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Article

Research on Digital Archives of Kunqu Opera in Chongqing and Protection of Intangible Cultural Heritage

Bohan John Jin ^{1,*}

¹ Bancroft School, Worcester, USA

* Correspondence: Bohan John Jin, Bancroft School, Worcester, USA

Abstract: Kunqu opera in Chongqing, as an important form of intangible cultural heritage that combines Bayu regional characteristics with classical Kunqu traditions, is currently facing multiple challenges in the process of digital preservation. Existing digital initiatives are largely confined to emergency documentation and basic recording, which leads to the omission of key performance skills, oral transmission practices, and contextual knowledge, thereby creating a potential crisis in long-term archival preservation. In addition, the lack of unified technical standards, fragmented and decentralized digital resources, and the absence of stable institutional and financial guarantee mechanisms significantly reduce the effectiveness and sustainability of protection efforts. This study analyzes the current situation of digital archiving of Kunqu opera in Chongqing, identifies core problems in technology, management, and resource integration, and proposes a framework for standardized technical systems and cross-regional resource-sharing platforms. It further discusses the potential of blockchain-based storage, long-term digital preservation strategies, and the construction of a comprehensive digital resource center to support both static preservation and dynamic transmission. By integrating multi-stakeholder participation and diversified support mechanisms, the research aims to promote the revitalization, dissemination, and innovative development of Kunqu opera performances in Chongqing in the digital era.

Keywords: intangible heritage; digital archives; performing arts; cultural preservation; blockchain; resource integration

1. Introduction

1.1. The History and Cultural Value of Kunqu Opera Performances in Chongqing

1.1.1. The Origin and Regional Characteristics of Kunqu Opera Performances in Chongqing

Kunqu opera performances in Chongqing originated from the integration of Jiangnan Kunqu Opera into Sichuan during the Ming and Qing Dynasties, as well as the fusion of Sichuan and Chongqing dialects and folk music to form a regional style characterized by "strong voice and performance." The singing style retains the rhythm of Kunqu opera's "shuimo diao" (water-polished tune) while incorporating the characteristics of Sichuan opera's "gao qiang" (high-pitched tune) with its accompanying chorus and percussion. The performance often reflects the rhythm of boatmen's work songs along the Yangtze River, as well as elements of dock culture. For instance, in Autumn River, the body movements integrate the gestures of boatmen, and the spoken parts in Zui Li (The Drunken Yamen Runner) are interspersed with Chongqing dialect and slang, making it a unique entity in Bayu culture that embodies both literati aesthetics and the vitality of the marketplace [1].

1.1.2. The Artistic Value and Social Function of the Intangible Cultural Heritage

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As an intangible cultural heritage, the artistic value of Kunqu opera performances in Chongqing is reflected in the complete opera system: the tune patterns preserve the metrical rules of combining northern and southern styles, the librettos strike a balance between elegance and popularity, and the performances integrate stylized conventions with life-oriented expression. In terms of social function, it serves as a memory carrier of Bashu history and culture, such as *The Story of the Red Plum*, which conveys regional ethics. It was historically a link connecting the identity of the clubhouse's fellow villagers, and it continues to bring people together during community festivals. Furthermore, its comprehensive art form plays an indispensable role in traditional aesthetic education.

1.2. The Significance of Digital Archives to the Protection of Intangible Cultural Heritage

1.2.1. The Innovative Role of Digital Technology in the Preservation of Cultural Heritage

Digital technology provides a transformative approach to preserving intangible cultural heritage [2]. Advanced tools such as 4K video and 3D scanning can precisely capture intricate details, including vocal cavities, figures, and costumes. Compared to traditional archives, digital resources offer significant advantages, including durable storage through cloud-based anti-aging backups, convenient retrieval enabled by metadata tagging, and broad dissemination via network sharing. This transition allows cultural heritage to move from static preservation to dynamic utilization, offering multidimensional data support for research and conservation efforts.

1.2.2. The Urgency and Necessity of Digital Protection of Kunqu Opera Performances in Chongqing

Kunqu opera performances in Chongqing face challenges such as an aging group of inheritors, with the average age of municipal inheritors exceeding 65 years, and a declining interest among younger audiences, who account for less than 15%. Digitalization offers a solution to preserve existing skills and prevent their loss [3]. Tools such as VR and short videos can overcome the limitations of offline communication and engage the younger generation. Additionally, if dialect phonology and regional characteristics are not systematically recorded, they risk fading away amidst urbanization. Digitalization is crucial for addressing these survival challenges.

2. The Present Situation and Problems of Digital Archives Construction of Kunqu Opera Performances in Chongqing

2.1. The Current Situation and Limitations of Technology Application

2.1.1. The Preliminary Application of Digital Acquisition Technology

Currently, Kunqu opera performances in Chongqing have implemented basic digital collection methods [4, 5]. Some cultural units utilize high-definition equipment to record classic repertoires, such as *Farewell to Mother* and *Performing in a Hail of Arrows*, and employ multi-track recordings to preserve vocals. A few pilot projects have experimented with three-dimensional scanning of costumes and oral history videos of veteran artists. However, the application of technology remains limited to "emergency recording," where only images are preserved, and performance details are inadequately documented. This includes the movement trajectories of performers and the lack of spectrum analysis for the area. Consequently, digital files face challenges in supporting technical analysis, and the documentation of personalized performances by inheritors lacks a systematic approach.

2.1.2. File Incompatibility Caused by Inconsistent Technical Standards

The lack of uniform standards in digitization has resulted in the creation of "data islands." Firstly, video formats such as AVI and MP4, audio sampling rates, and 3D model file formats vary across institutions. This inconsistency can lead to playback issues and image quality degradation during integration. Secondly, older media formats like DVDs

and tapes have become unreadable due to aging, and more recently, mobile hard disk interfaces have been phased out. Thirdly, metadata labeling is overly simplistic, with only the names of plays being recorded. The absence of detailed classification or indexing of professional information reduces retrieval efficiency and limits storage and utilization due to inconsistent technical standards.

2.2. *The Present Situation and Dilemma of Resource Integration*

2.2.1. Preliminary Arrangement of Scattered Resources

The digital resources of Kunqu opera performances in Chongqing have undergone partial organization [6]. The city group art museum has transcribed tapes from the 1980s, colleges and universities have scanned newspaper reviews from earlier periods, and folk music clubs have uploaded rehearsal videos. However, these resources remain fragmented, with music books, audiovisual materials, and images of historical objects dispersed across various institutions and private collectors, lacking a unified sharing mechanism. For instance, an improved script from the 1950s may be held by a cultural center in one district, while the corresponding performance recording might reside in another institution. Consequently, researchers face significant challenges in gathering information, and the integration of these resources remains difficult and scattered.

2.2.2. The Systematic Lack of Folk Resources

The loss of folk resources is significant: the old artists' songbooks and handwritten work scales have been scattered due to a lack of awareness among future generations, and posters from earlier performances are privately traded. Furthermore, the aging of artists skilled in the "Chuankun" technique has led to the absence of systematic documentation of improvisational details, while the distortion of folk collections has occurred due to equipment limitations [7]. Additionally, as Chongqing is a city with a substantial immigrant population, traces of early Kunqu-related activities are dispersed across various districts and counties. The absence of comprehensive field investigations has resulted in the loss of numerous physical and oral materials over time.

2.3. *The Current Situation and Shortcomings of the Guarantee Mechanism*

2.3.1. Results of the Construction of Short-Term Projects

Kunqu Opera Performances in Chongqing's digitization process have progressed through short-term projects. In 2018, the Municipal Culture and Tourism Bureau completed a 4K recording of 10 plays [1]. In 2020, colleges and universities collaborated with the troupes to compile more than 50 tunes, and some resources were made available through the intangible cultural heritage database. However, the limitations of project-based construction are evident: funding fluctuates with the budget, personnel are temporarily reassigned, and file maintenance is neglected after the project ends. For instance, an interview video from 2019 in a district was not backed up, resulting in hard disk damage and loss of contents, which highlighted long-term management deficiencies.

2.3.2. The Problems in Long-Term Talent Training and Capital Investment Mechanism

There is a talent gap in digitization. Individuals who possess expertise in both Kunqu opera and technology are extremely rare. Most of the current personnel are administrative agents lacking professional skills. Additionally, colleges and universities do not provide training programs that integrate Kunqu opera with digital technology. Consequently, many grassroots organizations depend on outsourcing, which can result in inaccuracies due to professional limitations [2]. This indicates that while technological tools may be accessible, the content risks becoming distorted. Financial support has traditionally relied on government special projects, with limited opportunities for social capital involvement. Since 2023, some district and county projects have been discontinued due to financial constraints, leaving funding sources restricted. Overall, there is an evident lack of diversified investment channels and mechanisms for cultivating talent.

3. The Direct Impact of Digital Short Board on the Intangible Cultural Heritage Protection of Kunqu Opera Performances in Chongqing

3.1. Risks in Inheritance Caused by Technical Limitations

3.1.1. Incomplete Digital Record of Traditional Skills

Currently, the application of digital technology is primarily used for recording content, which results in the loss of the essence of Kunqu opera performances in Chongqing. Most recordings are captured using full-motion video, and details such as pitch fluctuation and throat resonance of the prolonged tune of Chuanjiang Haozi are not analyzed using frequency spectrum technology. Furthermore, the movement track of Wusheng's "shoulder-carrying" figure is not examined using motion capture techniques. For instance, regional features such as rhyme variation caused by dialect accents and the improvisation of "vibrato" are often not systematically preserved due to the limitations of single recording methods. This approach of "emphasizing appearance but neglecting core" makes it challenging for digital archives to serve as "living teaching materials" for younger generations. Once older artists pass away, the performance paradigms that embody the unique characteristics of Bayu face the risk of permanent loss, thereby exacerbating the crisis of inheritance [8].

3.1.2. Hidden Dangers Caused by Unsustainable Preservation of Digital Files

The evolution of storage technology and the lack of standardized practices pose significant risks to the preservation of digital archives. For instance, among 12 discs containing early vocal materials of artists stored on DVDs and magnetic tapes, three became unreadable due to the deterioration of magnetic powder. Similarly, the adoption of newer USB interfaces has rendered some files on older mobile hard drives incompatible with modern devices. An even more critical issue is the absence of metadata labeling. For example, scanned copies of music books stored at a university lack essential information such as tonal modes, scales, and role types. Consequently, researchers are forced to manually browse through pages to locate relevant content, leading to inefficiencies and potential misinterpretations of cultural information. This situation highlights the unsustainable nature of "digital heritage," where Kunqu Opera performances in Chongqing face the risk of being reduced to mere data stored on hard drives. Even if the files remain physically intact, their cultural and interpretative value may be lost due to technical barriers.

3.2. Low Protection Efficiency Caused by Scattered Resources

3.2.1. Fragmented Resources Cannot Support Systematic Inheritance and Research

The decentralized storage of digital resources has disrupted the cultural integrity of Kunqu Opera Performances in Chongqing. Due to the absence of a unified management platform, resources such as republican-era opera scripts from the Municipal Cultural Research Institute, modern performance videos from the district cultural center, and photos of folk costumes cannot form a cohesive "text-performance-object" research chain. For instance, when studying the improvement practices of Kunqu Opera Performances in Chongqing during the 1950s, researchers must retrieve revised scripts, performance recordings, and media reports from various institutions. These materials are often categorized differently based on varying classification standards. As a result, researchers expend significant effort sifting through scattered information, leading to incomplete studies on critical topics, such as the evolution of aria. Consequently, protection efforts have remained fragmented over time.

3.2.2. No Cross-Regional Network of Kunqu Cultural Resources

The historical connection between Kunqu Opera performances in Chongqing and the regions of Sichuan-Kunming and Suzhou-Kunming has been disrupted due to the isolated nature of resource distribution. As a branch of Sichuan and Kunming traditions, the evolution of its vocal style has closely interacted with Chengdu and Kunming. However, digital resources in various locations remain fragmented, and no effective sharing mechanism has been established. For instance, the performance video of "Autumn River" by a Kunqu Opera Club in Chongqing and the Sichuan-Kunming stills from the same period at the Sichuan Museum are not accessible online, complicating the study of regional performance differences. This lack of resource integration has also resulted in redundant efforts; both Chongqing and Chengdu have recently invested in recording "The Story of the Jade Hairpin," but the absence of resource sharing has led to inefficiencies. Kunqu Opera performances in Chongqing face challenges in defining their unique characteristics within the broader tradition of "Grand Kunqu Opera," which diminishes their recognition as an independent form of intangible cultural heritage.

3.3. *Lack of Protection Motivation Caused by Lack of Mechanism*

3.3.1. No Successor in Digital Work

The lack of multidisciplinary talents has led digital work into a period of crisis. Many individuals specializing in Kunqu opera lack digital expertise, making it challenging for technicians to understand terms such as "vibrato" and "cloud hands," which disrupts workflow. For instance, during the recording of an old artist's vocals in a specific district, technicians mistakenly interpreted the rhythm of "slow 4/4 time" as a standard beat due to their unfamiliarity with Kunqu opera's rhythmic patterns, resulting in distortion. The shortage of higher education resources further aggravates the problem [9, 10]. In Chongqing, there is no dedicated professional research sector focusing on the "Digitalization of Kunqu Opera." Additionally, the only college offering courses on intangible cultural heritage prioritizes theoretical knowledge while lacking practical training opportunities, such as 3D modeling. Consequently, graduates often lack the necessary skills for their roles, forcing grassroots organizations to rely on outsourcing. However, this professional gap leads to the paradox of "advanced technology but a distorted culture."

3.3.2. Poor Participation Channels of Social Forces Limit Protection

First, the government-led model lacks social resonance in its protection efforts. Kunqu Opera performances in Chongqing's digital initiatives have long relied on budgets approved by cultural and tourism departments. In 2023, a district and county reduced funding by 30% due to financial adjustments, directly causing the stagnation of three projects [11]. Second, channels for social capital participation remain limited. A cultural technology company initially planned to sponsor the Kunqu VR project but ultimately withdrew due to unclear tax incentive policies. Spontaneously recorded short videos by the public are often excluded from official systems due to copyright disputes and inconsistent quality. More importantly, the role of the community as a traditional communication field has been overlooked; there was a folk custom of sitting and singing Kunqu Opera in the communities around Huguang Guild Hall. However, the absence of social organizations has led to young people perceiving local Kunqu Opera merely as "museum art." This situation hinders the establishment of a sustainable ecosystem for protection, inheritance, and consumption.

4. Collaborative Improvement of Digital Archives and Intangible Heritage Protection

4.1. Constructing Standardized Technology Application System

4.1.1. Formulate the Digital Acquisition Specification of Kunqu Opera Performances in Chongqing

Establishing technical standards that encompass the entire process, from acquisition to storage and utilization, is essential. High-resolution 4K video capture should include both panoramic and close-up shots, such as facial expressions and finger movements. The audio sampling rate should be set at a minimum of 96 kHz to preserve the intricate details of the sound cavity [12]. A metadata annotation guide should be developed specifically for Kunqu Opera Performances in Chongqing, requiring structured annotation of professional information, including repertoires, qupai, role types, and performing conventions. For instance, in Autumn River, the Dan character's rowing gestures in Nanlü Mode should be accurately documented. The accuracy error for three-dimensional scanning must be standardized to be less than or equal to 0.1 mm, with file formats uniformly exported as a combination of OBJ and MTL to ensure precise three-dimensional representation of costumes and props. By implementing standardized construction, issues such as format confusion and insufficient metadata are effectively addressed, creating a solid foundation for inter-agency resource integration.

4.1.2. Establish a Blockchain Deposit Certificate System

First, blockchain technology is introduced to construct a secure digital file repository. The collected audio, video, and three-dimensional models are hashed to ensure the integrity and immutability of the files. Second, a combination of distributed storage and cloud backup is employed, with data being simultaneously stored on a local server in Chongqing and the national blockchain innovative application pilot platform. This approach mitigates the risk of data loss due to damage to a single storage medium. Third, a blockchain-based copyright management module is developed to clearly define the intellectual property rights of inheritors, recording institutions, and users. This provides technical support for the authorized use of digital resources, addressing fundamental issues in the management of digital archives.

4.2. Establish Resource Integration and Sharing Mechanism

4.2.1. Build a Digital Resource Center about Kunqu Opera in Chongqing

Under the guidance of the municipal cultural tourism department, a digital platform will be developed to integrate storage, retrieval, and display functions [4, 10]. This platform will include scripts, audio-visual materials, and physical archives sourced from the Municipal Mass Art Museum, Cultural Research Institute, and universities. A comprehensive database will be established, categorized by repertoire, voice cavity, performance, and literature. Additionally, an intelligent retrieval function will be implemented to enable rapid resource identification using keywords such as the prolonged tune of Chuanjiang Haozi, audio clip matching, and image recognition. A dual access model will be adopted, allowing the public to browse low-definition materials online while researchers can access original data through an audit process. This approach aims to systematically integrate fragmented resources and enhance accessibility.

4.2.2. Promote the Sharing of Kunqu Resources in Sichuan and Chongqing

It is proposed to establish a Sichuan-Chongqing Kunqu digital cultural corridor by unifying digital standards and enabling data integration between the Chongqing Bayu Kunqu Library and the Sichuan-Kunming resource platform. This would facilitate cross-regional retrieval of works such as The Story of the Jade Hairpin and The Story of the Red Plum. Collaborative efforts are recommended to construct a specialized database for the comparative study of the Sichuan-Kunming vocal tradition, allowing simultaneous display of different performance versions of the same play in both regions. Additionally,

a resource co-construction mechanism should be developed, with Chongqing focusing on collecting performance materials related to dock culture, while Sichuan emphasizes materials from Kunqu Opera clubs in northwest Sichuan. This approach aims to avoid redundant efforts and create a Kunqu Opera resource network that integrates regional characteristics within a broader context.

4.3. Improve the Protection and Guarantee Mechanism

4.3.1. Establish a Digital Talent Cultivation Plan for Kunqu Opera

It is essential to establish a tripartite training system involving universities, institutions, and enterprises. Drama programs in colleges and universities in Chongqing have introduced a focus on intangible digital preservation, offering courses such as 3D modeling and audio processing. Academy groups have selected inheritors to serve as practical instructors, while enterprises provide technical training platforms. It is recommended to implement a "double-teacher mentoring" model, where young students learn performance techniques from renowned Kunqu Opera masters while acquiring digital skills from technical experts. Additionally, the establishment of a digital heritage scholarship for Kunqu Opera performances in Chongqing is proposed. This initiative would enable students to participate in international workshops on intangible digital heritage, addressing the gap between individuals knowledgeable in Kunqu Opera and those proficient in technology.

4.3.2. Multi-input Mechanism of Government Guidance, Enterprise Participation and Community Support

First, it is recommended to establish a dedicated fund for the digitalization of Kunqu Opera within the municipal budget, with a fixed allocation of 15% of the annual budget. Second, digital sponsorship incentives for Kunqu Opera performances in Chongqing can be introduced, providing tax relief for corporate donations and encouraging cultural and technological enterprises to support initiatives such as Kunqu VR laboratories and other specialized projects [11]. Third, a crowdfunding platform for the digital preservation of Kunqu Opera should be developed, making it accessible to the public and establishing user-friendly crowdfunding projects, such as preserving digital records of veteran artists and supporting the cloud-based development of Kunqu Opera. Fourth, the community is encouraged to establish a Kunqu digital protection group to collect scattered folk resources and exchange points for rewards, thereby forming a sustainable investment model that integrates government support, enterprise involvement, and community participation.

5. Conclusion and Prospect

The digital preservation of Kunqu Opera performances in Chongqing has entered a phase marked by significant technical challenges, including the lack of unified technical standards, fragmented resources, and insufficient mechanisms. These issues contribute to the distortion of traditional technical records and the gradual erosion of cultural heritage. This research highlights that the establishment of a standardized technical system, the integration of cross-regional resources, and the development of robust multi-faceted mechanisms are essential to transitioning from emergency documentation to sustainable live transmission. Digitalization serves not only as a preservation tool but also as a means to revitalize regional cultural elements. By employing technical tools such as blockchain-based certification and digital resource centers, unique skills like the Chuanjiang Haozi-style prolonged tune and dock figure can be systematically safeguarded. This approach offers a solution that balances technical feasibility with cultural adaptability, ensuring the protection of intangible cultural heritage.

Future efforts in the digital preservation of Kunqu Opera performances in Chongqing should focus on three critical areas. First, technological applications should evolve from mere recording tools to creative media, exploring innovative possibilities

such as AI-based sound cavity simulations and virtual stage environments. These advancements can engage younger audiences by providing interactive experiences that bridge tradition and modernity. Second, a collaborative network involving government entities, academic institutions, and local communities should be established. This network could transform traditional practices, such as the community-based Kunqu Opera sitting and singing around the Huguang Guild Hall, into digital cultural assets, creating a seamless integration of online archives and offline experiences. Third, efforts should be made to integrate the Sichuan-Chongqing cultural community, highlighting the unique role of Chongqing Kunqu Opera within the broader southwest Kunqu Opera tradition through cross-regional resource sharing. These initiatives would elevate the status of Chongqing Kunqu Opera from a preserved cultural heritage to a dynamic living tradition in the digital era, positioning it as a modern medium for communicating Bayu culture.

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