In this research, blockchain is utilized as an infrastructure for recording digital asset ownership through NFT, so that every transaction and ownership history of AI works can be verified transparently and permanently (Laghari et al., 2026).

Ethereum Blockchain

Ethereum is a second-generation public blockchain platform that facilitates the running of smart contracts globally (Wang et al., 2021). Unlike Bitcoin, which functions solely as a peer-to-peer payment system, Ethereum provides a decentralized virtual machine known as the Ethereum Virtual Machine (EVM). The EVM executes bytecode instructions uploaded by developers to the blockchain network. Users interact with Ethereum using cryptocurrency wallets like MetaMask to sign each transaction using private keys (Rino et al., 2025). Every change in the state of data on the Ethereum network requires a computational cost called a gas fee, which is paid using Ether (ETH) units to the network validators.

Smart Contract

A smart contract is a digital agreement that runs automatically on a blockchain network, where transaction rules and logic are written directly in program code. Smart contracts enable transaction execution without third-party intermediaries by utilizing the transparent, secure, and decentralized blockchain mechanism (Aggarwal and Kumar, 2021; E. Chen et al., 2021; Dutta, 2020). The main characteristics of smart contracts include automation of execution based on predetermined conditions, validation through a distributed network, and immutable storage of transaction data so that all activities can be tracked and verified (Wanigasooriya et al., 2022). In this research, smart contracts are used to automatically manage the minting process, ownership transfer, and NFT transactions on the Ethereum network. In the NFT marketplace ecosystem developed in this research, all transaction rules are represented by key on-chain functions, such as :

1. mintArtwork(): A function to mint a new token and associate it with URL metadata.
2. buyNFT(): A function that facilitates token purchase transactions by simultaneously transferring ownership and disbursing payments.
3. transferNFT(): A function to manually send NFT ownership to another wallet address.
4. verifyOwner(): A gas-free, locally executed function that reads the current owner's address data.

NFT (Non-Fungible Token)

NFTs are cryptographic tokens that represent ownership of a unique digital asset that cannot be exchanged one-to-one due to their distinct metadata characteristics (Wang et al., 2021). NFT implementations on the Ethereum network generally adhere to the ERC-721 protocol standard. The main components that make up an ERC-721 token include:

1. Token ID: A unique identification number that acts as a primary key to distinguish tokens within the network.
2. Owner Address: The digital wallet address that has exclusive ownership rights to the ID Token.
3. Metadata URI: An external link that directs the system to a JSON description file that defines the properties and visual assets details of the token.

IPFS (Interplanetary File System)

The InterPlanetary File System (IPFS) is a decentralized peer-to-peer (P2P) distributed file system created to address the shortcomings of conventional centralized systems such as HTTP (Doan et al., 2022). This system facilitates effective data storage, sharing and retrieval by leveraging content-based addressing along with P2P networking principles (El Sehayl et al., 2026; Shi et al., 2019). Storing large multimedia files directly on the Ethereum blockchain is highly inefficient and requires very expensive gas fees (Rino et al., 2025). Therefore, IPFS is used as a secure off-chain storage solution. Digital art image files and JSON metadata files are uploaded to the IPFS network, which then returns a unique cryptographic identifier in the form of a CID hash (Content Identifier) (Rahman and Candra, 2023). The Ethereum blockchain only needs to store the CID hash as the value of the Metadata URI, thus maintaining the integrity of the file from the risk of changes without burdening the blockchain's memory capacity.

METHODS

This research uses a Research and Development (R&D) methodology. The primary objective of this methodology is to design, build, test, and evaluate the functionality of an integrated decentralized application (DApp) prototype capable of bridging the generative AI ecosystem with the decentralized Ethereum blockchain network. The research was conducted through a structured, systematic process to ensure the quality of the output could be objectively tested. The system architecture was designed with a hybrid approach to balance the needs of off-chain computational speed and on-chain recordkeeping security.

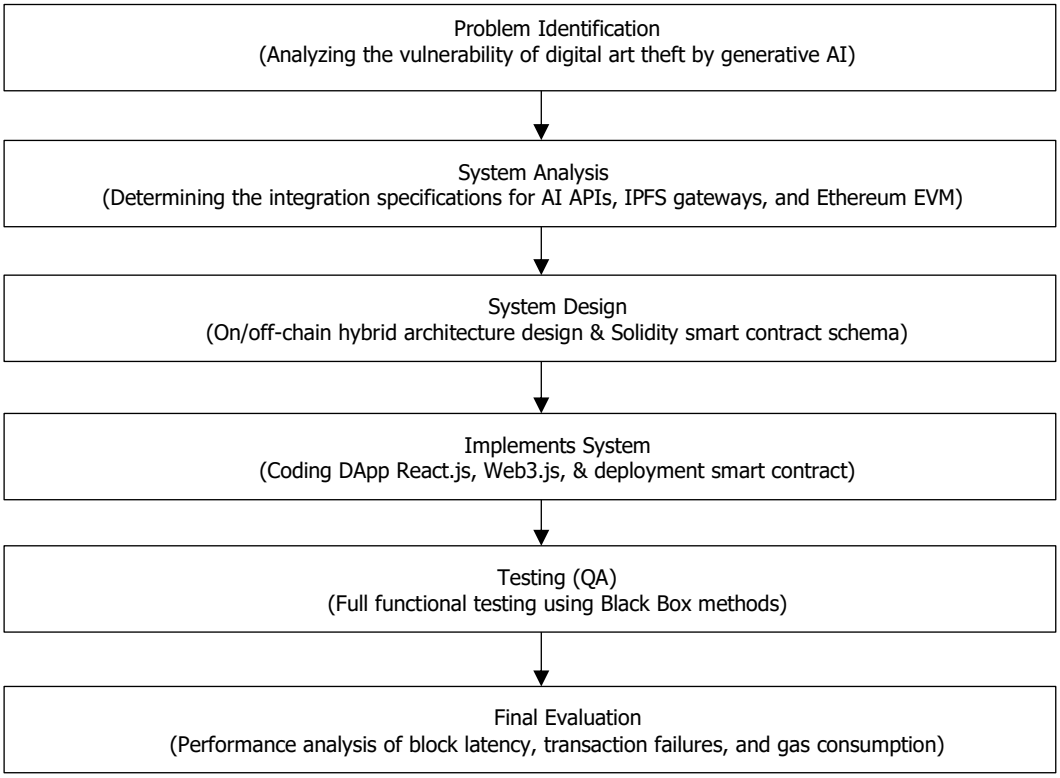

Figure 1. Research and Development Methodology Framework

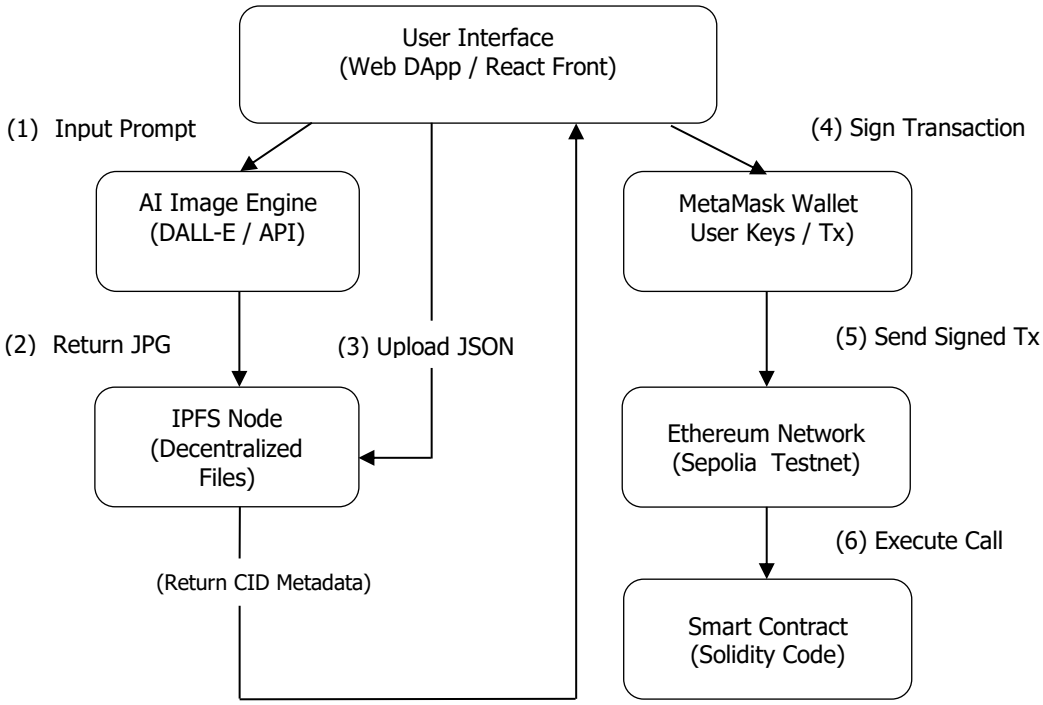

Figure 2. System Architecture and Data Flow of the AI-Enabled Decentralized Application

The user interface was developed using React.js to generate an interactive SPA (Single Page Application) display. The Web3.js library bridges the web interface with the Ethereum node. The frontend is responsible for capturing user-generated text input, passing it to the AI generator engine's REST API, processing the returned visual files, uploading them to IPFS to obtain a CID hash, and compiling the ERC-721 standard JSON file metadata before triggering a MetaMask digital wallet transaction. Every work produced by the AI generator is permanently stored within the IPFS network.

```
JSON
{
  "name": "Generative Abstract Echoes #1",
  "description": "Karya seni generatif yang dihasilkan oleh algoritma kecerdasan buatan.",
  "image": "ipfs://bafybeihd6k3xvhshmwyh2kndn2p7y6qxp7b3a9jh1039da73ksda921",
  "attributes": [
    { "trait_type": "Generator Model", "value": "DALL-E 3" },
    { "trait_type": "Original Prompt", "value": "Futuristic abstract city in glowing neon color palette, highly detailed digital painting" },
    { "trait_type": "Generation Timestamp", "value": "1710920184" }
  ]
}
```

Figure 3. JSON Metadata Structure for AI-Generated Digital Artwork

The smart contract is written using Solidity version 0.8.20 by inheriting the OpenZeppelin industry standard ERC721URIStorage library to ensure the security of the token URI storage method safely. Complete smart contract code. Furthermore, system functionality testing is conducted periodically using black box testing methods to verify the application's accuracy according to the planned scenario.

Table 1. Test scenario

ID Uji	Testing Features	System Input Action	Functional Success Criteria
BB-01	AI Creation	Enter a creative text description string in the input field and trigger the generate trigger.	The system successfully renders new digital visuals in real-time on web pages.
BB-02	IPFS Upload Integration	Sends image binary data and metadata JSON payload to IPFS node.	Returns a valid, publicly accessible, unique CID hash address.

ID Uji	Testing Features	System Input Action	Functional Success Criteria
BB-03	Execute mintArtwork()	Sign a minting transaction in the MetaMask wallet by attaching the CID URI.	The blockchain mints new tokens, records the token ID, and generates an on-chain success status history.
BB-04	BuyNFT execution()	Purchase a registered NFT with a different wallet that has sufficient balance.	Token ownership transfers automatically, the buyer's balance decreases, and the seller's balance increases.
BB-05	NFT transfer execution()	Sending tokens to the destination Ethereum wallet address manually.	ID token changes hands and verified ownership belongs to the destination wallet
BB-06	Execute verifyOwner()	Calling the verify function on a specific ID Token.	The system returns the current legitimate owner's wallet address and reads the metadata JSON file link accurately.

RESULT

System Interface Implementation

The AI Generator page presents a minimalist yet functional interface for art creators. It includes a text area for entering creative description parameters. Behind the scenes, the platform makes a REST API call to the AI generator. The results of the image computation process are instantly displayed in a visual image viewer within the web interface, complete with the option to automatically mint as an NFT.

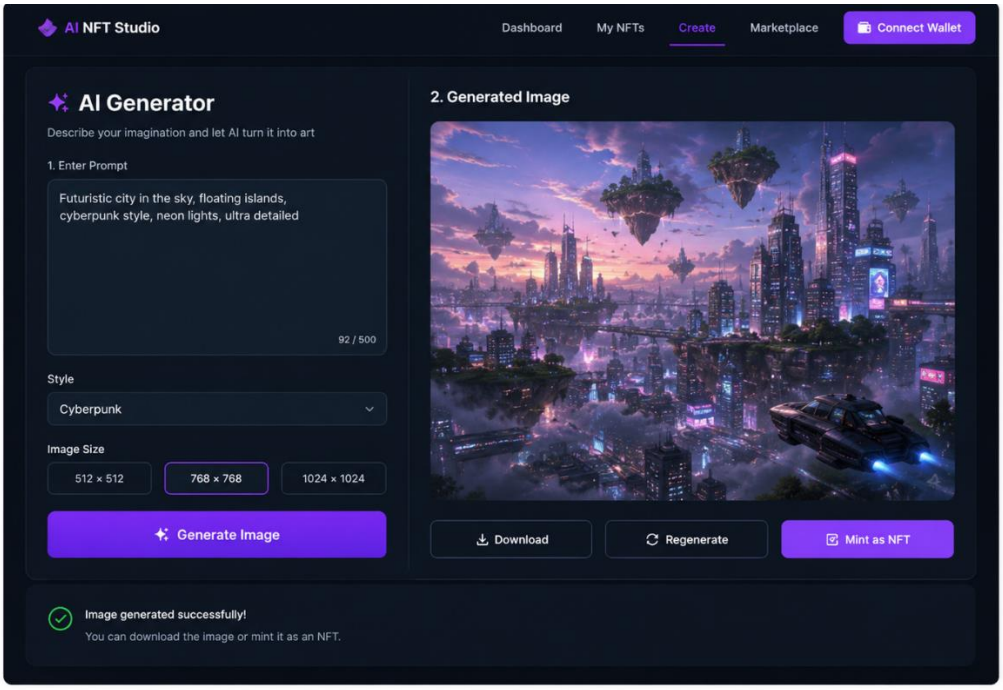

Figure 4. AI Generator User Interface on AI NFT Studio Platform

The NFT Marketplace page displays a list of generative AI artworks minted as NFTs on-chain in a responsive grid layout. Key information embedded directly on the page includes a visual of the digital art asset from the IPFS gateway, the nominal bid price in Ether (ETH), the identity of the original creator, and a unique ID Token.

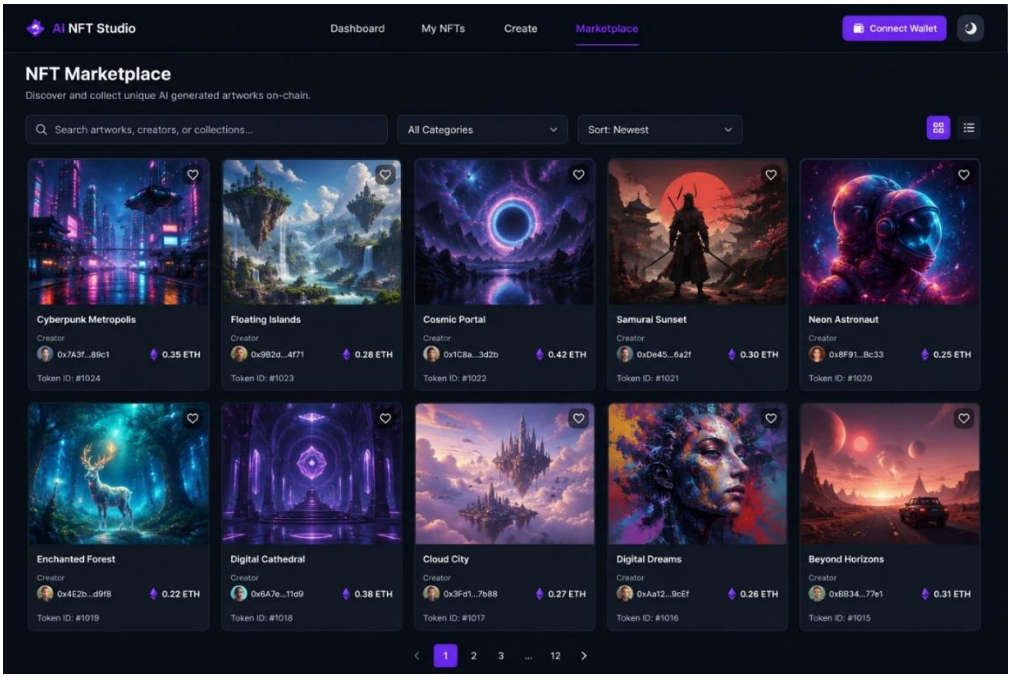

Figure 5. NFT Marketplace User Interface on AI NFT Studio Platform

The Wallet page is the Web3 connectivity control panel. When a user clicks the "Connect Wallet" button, a MetaMask pop-up will appear requesting the user's cryptographic signature authentication. Once connected, the page will display the active wallet status, the public wallet address (e.g., 0x71C249E6A562B9038234676451a923891c3a93b4), and the account's real-time balance in ETH.

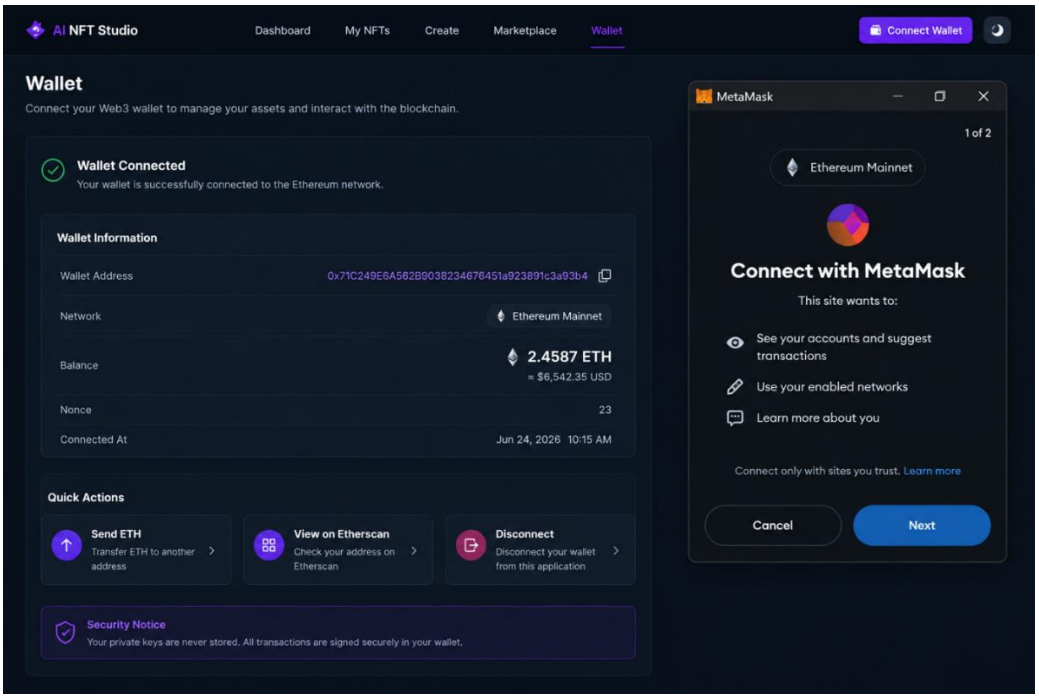

Figure 6. Web3 MetaMask Wallet Connection Interface

The NFT Details page provides complete transparency of asset data. In addition to displaying a full-resolution image visualization, it directly queries the smart contract to display the current owner's wallet address, historical ownership transfer history, and a visualization of the original metadata parameters from IPFS containing the creator's original prompt text.

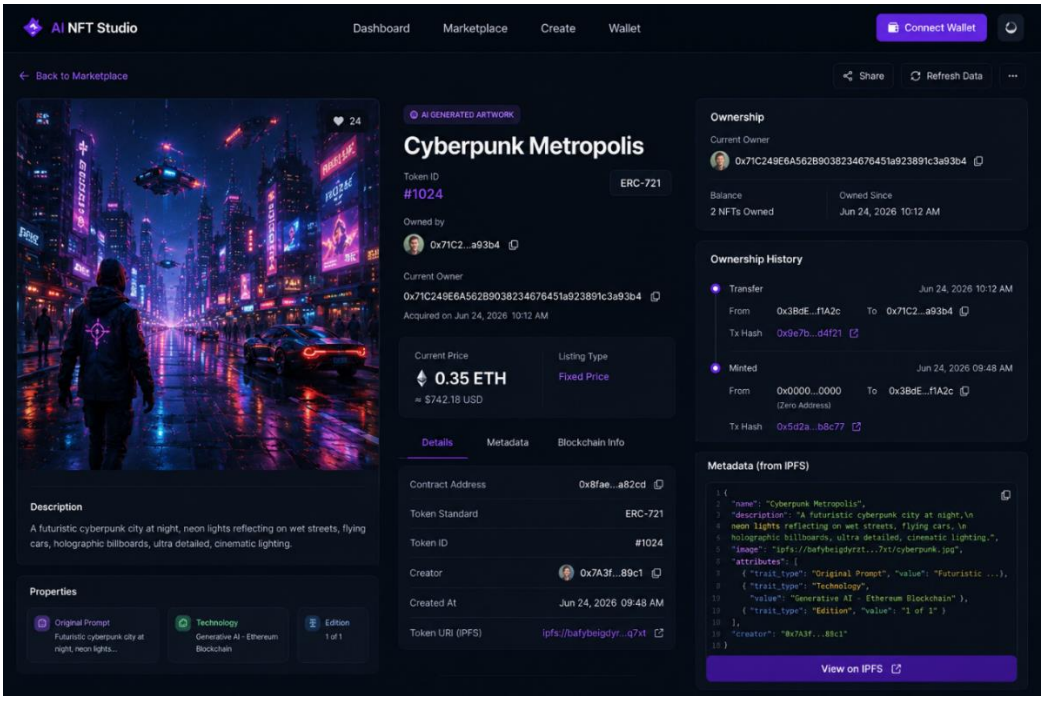

Figure 7. NFT Details Page Interface

Smart Contract Execution Results

The implementation of smart contracts in this study was successfully carried out using the AISmartContractNFT smart contract developed with the Solidity programming language and deployed on the Ethereum Sepolia Testnet network using the Hardhat development framework. The smart contract functions as a key component in managing NFT digital assets, from the minting process, ownership recording, to storing AI-based artwork metadata references on the blockchain network. The test was conducted by running the mintArtwork() function through a Web3 application connected to the MetaMask digital wallet. The function accepts a tokenURI parameter, which points to the digital artwork's metadata stored on the IPFS network, and the NFT asset's price of 0.05 ETH. Once the transaction is confirmed by the user, the smart contract performs the validation process and records the asset information permanently into the Ethereum blockchain.

The execution results show that the transaction was successfully processed and recorded in block 5849201 with a success status (Success Transaction Confirmed). The blockchain generates a unique identity in the form of Token ID 001 as a representation of the created NFT asset. Furthermore, the owner's wallet address is successfully recorded in the smart contract, allowing transparent verification of ownership of the digital work through the blockchain network.

```
[Status] Success (Transaction Confirmed on Block #5849201)
------------------------------------------------------------------------
Transaction Hash : 0x8fae839e0839a8bc89493f9de7293b1029e843fa723da89b910123efab9a82cd
Token ID         : 001
Owner Address    : 0x71C249E6A562B9038234676451a923891c3a93b4
Gas Consumed     : 124,532 Gas
Gas Fee Paid     : 0.002131 ETH (on Sepolia Testnet Price)
Metadata URI     : ipfs://bafybeihd6k3xvhshmwyh2kndn2p7y6qxp7b3a9jh1039da73ksda921
------------------------------------------------------------------------
```

Figure 8. Smart Contract Execution Results on Ethereum Sepolia Testnet

Functionality Test Results

System functionality testing was conducted to evaluate the performance of each major component of the Ethereum blockchain-based AI-Generated Artwork NFT system. The testing method used was Black Box Testing, which focuses on the suitability of system functions based on the input and output generated without examining the application's internal code structure. Testing was conducted on the Ethereum Sepolia Testnet, replicating each test scenario 10 times to ensure consistency of system execution. The test scenarios covered all key stages of the

system, from creation using the AI Image Generator, asset storage via IPFS, NFT minting, purchase transactions, ownership transfers, and digital asset owner validation. The test results are shown in Table 2.

Table 2. System Functionality Test Results

Scenario ID	Test Scenario	Test Results	Success Percentage	Average Latency
BB-01	Generate Gambar AI	Succeed	100% (10/10)	12.4 Seconds
BB-02	Upload IPFS	Succeed	100% (10/10)	2.8 Seconds
BB-03	Mint NFT	Succeed	100% (10/10)	3.2 Seconds
BB-04	NFT Purchase	Succeed	100% (10/10)	3.5 Seconds
BB-05	Transfer NFT	Succeed	100% (10/10)	3.1 Seconds
BB-06	Owner Validation	Succeed	100% (10/10)	1.2 Seconds

Based on the test results in Table 2, all the main features of the system were successfully executed with a success rate of 100% in all test scenarios. The AI Image Generation process (BB-01) had the highest execution time with an average of 12.4 seconds because it involved the AI model's computational process in generating digital images based on user-prompted parameters. In the asset storage process, the IPFS Upload test (BB-02) resulted in an average time of 2.8 seconds. This demonstrates that the decentralized storage mechanism is capable of stably storing image files and JSON metadata and generating a Content Identifier (CID) as a unique reference to digital assets.

Meanwhile, processes involving status changes on the blockchain, such as NFT Minting (BB-03), NFT Purchasing (BB-04), and NFT Transferring (BB-05), take an average of 3.1 to 3.5 seconds. This time is influenced by transaction validation, block formation, and the Ethereum Sepolia Testnet network's confirmation mechanism. Each successful transaction is permanently recorded on the blockchain through smart contract execution. Unlike the transaction process (write operation), the Owner Validation test (BB-06) has the lowest execution time, at 1.2 seconds. This is because the validation process only reads the ownership information stored in the smart contract without changing the blockchain state, thus eliminating gas costs.

Overall, the test results demonstrated that the system was able to consistently perform all key functions, from the AI creation process to NFT ownership verification. The Ethereum smart contract implementation successfully provided a transparent, automated, and verifiable transaction mechanism, thus supporting the research objective of building a secure and reliable digital asset management system based on AI-Generated Artwork.

DISCUSSION

The Impact of Generative AI and Blockchain Integration in Digital Asset Management

The research results show that the integration of Generative Artificial Intelligence (GenAI) and the Ethereum Blockchain can create a new mechanism for creating, managing, and verifying NFT-based digital art assets. Generative AI enables users to automatically generate digital visual works through the use of deep learning models that can translate text prompts into digital image representations (Melzi et al., 2023). Technological developments such as Stable Diffusion, DALL-E, and Midjourney demonstrate that generative AI models have expanded human capabilities in creating creative content with faster and more flexible processes. However, these enhanced capabilities also present new challenges related to authentication, ownership, and copyright protection of digital works generated by AI (Amar et al., 2023).

In this research, Generative AI's role is focused on as a mechanism for creating digital artwork, while the Ethereum blockchain is used as the infrastructure to provide trust and validate ownership of the resulting assets. Blockchain's characteristics include decentralization, transparency, and immutable nature, enabling it to provide a secure transaction recording system without relying on a central authority. Every transaction recorded in the blockchain must go through a network validation process so that it can reduce the possibility of data manipulation and increase trust in digital asset ownership information.

Based on the system implementation results, the integration process between the AI Image Generator, IPFS, and Ethereum smart contracts successfully established a digital workflow, from artwork creation and metadata storage to NFT issuance. The use of NFTs allows each digital artwork to have a unique identity in the form of an ID Token recorded on the blockchain, which can then be used as proof of digital ownership. The smart contract execution results in this study show that the mintArtwork() function successfully records AI-generated artwork assets to the Ethereum Sepolia Testnet network, including token information, owner addresses, and metadata stored via IPFS. This mechanism strengthens the concept of digital provenance, namely the system's ability to transparently trace the origin and ownership history of a digital asset.

1. Transparency and Verification of Ownership of AI Works

One of the main impacts of implementing blockchain in this research is increased transparency regarding the ownership process of digital works created by Generative AI. In conventional digital systems, image files can

be easily copied and distributed without any mechanism to prove the original creator of the work. Furthermore, the metadata of digital files can be modified or removed, making it difficult to verify the work's provenance. This problem is further complicated in AI works because the creation process involves not only humans but also algorithmic models that generate output based on specific training data.

This research addresses this issue by storing artwork metadata on IPFS and linking it to ERC-721-based NFTs on the Ethereum blockchain. This metadata not only contains information about the image but also records important parameters such as the original prompt used in the AI generation process. This approach provides additional information about a work's creative process, allowing users to understand how a digital asset is created. This kind of transparency is important because one of the main challenges of Generative AI is the limited ability of users to understand the internal processes of AI models which are black box in nature (Janiesch et al., 2021; Meske et al., 2022).

According to research on Generative AI-based systems, the need for transparency is growing as users require an understanding of how the system generates output and how those decisions or results can be held accountable (Brasse et al., 2023). Therefore, the integration of blockchain in this study adds value by providing a permanent record of the digital assets that have been created, even though the internal process of image generation remains dependent on the AI model used.

2. The Challenges of Bias and Output Quality in Generative AI

Although the developed system successfully carried out the NFT minting and ownership verification processes, the quality of the resulting works is still influenced by the limitations of generative AI technology. Generative AI models are highly dependent on the quality of the training dataset, as non-representative data can lead to biased results (Ferrara, 2023; Schramowski et al., 2022). Bias in AI systems can arise from issues such as data imbalance, labelling errors, or a lack of data diversity during the model training process (Mehrabi et al., 2021; Ntoutsi et al., 2020).

In the context of this study, blockchain does not serve to improve the quality of AI-generated output, but rather provides a mechanism to protect the work once it has been successfully created and published as an NFT. Therefore, image quality validation, AI model selection, and the formulation of appropriate prompts remain critical factors in producing digital assets with creative and commercial value. Human evaluation is still necessary to ensure that AI-generated results align with user objectives and do not produce unwanted content (Banh and Strobel, 2023).

3. The Challenge of Hallucinations in AI-Generated Artwork

Besides bias, Generative AI also faces problems in the form of hallucination, which is a condition where the model produces output that looks correct but is actually not in accordance with the context or user instructions (Ji et al., 2023). This phenomenon occurs because the AI model works based on probabilistic patterns from the training data so that the results provided do not always have the same level of accuracy (Susarla et al., 2023).

In this study, the risk of hallucinations can occur during the image creation stage when the system generates visuals that differ from the user's description prompt. However, the application of NFTs and blockchain provides a mechanism for recording versions of the created work, allowing each generation to have a unique identity and be traced back through transaction history. Future system development may consider additional validation mechanisms such as human evaluation or automated detection methods to ensure the quality of the work before it is minted onto the blockchain (Zhou et al., 2023).

4. Security and Prevention of Misuse of Digital Works

Generative AI's ability to generate realistic content also carries the risk of misuse, particularly regarding identity forgery, digital content manipulation, and unauthorized claims of ownership of works (Weidinger et al., 2022). Easy access to AI content creation technology can be used for creative purposes, but it can also be used to generate false information or manipulative content if not properly controlled (Mirsky and Lee, 2022). In this research, the implementation of smart contracts and NFTs provides a mitigation mechanism for ownership claims issues because each issued asset has a Token ID, owner address, and transaction history stored on the blockchain. The system cannot completely prevent the creation of copies of digital works, but it can provide authentic proof of the asset's initial recording on the blockchain network. This provides a stronger basis for verification than traditional digital storage systems.

5. Research Implications

Overall, the research findings show that the combination of Generative AI and the Ethereum Blockchain offers opportunities for building a more transparent, secure, and verifiable digital asset ecosystem. Generative AI accelerates the process of creating digital artwork, while the blockchain provides a permanent and publicly auditable ownership record. However, the implementation of this technology still presents challenges related to AI data quality, model transparency, the risk of bias, and the legal aspects of ownership of AI-generated works (Brasse et al., 2023; Ferrara, 2023). Therefore, this study shows that the integration of AI and blockchain is not only focused

on the creation of new digital assets, but also requires an approach that pays attention to aspects of security, transparency, and responsibility in the development of future creative technologies.

Comparison with previous research

The development of blockchain technology, non-fungible tokens (NFTs), smart contracts, and generative artificial intelligence (GenAI) has spurred a variety of research related to digital asset management, ownership security, and decentralized transaction automation. Previous research has largely focused on leveraging blockchain to increase the transparency of digital transactions, verify asset ownership, and reduce dependence on third parties. However, integrating generative AI's capabilities in creating digital works with blockchain as an ownership validation mechanism remains a relatively new area of development.

Research by Rino et al. (2025) discusses the implementation of smart contracts on the Ethereum network for NFT image trading transactions. The study developed a web-based application that integrates Solidity smart contracts, Ethereum, MetaMask, and IPFS to support the minting, purchasing, and transfer of NFT ownership. Research results show that smart contracts can increase transaction transparency and provide proof of ownership of digital assets through blockchain records. However, this research still focuses on existing digital images and does not address the process of asset creation using Artificial Intelligence technology.

Other research on Generative AI shows that this technology can generate various types of digital content through deep learning models, such as text-to-image generation. However, generative AI-based systems face challenges related to the transparency of the creation process, data bias, and validation of the origin of the generated content, as AI models are often considered black box systems (Janiesch et al., 2021; Meske et al., 2022). Therefore, an additional mechanism is needed that is capable of transparently recording the history of creation and ownership of digital works.

Based on previous research, this study develops a new approach by integrating an AI Image Generator, IPFS, ERC-721 NFTs, and Ethereum Smart Contracts into a single integrated system. The main difference lies in the addition of recording the AI's creative process in the form of original prompts as part of the NFT metadata, allowing the system to not only certify digital asset ownership but also provide information on the work's provenance.

Based on this comparison, it can be seen that previous research has successfully applied blockchain and NFTs to digital asset management, but most still focuses on pre-existing assets. Research on Generative AI focuses more on content generation capabilities and challenges such as bias, transparency, and security of generated results, but has not yet integrated blockchain-based ownership mechanisms.

Therefore, this research contributes by integrating Generative AI and the Ethereum Blockchain to build a digital artwork management system that not only automatically generates assets but also provides ownership certification through NFTs. Furthermore, storing AI-generated prompts in IPFS metadata is a key differentiator, allowing the system to record the creative process of a work, thereby increasing transparency and establishing the concept of digital provenance.

System Limitations

Although the system developed in this research successfully integrates Generative Artificial Intelligence (GenAI), IPFS, ERC-721 NFTs, and Ethereum Smart Contracts in the creation and ownership verification of digital works, several limitations remain that require further consideration in further implementation. The use of a testnet is a major limitation because this environment does not fully represent the conditions of the Ethereum Mainnet, which has a higher number of users, transaction volume, interaction complexity, and security risks (Lee et al., 2022; Manoj and Joshi, 2023). Although the test results on the Ethereum Sepolia Testnet show a 100% success rate across all functional scenarios, these conditions do not fully reflect the system's performance when deployed at scale, particularly regarding changes in gas fees, transaction density, block confirmation times, and the possibility of attacks on production environments (Lee et al., 2022).

In addition, the system still has a dependency on external Generative AI services in the process of creating digital works, so the quality and sustainability of the system are greatly influenced by the availability of AI models, changes in model versions, and the policies of API service providers (Y. Chen et al., 2023). Generative AI models also have limitations because their results depend on the quality of the training dataset, the learning algorithm, and the potential for bias in the resulting visual output. These issues demonstrate that while blockchain can guarantee the authenticity and ownership of assets after a work is published as an NFT, it cannot fully guarantee the quality or validity of the creative process carried out by the AI model. Beyond technical aspects, integrating AI-generated artwork with blockchain also presents legal and regulatory challenges, particularly regarding copyright, authorship, and the boundaries of ownership between creators, AI users, and NFT owners (Komalavalli et al., 2025; Valencia et al., 2026). Ownership of an NFT recorded on the blockchain does not automatically grant full intellectual property rights to the digital work, so a licensing mechanism or additional legal regulations are still needed to define the rights to use, distribute, and commercialize the asset (Martínez Luna et al., 2026; Valencia et al., 2026).

From a security perspective, smart contract implementation also poses risks of code vulnerabilities such as reentrancy attacks, contract logic errors, and transaction function exploits due to the permanent nature of smart contracts after deployment on the blockchain. Therefore, even if functional testing shows all features are running as designed, further research needs to conduct smart contract security audits, vulnerability analysis, and load testing before implementation on the main network. Furthermore, the use of Generative AI in the creative industry also raises ethical challenges related to the transparency of training data sources, the potential for algorithm bias, and the possibility of using the technology to generate digital content that harms others. Another challenge that still needs to be developed is interoperability between blockchain platforms, as NFT assets created on one network may not be directly usable on another blockchain ecosystem. Thus, this research has demonstrated that the integration of Generative AI and the Ethereum blockchain can be a solution for building a transparent and verifiable digital asset ownership system. However, further development is needed in terms of scalability, security, regulation, and the implementation of responsible AI principles for the system to be more widely implemented in future digital ecosystems.

CONCLUSION

This research has successfully developed and implemented an AI Generated Artwork system based on Non-Fungible Tokens (NFTs) using the Ethereum blockchain and Solidity smart contracts as an approach to support authentication, ownership verification, and AI-based digital asset management. The developed system integrates several key components, namely the AI Image Generator as a mechanism for creating digital works, the InterPlanetary File System (IPFS) as a decentralized storage medium for assets and metadata, and an ERC-721 smart contract on the Ethereum network to regulate the minting process, transactions, and transfer of NFT ownership.

The implementation results show that the system is able to run the entire process flow in an integrated manner, starting from the creation of digital artwork based on user prompts, storing images and metadata via IPFS, to permanently recording asset ownership on the Ethereum blockchain. The implementation of the AI Smart Contract NFT successfully runs key functions such as mintArtwork(), resulting in a Token ID, owner address, and Metadata URI that are transparently recorded on the blockchain network. This demonstrates that blockchain is capable of providing a secure, verifiable, and third-party-independent digital ownership recording mechanism. Based on the results of testing using the Black Box Testing method, all key system functions—including AI image creation, IPFS upload, NFT minting, NFT purchase, ownership transfer, and owner validation—were successfully executed with a 100% success rate (10/10 tests). These results demonstrate that the integration between Generative AI, IPFS, and Ethereum smart contracts can function as designed. Furthermore, the implementation of NFTs provides the ability to build the concept of digital provenance, namely the transparent recording of the origin, transaction history, and ownership of digital works through ID Tokens and blockchain transaction data.

This research also demonstrates that the combination of Generative AI and the Ethereum Blockchain provides a new approach to managing digital artworks. Generative AI accelerates the visual creation process through text-to-image generation, while blockchain provides a trust mechanism through its decentralization, transparency, and immutability. The addition of original prompt information as part of NFT metadata is a key contribution of this research, as the system not only records asset ownership but also documents the creative process behind the creation of AI-based digital artworks. However, the developed system still has several limitations, such as testing conducted on the Ethereum Sepolia Testnet, dependence on external AI services, regulatory challenges related to AI copyright, and the need to improve smart contract security before deployment in production environments. Therefore, further research can be directed at testing using the mainnet, optimizing transaction costs (gas fees), smart contract security audits, developing digital licensing mechanisms, and improving interoperability between blockchain platforms.

The implications of this research indicate that the integration of Generative AI and blockchain can be a potential solution in building a more transparent, secure, and verifiable digital asset ecosystem. The developed system provides a practical contribution to the digital creative industry through an NFT-based ownership certification mechanism, while also contributing academically to the development of Web3 studies, AI-generated content, and digital ownership. Furthermore, this research emphasizes that the application of AI and blockchain technology requires consideration of security, ethics, data source transparency, and intellectual property rights regulations for its sustainable implementation in future digital ecosystems.

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