Research on the Mode Construction and Practical Exploration of Blockchain-Enabled AI Music Copyright Protection

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Abstract: With the in-depth application of artificial intelligence technology in music creation, AI music production is experiencing explosive growth. However, issues such as ambiguous copyright ownership, difficulty in identifying infringement, and high costs of rights protection are becoming increasingly prominent. Blockchain technology, characterized by decentralization, immutability, and traceability, provides an innovative solution to the dilemma of copyright protection. Based on the theoretical foundations of blockchain and AI music copyright protection, this article systematically constructs two innovative protection models: full copyright lifecycle management and a decentralized copyright service ecosystem. It analyzes typical domestic and international practical cases, distilling both successful experiences and current challenges in technology application. It also proposes targeted response strategies from the perspectives of technology, legal policies, and market ecology. Research demonstrates that blockchain technology has significant value in improving the efficiency of AI music copyright protection and optimizing rights distribution mechanisms. Future efforts will require technological innovation, institutional improvement, and ecosystem collaboration to promote the development of a sustainable AI music copyright protection system.

1. Introduction

With the booming digital music industry, the development of AI technology in music creation, production, and distribution has spawned a massive number of AI music works. However, this has also brought new challenges such as ambiguous copyright ownership, difficulty in identifying infringements, and high costs of rights protection. Traditional copyright protection mechanisms have gradually revealed problems such as inefficiency and a lack of trust when dealing with the digital and intelligent characteristics of AI music. Blockchain technology, with its core characteristics of decentralization, immutability, and traceability, provides a new approach to solving the dilemma of AI music copyright protection. Based on the current development status of the digital music industry, this article focuses on the practical pain points of AI music copyright protection. Through literature research and case analysis, this article systematically explores the mechanism of blockchain technology in enabling AI music copyright protection, constructs an innovative protection model, and analyzes its application results based on practical cases. Finally, it summarizes the current challenges and proposes coping strategies, aiming to provide theoretical reference and practical guidance for improving the AI music copyright protection system and promoting the healthy development of the music industry.

2. Blockchain and AI: Theoretical Basis for Music Copyright Protection

2.1 Analysis of the Core Principles and Characteristics of Blockchain Technology

As a distributed ledger technology, blockchain's core principles are based on a decentralized node consensus mechanism, a chained data storage structure, and an asymmetric encryption algorithm,

creating an immutable timestamp record and a fully traceable information chain. Technically, blockchain consists of a data layer, a network layer, a consensus layer, a contract layer, and an application layer. The connection between these layers ensures system security. The data layer encrypts transaction information using a hashing algorithm, generating a fixed-length hash value. Any slight change in the data results in a significant change in the hash value, providing the technical foundation for verifying the integrity of the information. The network layer utilizes a peer-to-peer (P2P) transmission protocol, enabling distributed data storage and synchronization between nodes.

The consensus layer is the core of blockchain technology. Through consensus mechanisms such as Proof of Work (PoW), Proof of Stake (PoS), and Delegated Proof of Stake (DPoS), distributed nodes achieve data consistency without the need for a third-party authority. Different consensus mechanisms have their advantages and disadvantages. PoW offers high security but high energy consumption, while PoS offers lower energy consumption but may pose issues of concentrated stake. In practical applications, the appropriate consensus algorithm should be selected based on the specific scenario. The contract layer incorporates smart contract technology, which enables automated transaction execution through coded rules. When pre-set conditions are met, smart contracts can automatically complete operations such as asset transfers and stake distribution [1].

The core characteristics of blockchain are of particular value to copyright protection. Immutability ensures that copyright registration information, once uploaded to the blockchain, cannot be maliciously altered, providing reliable proof of copyright ownership. Traceability, through a chained data structure, records the entire process from creation to circulation, making copyright traceability accurate and efficient. Transparency ensures that all nodes can access transaction records on the blockchain, enhancing the credibility of copyright transactions. Decentralization reduces reliance on traditional copyright intermediaries and mitigates the risk of infringement caused by information asymmetry. These characteristics collectively form the technical foundation for blockchain-enabled copyright protection, offering the potential to address numerous challenges in the field of AI-powered music copyright [2].

2.2 Dilemma and Technical Adaptability of AI Music Copyright Protection

The rapid development of AI music is characterized by a diversification of creative entities, intelligent creative processes, and diverse work formats. These characteristics pose significant challenges to traditional copyright protection mechanisms. Regarding copyright ownership, AI music creation involves multiple parties, including training data providers, AI algorithm developers, and human creators, leading to blurred boundaries of rights. In human-machine collaborative creation, current laws have yet to provide a clear answer to the question of how to divide the rights between the creative input of human creators and the generated output of AI systems [3].

Infringement monitoring and protection present even more prominent challenges. AI music works are easily disseminated and modified digitally, making infringements highly concealed, rapidly spreading, and widespread. Traditional copyright monitoring relies primarily on manual review or keyword matching, making it difficult to monitor massive amounts of AI music content in real time. Due to the difficulty of providing evidence, long turnaround times, and high costs involved in rights protection, third-party copyright authentication is often required, and the authority of these authentication results can be questioned. Even if protection is successful, the compensation often falls short of covering the copyright holder's actual losses.

Blockchain technology is highly compatible with AI music copyright protection and can address these challenges. During copyright transactions, smart contracts can pre-set authorization conditions and revenue distribution rules, automating copyright licensing and royalty settlement, reducing the interception of profits by middlemen. For infringement monitoring and rights protection, blockchain's distributed evidence storage allows for real-time tracking and tracing of infringement evidence. Copyright holders can directly access evidence through the blockchain, significantly reducing the difficulty of proving infringement and the cost of rights protection. Furthermore, blockchain's transparency facilitates the establishment of a public and credible copyright information database, fostering a balanced and transparent trading environment for the copyright trading market.

3. Blockchain-Enabled AI Music Copyright Protection Model

3.1 Copyright Lifecycle Management Model

A full-lifecycle management model for AI music copyrights is built based on blockchain technology, covering the entire process from creation to rights protection, achieving closed-loop management. During the creation and rights confirmation phase, the system connects to AI music creation tools via an API interface [4]. When the creator completes the work, the copyright registration process is automatically triggered. Core information, including the work's audio file, score data, creation parameters, and creation time, is generated using a hash algorithm to produce a unique identifier. This identifier, combined with a timestamp record, is uploaded to the blockchain to form an unalterable certificate of ownership. Figure 1 illustrates AI in the music industry. For works created through human-machine collaboration, smart contracts can be used to predetermine the rights distribution ratio between the human creator and the AI system, clarifying each party's copyright share and usage rights.
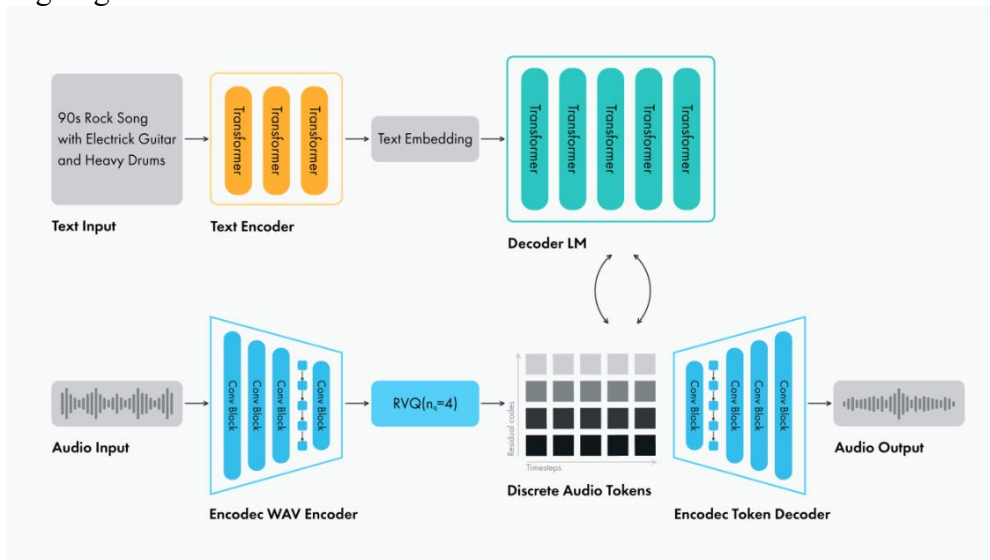

Fig. 1 AI in the music industry

The authorization process utilizes a dynamic authorization mechanism based on smart contracts, automatically enforcing authorization rules based on different usage scenarios and authorization scopes. Copyright holders can set parameters such as the authorization type, duration, and fee for their work on the blockchain platform. These parameters are encoded and stored on the blockchain in the smart contract. After the user initiates an authorization request and pays the corresponding fee through the platform, the smart contract automatically verifies the payment information, generates an authorization certificate, and records the authorized usage. For bulk authorization or split-account scenarios, smart contracts can automate royalty calculation and distribution, transferring revenue to copyright holders in real time according to a pre-set ratio, addressing the long settlement cycles and low transparency of traditional royalty systems.

The infringement monitoring and evidence storage module utilizes a distributed node network for network-wide monitoring, incorporating AI content recognition technology to conduct real-time comparisons of music content across internet platforms. When suspected infringement is detected, the system automatically captures evidence, including the infringing content, dissemination path, and dissemination time, and uploads it to the blockchain for storage after hashing, creating a complete chain of evidence. After an infringement occurs, copyright holders can quickly initiate rights protection based on the evidence stored on the blockchain, eliminating the need for complex evidence notarization processes. Evidence stored on the blockchain can be used as valid evidence in legal proceedings, increasing the success rate of rights protection [5]. Furthermore, the system incorporates an infringement early warning mechanism that automatically sends warning notifications to copyright holders when potential infringement risks are detected, enabling early intervention.

3.2 A Model for a Decentralized Copyright Service Ecosystem

The decentralized copyright service ecosystem model utilizes blockchain as its underlying technology architecture, building a comprehensive service platform integrating copyright registration, transaction flow, monitoring, protection, and community governance, forming a copyright protection ecosystem with the collaborative participation of multiple parties. The platform adopts a hybrid architecture, storing core copyright information on a consortium blockchain to ensure data security and privacy; public copyright information and transaction records are uploaded to a public blockchain to ensure transparency and traceability.

In terms of functional design, the platform integrates multiple core service modules. The copyright registration module provides a standardized AI-powered music registration process, supports multi-format uploads and metadata annotation, and rapidly verifies copyright information and stores it on-chain through an intelligent review mechanism. The transaction flow module establishes a decentralized copyright trading market, allowing creators to independently set prices and publish copyright transaction information. Users connect directly with creators through the platform, completing copyright transactions and payments based on smart contracts. The platform also introduces a token incentive mechanism, rewarding users with tokens for participating in copyright registration, infringement reporting, and node verification, encouraging ecosystem members to actively participate in platform development [6].

The monitoring and rights protection module utilizes a distributed node monitoring network combined with AI recognition technology to implement network-wide AI-powered music copyright monitoring. Regular users can report infringements via the platform and earn rewards upon verification by nodes, creating a nationwide infringement monitoring network. The platform has established data integration mechanisms with major music and social media platforms. When infringing content is detected, smart contracts automatically send removal notifications to the platforms, enabling rapid resolution. For cases requiring legal protection, the platform provides services for retrieval and notarization of blockchain-stored evidence and connects with professional legal services agencies for rights protection support.

In terms of ecosystem governance, a blockchain-based community self-governance mechanism has been established, with ecosystem rules and decision-making processes defined through smart contracts. Major platform rule adjustments and technology upgrades are subject to community vote to ensure fairness and transparency. The platform regularly publishes copyright protection reports, disclosing copyright transaction data, infringement handling status, and other information, and is subject to community oversight. It creates a mutually beneficial relationship among multiple stakeholders, including creators, users, and service providers. It promotes the evolution of AI music copyright protection from a single technology application to an integrated ecosystem.

4. Practical Case Analysis of Blockchain-Enabled AI Music Copyright Protection

4.1 Overview of Typical Cases at Home and Abroad

Many international organizations have explored the practical application of blockchain technology to empower music copyright protection, resulting in several representative use cases. Audius, a decentralized music streaming platform, uses blockchain technology to build a music copyright management system, allowing musicians to directly upload their works while retaining copyright control. The platform uses ERC-20 tokens to facilitate value transfer. Musicians can independently set access rights and revenue distribution rules for their works, and users pay with tokens to gain access to music. Audius 's core innovation lies in its blockchain-based music copyright database, which records the creation and licensing history of works, addressing the lack of transparency in copyright information on traditional streaming platforms. As of 2024, the platform has attracted over one million musicians and registered over five million works, making it a benchmark project in blockchain music copyright protection.

In China, NetEase Cloud Music has launched a blockchain-based "Music Copyright Notification Platform," focusing on addressing copyright verification issues for AI-generated music. This platform

integrates with NetEase Cloud Music's AI creation tool, NetEase Tianyin. Once users create music using the AI tool, they can apply for copyright notification with a single click. The platform stores information such as the work's audio characteristics, creation parameters, and creation time on the blockchain, generating a legally binding notification certificate. Tencent Music Entertainment Group has also developed a "blockchain + AI" copyright protection system, integrating copyright registration, infringement monitoring, and rights protection services.

4.2 Case Analysis

In practice, the application of blockchain technology in AI-powered music copyright protection has demonstrated significant value. Copyright verification efficiency has been significantly improved. Traditional copyright registration typically takes days to weeks, while blockchain-based copyright notarization can be completed in minutes, reducing notarization costs by over 60%. Data from the Audius platform shows that the time it takes to verify copyright for a musician's work has been reduced from an average of 7 days to 10 minutes, reducing copyright registration costs by 80%.

The effect of infringement rights protection has been significantly improved, and the admissibility rate of blockchain evidence in legal proceedings has been greatly improved. Data from NetEase Cloud Music's copyright evidence storage platform shows a high success rate for infringement protection against AI-powered music works using blockchain-stored evidence, significantly enhancing monitoring capabilities.

Practical cases have accumulated successful experiences, providing insights for the application of blockchain technology. In terms of technical architecture, most platforms adopt a hybrid architecture combining consortium and public blockchains, balancing the needs for data security and transparency. Furthermore, they utilize sidechain technology to address blockchain performance bottlenecks. In terms of ecosystem collaboration, successful cases emphasize establishing partnerships with all parties in the industry chain, fostering a multi-stakeholder ecosystem. Business model innovation is key to sustainable development, and diversified profit models such as token incentives, value-added service fees, and copyright transaction commissions ensure the long-term operation of the platform.

4.3 Problems and Challenges in Practice

Despite some practical success, blockchain-enabled AI music copyright protection still faces numerous practical challenges. Technical performance bottlenecks exist, and blockchain's transaction throughput cannot meet the real-time processing requirements of massive AI music productions. Inadequate cross-chain interoperability prevents copyright information from being shared across different blockchain platforms, creating a "data island." Users must repeatedly register copyright information on multiple platforms, increasing costs. Privacy protection and information transparency conflict, and blockchain technology could potentially leak creators' trade secrets. Ensuring the traceability of copyright information while protecting user privacy presents a significant challenge in the application of the technology.

Uncertainty at the legal and policy level has hindered the further application of technology. The legal validity of smart contracts has yet to be recognized, and some courts have differing standards for the admissibility of blockchain-stored evidence, leading to inconsistent enforcement efforts. The legal definition of AI music copyright is murky, particularly regarding the recognition of copyright for purely AI-generated works. Conflicting legal provisions across different countries and regions present challenges for cross-border copyright protection [7]. The lack of regulatory policies has exposed blockchain platforms to compliance risks, with some platforms facing regulatory scrutiny for failing to clarify the compliance of their token issuances.

Numerous obstacles exist to market promotion and application. Industry awareness is insufficient, and most musicians lack understanding of blockchain technology. User habits are difficult to change, and traditional copyright protection methods still dominate. It will take a long time for musicians to accept new technologies. Inconsistent industry standards have led to differences in technical solutions and data formats across platforms, hindering the interconnection and interoperability of copyright information and the coordinated development of the industry.

5. Challenges and Strategies of Blockchain-Enabled AI Music Copyright Protection

5.1 Technical Bottlenecks and Breakthrough

Blockchain technology faces multiple technical constraints in empowering AI-powered music copyright protection. Regarding performance, existing blockchain throughput cannot meet the real-time storage requirements for massive AI-powered music productions. Regarding compatibility, differing technical standards across blockchain platforms hinder cross-chain sharing of copyright information, creating data silos. There is also a paradox between security and privacy, as the transparency inherent in blockchain can potentially leak sensitive information such as core parameters of AI-generated music.

The path to breakthrough requires the construction of a collaborative technology system. First, sharding technology and state channels should be used to improve transaction processing efficiency by migrating high-frequency evidence storage operations to sidechains, thereby reducing the burden on the main chain. Second, it is recommended to develop a cross-chain interaction protocol to establish a copyright information consortium chain network and achieve cross-platform ownership confirmation and mutual recognition through distributed identity. Third, it is necessary to integrate zero-knowledge proofs and homomorphic encryption technologies to ensure the traceability of copyright information while protecting commercial privacy, and build an adaptive lightweight blockchain architecture.

5.2 Institutional Ecological Barriers and Optimization Strategies

Institutional and ecological barriers hinder the successful implementation of this technology. Legally, there are legislative gaps regarding the identification of copyright holders for AI-generated content, the legal validity of smart contracts remains uncertain, and there is a lack of unified standards for the judicial acceptance of blockchain evidence. Regarding the industry ecosystem, collaborative barriers exist between music platforms, creative entities, and technology service providers, and a lack of industry standards has led to fragmented technology applications. Market perception biases have also hindered the acceptance of blockchain technology by small and medium-sized creators.

Optimization strategies require a multi-faceted and coordinated approach. First, promoting legislative revisions to clarify AI music copyright ownership rules is recommended. Additionally, establishing a judicial certification mechanism for blockchain evidence storage and forming a cross-industry alliance to develop technical standards and data specifications are necessary steps. It will help build an industry collaboration mechanism. Second, it is necessary to carry out technical training and case promotion through industry-university-research collaboration to lower the barrier to entry for creators and explore sustainable business models based on value sharing.

6. Conclusion

This study systematically examines the model construction and practical application of blockchain-enabled AI music copyright protection. Through theoretical analysis, it clarifies the adaptability and mechanism of blockchain technology in resolving the AI music copyright dilemma. It constructs two core protection models: full lifecycle management and a decentralized ecosystem. The study found that blockchain technology has significant value in improving copyright protection efficiency, reducing rights protection costs, and optimizing revenue distribution. However, it still faces multiple challenges, including technical performance, legal policies, and market ecology. Future efforts will require technological innovation, institutional improvement, and ecological collaboration to promote the in-depth application of blockchain technology in AI music copyright protection and provide strong support for the sustained and healthy development of the digital music industry.

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