

## Retraction

# Retracted: Protection of Jingdezhen Ceramic Heritage Based on Blockchain Technology

### Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### References

- [1] L. Yang, F. Yu, and Y. Nie, "Protection of Jingdezhen Ceramic Heritage Based on Blockchain Technology," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 9710902, 7 pages, 2022.

## Research Article

# Protection of Jingdezhen Ceramic Heritage Based on Blockchain Technology

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Jingdezhen ceramic heritage is the largest existing ceramic cultural heritage in China, with the richest connotation and the most complete system. It has the characteristics of strong systematization, complicated preservation, and diversified use. With the vigorous development of cultural industry, Jingdezhen's ceramic heritage has a broad application prospect, but at the same time, it faces the problem of being destroyed or improperly developed. With the progress of science and technology and the development of machinery, the traditional hand-made porcelain technology of Jingdezhen ceramics is gradually being eliminated. The value and distinctive feature of Jingdezhen ceramic heritage is the importance and necessity of its protection, and the protection of Jingdezhen ceramic heritage has become an urgent problem to be solved. In order to solve this problem, this paper takes the protection of Jingdezhen ceramic heritage as the research object, analyzes the characteristics and protection status of Jingdezhen ceramic heritage, and applies blockchain technology to the protection of Jingdezhen ceramic heritage, which promotes the protection of ceramic heritage. The decentralized, traceable, and open characteristics of blockchain technology provide innovative technical support for the digital construction of ceramic heritage and strong technical support for the protection of ceramic heritage. The results show that by analyzing the current situation of Jingdezhen ceramic heritage protection and construction, the digital model of Jingdezhen ceramic heritage based on blockchain technology is established by combining blockchain technology with digital construction of ceramic heritage, and a digital identity is built for Jingdezhen ceramics. The collected Jingdezhen ceramic information is attached to the blockchain, which ensures its unique and effective identity information, realizes the integration of Jingdezhen ceramic information, and actively promotes the informatization and standardization of ceramic heritage protection. The research results provide new ideas for Jingdezhen ceramic heritage protection and theoretical support for heritage protection and inheritance.

## 1. Preface

China, as the first country to invent porcelain, is a great contribution to the material culture of the world [1]. The development of porcelain has gone through a process from low level to high level, leaving a large number of material and intangible cultural heritages in the continuous development, giving people valuable material and spiritual wealth [2, 3]. In Jingdezhen, as the birthplace of ceramics, along with the rapid development of urban economy, the vigorous development of real estate and infrastructure projects, most of the

ceramic remains have been abandoned, resulting in unmanned management and more and more serious damage [4, 5]. How to reasonably protect the ceramic heritage is imminent. With the protection and reuse of ceramic heritage, in order to avoid the destruction of ceramic heritage, people's awareness of ceramic heritage protection has been continuously improved, and heritage protection and reuse has become an urgent problem to be solved [6–8].

There are many research achievements on Jingdezhen ceramic heritage. Some researchers elaborated the present situation of Jingdezhen ceramic heritage, analyzed the value

and main problems of Jingdezhen ceramic heritage, and put forward corresponding measures and methods from the aspects of ceramic heritage protection, management, and benefit [9]. In the article “Protection and Utilization of Jingdezhen Ceramic Industry Heritage,” some researchers summarized the main value of Jingdezhen ceramic heritage and analyzed the problems and measures of its protection and utilization. In the process of ceramic heritage protection, protection and inheritance are the eternal subjects, which are mainly reflected in the digitalization of heritage [10, 11]. With the application of the Internet, big data, and other technologies in heritage protection, some scholars put forward that there are four problems in heritage protection, such as collection, identification, cooperation, and security. The sources of heritage materials are wide and relatively scattered, and the rich data of heritage requires different professionals to identify [12]. At the same time, there are many subjects of heritage protection, such as social institutions, government agencies, and inheritors. Multimangement of heritage leads to time-consuming and labor-intensive, and the intellectual property rights of heritage are also infringed.

With the development of blockchain technology, it has been applied to more and more industries, and it is also an important application in the protection of ceramic heritage. Some researchers put forward that blockchain is a decentralized way of trust, in which multiple members maintain a specific database, and through the interactive transmission of data, a data block and fingerprint are generated by cryptography and saved to the next data block through the chain, and all system users can verify the authenticity of the data block [13–15]. Blockchain is essentially a kind of bookkeeping by all people. People who participate in bookkeeping can record the changes of data and then update the recorded content to the account book, so as to ensure that each participant has a consistent account book and achieve the purpose of distributed sharing. At present, blockchain is divided into public chain, private chain, and alliance chain according to its openness. As a decentralized, traceable, open, and transparent digital technology, blockchain has the following main features: each node of blockchain keeps transaction records, and node participants supervise the legality of transactions and act as witnesses [16]. The asymmetric encryption algorithm is used to store the transaction information of blockchain, and only the authorized person can query the transaction information [17, 18]. Use the consensus mechanism to ensure the authenticity of the data in the block, and avoid data tampering or illegal use. Some researchers have deeply integrated the protection of ceramic heritage with blockchain technology, forming digital heritage based on blockchain technology. These digital heritages define their ownership through blockchain technology and enable users to trade and enjoy them through app and website platform, thus ensuring the characteristics of nonduplication, permanent preservation, and appreciation of heritage at any time. Blockchain technology endows digital heritage with a unique digital certificate, and at the same time, it guarantees its authenticity in the activities of distribution, trading, collection, etc. and protects its copyright and rights. As a new commodity form, digital heritage can not only fully embody

traditional culture, but also develop new commercial value. The success in commercial level also makes the public pay more attention to traditional culture, creating a new atmosphere of carrying forward traditional culture.

China has a long history and culture, and its heritage is huge and varied. Taking porcelain as an example, the number of unearthed and handed down products and fine products ranks first in the world. Jingdezhen ceramic heritage is the largest existing ceramic cultural heritage with the richest connotation and the most complete system in China. With the development of digital technology, the digitalization of ceramic heritage will be the future trend, and it is very important to establish safe and shared digital assets. Taking the protection of Jingdezhen ceramic heritage as the research object, this paper analyzes the characteristics and protection status of Jingdezhen ceramic heritage and applies blockchain technology to the protection of Jingdezhen ceramic heritage, which promotes the protection of ceramic heritage. The decentralized, traceable, and open characteristics of blockchain technology provide innovative technical support for the digital construction of ceramic heritage and strong technical support for the protection of ceramic heritage.

## 2. Research Methods

*2.1. Present Situation of Jingdezhen Ceramic Heritage.* Jingdezhen covers an area of 5,262km<sup>2</sup>, and ceramic heritages spread all over the city, with rich types, huge quantities, and wide distribution. At the same time, many historical and cultural sites in some historical urban areas are also covered by modern buildings, and some sites are in danger of being demolished, which brings challenges to heritage protection and management.

At present, urban construction is relatively random, and unscientific planning has led to chaos in Jingdezhen, and some historical and cultural sites have also been destroyed. Too many modern and commercialized elements in the blocks have greatly reduced the aesthetic value of cultural heritage, so it has become an important research issue to establish a heritage protection scheme for rational planning of urban development.

At present, there are many management offices and inadequate supervision in Jingdezhen’s management. Except for the central government, provincial, and municipal management departments, the management responsibilities of Jingdezhen municipal government, museums, and cultural relics bureaus are unclear, with overlapping work contents, lack of effective cooperation, and mutual shirking of supervision.

Jingdezhen ceramic heritage has suffered both constructive and protective damage, and many ceramic sites have been abandoned. Effective protection measures have directly reduced the diversity and integrity of Jingdezhen ceramic sites. There is no legal restriction and supervision on underground ceramic excavation, which leads to the destruction and loss of valuable ceramic cultural relics.

Jingdezhen ceramics are well known in the world, and all kinds of beautiful porcelain have attracted the attention of countries all over the world. However, the joint development

of porcelain and the city was less, which limited the development space of the porcelain industry, and the city's protection of the industry was not enough. There are not only ceramics in Jingdezhen, but also sites left by ceramic production, which requires the establishment of comprehensive protection measures and clear protection contents.

*2.2. Design Principle.* Ceramic heritage protection mainly faces problems such as collection, identification, infringement, sharing, storage, and safety (Table 1). By analyzing the difficult problems of ceramic protection, clarifying the solution direction, and establishing a large-scale network data platform with the participation of inheritors, organizations, researchers, and so on, we can achieve the ability of real-time sharing without intervention, reduce the labor cost, and protect the rights and interests of all parties, thus ensuring the accuracy and safety of heritage information, querying and tracing heritage information in real time, improving the anticounterfeiting ability of heritage, and ensuring the ownership of intellectual property rights.

The decentralization of blockchain, the consensus mechanism, and the characteristics of intelligent contract provide a scheme for the protection of ceramic heritage. Blockchain generates blocks based on cryptography. Each block inherits the hash value, time stamp, heritage transaction, and other information of the previous block and stores and maintains the information through a distributed system. When the blockchain is running, the decentralized network ensures the equal transaction of each node and the storage value of data, and the data can be traced back and cannot be tampered with. By introducing the consensus mechanism, the fairness of each node in system maintenance is ensured. Through the intelligent contract, the data cannot be tampered with and distributed, and the decentralized network and consensus mechanism of the third party are not needed (Figure 1).

Once the data information of ceramic heritage is uploaded to the blockchain, it can be permanently stored and cannot be tampered with. Only more than 51% of the nodes agree to modify the data. After this consensus mechanism is built, all participants become the nodes of the network, and anyone can query it, which ensures the openness and truthfulness of the whole process of ceramic heritage information. Intelligent contract is to execute the program through script, which ensures the safe data exchange of all nodes in the whole system, reduces the transaction cost, and realizes the digital storage, data transmission, and real value of ceramic heritage.

*2.3. Design Method.* The main architecture of blockchain technology is divided into application layer, network layer (contract layer), and data layer (Figure 2). Through the decentralization of application layer, P2P network, consensus algorithm and intelligent contract of network layer, and the storage function of data layer, the decentralized, unchangeable, traceable, trust, and consensus point-to-point transmission of ceramic heritage protection can be realized.

Ceramic heritage protection should be open and transparent, broadcast all transactions in the blockchain system in a timely manner, and send transaction records to every user, all of whom can access the network open interface to query transaction records. Ceramic heritage protection still needs participants to agree to open a blockchain network to each device as a node; the node can obtain the complete data, mechanism, and competition between nodes through consensus algorithm to maintain the whole blockchain; even if a node fails, the remaining nodes can still work normally, so as to realize the opening of legacy data and authenticity; it avoids network attacks and hardware security threats to data security.

Through the decentralized application of blockchain, the decentralized bookkeeping weakens the centralized organization, the rights and obligations of each node are the same, and the information exchange among nodes cannot be faked, which greatly reduces the pressure of intermediate links and establishes deeper mutual assistance and cooperation among all participants. The irreversibility of blockchain technology is realized by the irreversibility and uniqueness of hash256 algorithm, which is difficult to realize for general open systems. For the fake cost, it needs more than 51% computing power of the whole network, which is obviously impossible to achieve. Therefore, blockchain ensures the extremely high stability and reliability of data and improves the discrimination ability of each participant. Due to the traceability of blockchain, the transaction and storage of ceramic heritage are open and transparent, and the source and intellectual property rights are clear, which ensures the ownership of intellectual property rights to the greatest extent and improves the anticounterfeiting ability of heritage. At the same time, every transaction is connected in series by cryptographic algorithm and adjacent blocks, thus realizing traceability and no tampering.

### 3. Ceramic Heritage Protection Based on Blockchain

When Jingdezhen ceramic heritage established a digital system, with the help of blockchain technology, the information sharing of ceramic heritage was realized. In order to improve information security, blockchain system gives different rights to different nodes and constructs private chain and public chain. Private chain is mainly used to store digital data and user access information of ceramic heritage; the public chain is used to store metadata and data summaries of the corresponding resources of all ceramic heritage. The digital model of ceramic heritage based on blockchain can be divided into five functional modules: user module, heritage preservation module, digital service module, consensus module, and ownership module (Figure 3).

The digital construction of ceramic heritage is equipped with blockchain technology, and with the help of the driving force brought by digital construction and dissemination, the system provides hardware support for the digital construction of ceramic heritage and consolidates the foundation of digital construction of ceramic heritage, and the functional module provides software support for the system service,

TABLE 1: Problems and solutions of ceramic heritage protection.

Question	Explain	Target solution
Collect	The amount of data of the heritage is huge, the repetition rate is high, and there are cases of fraud	Simplify the identification procedure, fully mobilize the identification of many parties, and ensure the authenticity and credibility of the data
Infringe on sb's rights	There are counterfeiting and infringement in the circulation of ceramic heritage, infringing on intellectual property rights	Establish an open and transparent platform to obtain real and reliable data information through quick retrieval
Share	Ceramic heritage information lacks openness and transparency, so it is difficult to provide reliable information	Establish an open and transparent platform to ensure that all parties can obtain reliable information
And storage security	Huge amount of data, too serious storage centralization, single backup method	Establish multiparty storage and backup methods by integrating databases

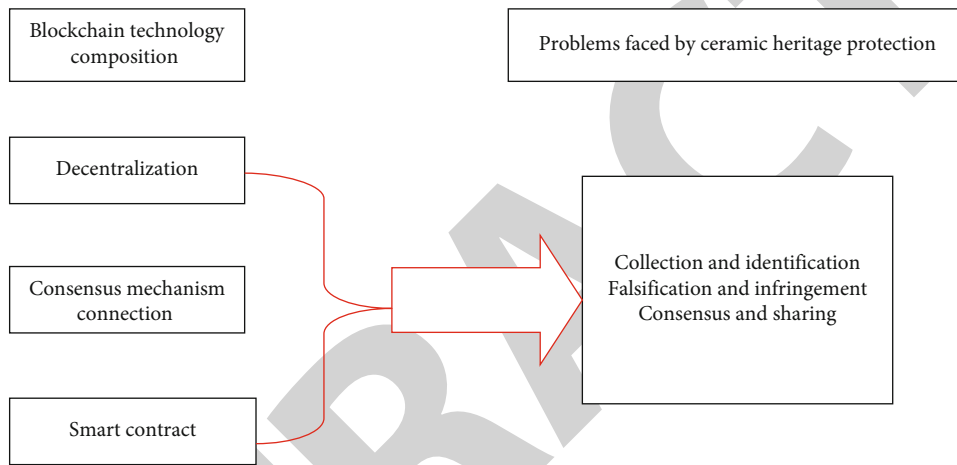


FIGURE 1: Blockchain technology and problems faced by ceramic heritage protection.

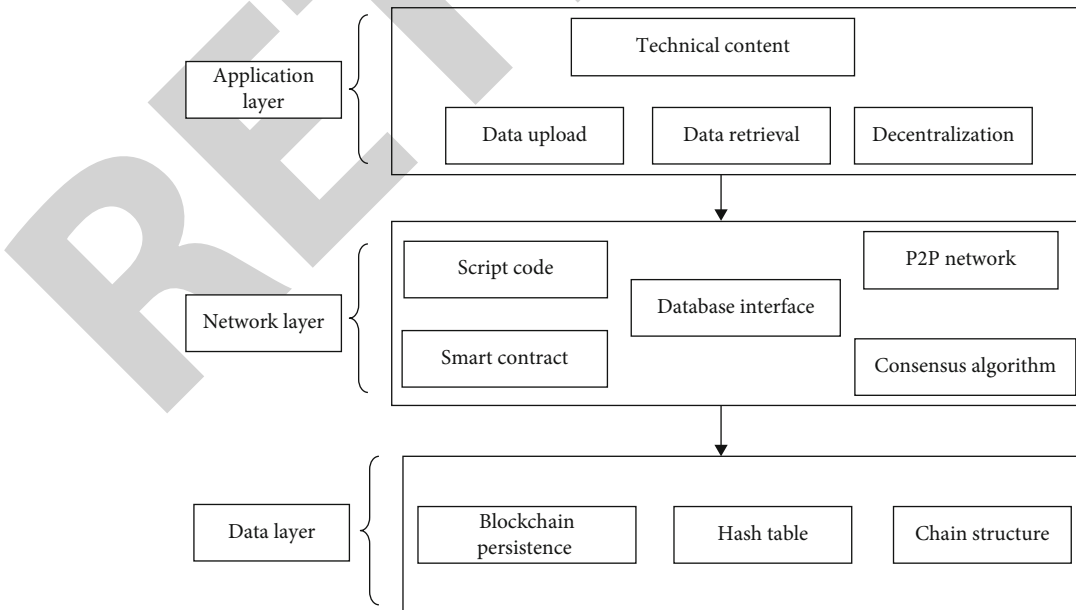


FIGURE 2: Main logical architecture of blockchain technology.

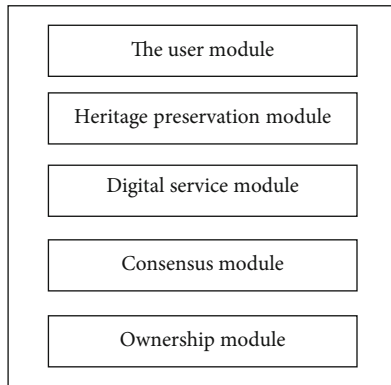


FIGURE 3: Digital function module of ceramic heritage of blockchain.

which strengthens the opening and sharing of digital heritage and strengthens the inheritance effect of ceramic heritage.

**3.1. Digitization of Ceramic Heritage.** Through multisource data fusion technology combined with 3D reconstruction and hyperspectral color texture collection, the shape, internal and external structure, material, texture, and other information of ceramic heritage were collected and recorded, and a digital multimodal identity information system was established for ceramic heritage.

Three-dimensional reconstruction can directly and accurately record the form of ceramic heritage and realize the exhibition of virtual reality. After the ceramic heritage changes, it is helpful to determine the damage and guide the restoration by comparing with the original records. According to the types of scanned objects, different 3D model building techniques are adopted. In this paper, a structured light camera is used, and the modeling accuracy reaches  $10\mu\text{m}$ . By projecting the structured light onto the ceramic surface, the camera receives the structured light pattern reflected by the ceramic surface and corrects the position and deformation of the pattern to obtain the spatial information of the ceramic. In the case of strong reflection on the ceramic surface, a laser scanner is used to build a three-dimensional model. By recording the three-dimensional coordinates, texture, and reflection information of a large number of dense points on the ceramic surface, the three-dimensional model of the ceramic is built in time. Through the laser scanning system of high-speed laser scanning measurement, the three-dimensional coordinate data of ceramic surface can be acquired quickly and in high resolution, and the spatial structure information of ceramics can be collected quickly and in large quantities.

The material and texture information of ceramics is also its most important feature, so it is necessary to record it accurately. Different elements and compounds on the earth have different spectral characteristics, and the spectrum is considered as the fingerprint to identify substances. Through spectral analysis, the composition of objects can be quickly obtained. The material information of ceramic surface is obtained by spectral analysis, and hyperspectral imaging is

realized by continuously improving the performance of spectral system and improving the spectral method. Hyperspectral camera captures continuous spectral data and hundreds of images with different wavelengths by photographing the ceramic surface, and the images are superimposed in three-dimensional space to form an image cube, thus forming a spectral curve. The spectral information reflected by different substances or even substances of different ages will be different, and it will be presented as a fingerprint spectrum that belongs to it alone.

Besides recording the three-dimensional model, material, and texture data of ceramics, it is also necessary to record its name, unearthed time, storage place, time stamp of three-dimensional model construction, time stamp of hyperspectral imaging, operator, and other basic information. Each time the ceramic heritage identity is created, the digital signature is stored in the distributed storage platform, and the digital signature (hash value) is generated at the same time, which is hung on the blockchain for permanent preservation and management. Using the digital signature aggregation module, the hash values of each new ceramic heritage will be aggregated into a file with all the existing hashes and linked to the public chain.

**3.2. Digital Function Module of Ceramic Heritage.** User function module mainly manages users, including owners, demanders, and suppliers of ceramics. The preservation module of ceramic heritage is mainly to build a public chain, taking the national digital system of Jingdezhen ceramics as the initial node, then joining the digital systems of provincial and municipal places in turn, and forming the digital blockchain system of Jingdezhen ceramics. When new nodes, such as museums and nongovernmental organizations, join, the new nodes broadcast and send the IP address information to neighboring nodes and forward it in turn, so that multiple nodes can receive the new node information, which makes the blockchain network stronger.

Digital service module mainly stores, encrypts, and transmits digital information of ceramics. Because the private chain and the public chain store different contents in the system, the blocks of the two chains have different structures. Public chain is the main form of blockchain adopted in this paper. Public chain blocks include block header, body, signature, and time stamp (Figure 2). Block mainly contains the original data to define the digitization of ceramic heritage and describes the digitized information of ceramic heritage through the established unified language, while nonstandardized information is identified by RDF description system and URI, such as keywords and database location, and at the same time, the consistency of data summary is ensured, which is convenient for users to accurately retrieve information. The header is composed of the block number and size and the hash value of the previous block, and the block body is composed of the information storage server, the identity of the ceramic owner, the digitized information digest, and the encrypted hash value. All information of digital ceramic heritage is stored in encrypted text format, which protects the rights and interests of owners. Time stamp shows the generation time of blocks (Table 2).

TABLE 2: Data structure of public chain block.

Block head	Block number	NO.X
	Block size	56Bytes
	Hash value of previous block	Hsah(X-1)
Block body	Block production server	Site:(IP)
	Metadata	EAD
	Data summary	URI
	Producer signature	Publisher: n/a
	Time stamp	Sign(X)

As the realization way of the consensus mechanism of the core technology of blockchain, the consensus module ensures the security and reliability of the whole system by sharing new blocks and execution. At present, the commonly used consensus mechanisms include POW and POS. Different blockchains adopt different consensus mechanisms, and the maintenance costs and resource sharing speeds of different consensus mechanisms are quite different. The consensus mechanism needs to be achieved through multiple nodes and participants.

The main function of ownership module is to query ownership information and trace the source of information. The ceramic information has been stored in each node during the block construction of the ceramic heritage digitization system, and users can obtain ceramic owner information and inquire about the ownership of other ceramics by visiting. With the trade of ceramics market, the information will be constantly updated and cover the original ownership information. The time stamp of blockchain makes it possible to trace the source of information, which guarantees the owner's authority of ceramics.

Blockchain technology provides a strong guarantee for the protection of ceramic heritage from the technical characteristics, organizational structure, and application scenarios. The public chain realizes the storage and traceability of digital information of ceramic heritage; ensures the openness, transparency, and credibility of information; and also realizes the purpose of sharing and consensus. The distributed storage and decentralized consensus mechanism of blockchain ensures the reliability of ceramic heritage information, protects intellectual property rights, reduces the cost of information storage, and improves work efficiency. The combination of blockchain technology and ceramic heritage protection has reshaped the digital model of heritage protection.

#### 4. Conclusion

- (1) With the development of the digital age, the decline of traditional ceramic technology is the result of the times and the necessity of social modernization. The development of digital technology provides a new direction for the protection and inheritance of Jingdezhen ceramic heritage. Jingdezhen ceramic heritage, as the largest and most complete ceramic cultural heritage in China, is facing the problem of being destroyed or improperly developed. The pro-

tection of Jingdezhen ceramic heritage has become an urgent problem to be solved. Taking Jingdezhen ceramic heritage protection as the research object, this paper applies blockchain technology to Jingdezhen ceramic heritage protection and establishes a decentralized, traceable, and open digital blockchain of ceramic heritage, which provides strong technical support for the protection of ceramic heritage

- (2) By analyzing the present situation of Jingdezhen ceramic heritage protection and construction, combining blockchain technology with digital construction of ceramic heritage, a digital model of Jingdezhen ceramic heritage based on blockchain technology is established, and a digital identity is built for Jingdezhen ceramics. The collected Jingdezhen ceramic information is attached to the blockchain, which ensures its unique and effective identity information, realizes the integration of Jingdezhen ceramic information, and actively promotes the informatization and standardization of ceramic heritage protection
- (3) The distributed ledger, consensus mechanism, and asymmetric encryption algorithm of blockchain technology promote the social and economic development, and apply it to the protection of Jingdezhen ceramic heritage, provide a new driving force for heritage protection, and improve the digital sharing effect of ceramic heritage. Based on blockchain technology, it ensures the openness, transparency, and credibility of information and also realizes the purpose of sharing and consensus. The distributed storage and decentralized consensus mechanism of blockchain ensures the reliability of ceramic heritage information, protects intellectual property rights, reduces the cost of information storage, and improves work efficiency

#### Data Availability

The figures and tables used to support the findings of this study are included in the article.

#### Conflicts of Interest

The authors declare that they have no conflicts of interest.

#### Acknowledgments

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