

Research Hotspots and Digital Information of ICH Digitalization Based on Scientific and Technological Mapping

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Abstract:

With the iterative development of digital technology, research on the digital protection of China's intangible cultural heritage (ICH for short) has become a focus in academic circles. Based on 367 core journal articles themed on "intangible cultural heritage" and "digitalization" from China National Knowledge Infrastructure (CNKI) between 2005 and May 2025, this study systematically sorts out the development context and cutting-edge trends of China's ICH digitalization research over the past two decades using CiteSpace software. The research shows that ICH digitalization research has undergone a phased evolution, progressing from "digital recording" to "technological integration and innovation," and then to "reconstruction of cultural communication ecology." High-frequency keywords include "digitalization," "ICH archives," "inheritance," "artificial intelligence," "dynamic inheritance," and "metaverse." Further cluster analysis identifies ten core research directions, such as "digitalization," "information resources," "ICH inheritance," and "artificial intelligence." At present, the research still has problems including the lack of refinement in technological adaptation and insufficient in-depth exploration of cultural connotations.

Keywords:

Intangible Cultural Heritage, Digital Display, CiteSpace

1. Introduction

As a core carrier of China's excellent traditional culture, intangible cultural heritage (ICH) bears the nation's genetic code and cultural bloodline, and serves as an irreplaceable resource of civilization. Amid the wave of the internet-driven digital revolution and information civilization, the protection, preservation, inheritance, innovation, and interactive communication of ICH have been deeply integrated into the digital technology system. In 2023, the Report to the 20th National Congress of the Communist Party of China explicitly outlined the plan to "build a cyber power and a digital China" and implement the national cultural digitization strategy; in the same

year, the Xi Jinping Thought on Culture, proposed at the National Conference on Publicity, Ideology and Culture Work, emphasized the need to “focus on carrying forward China’s cultural context, promoting the creative transformation and innovative development of China’s excellent traditional culture, and strengthening the development of international communication capacity to facilitate cultural exchanges and mutual learning among civilizations”. The 14th Five-Year Plan for the Development of the Digital Economy lists “industrial digital transformation” as a key task, while the 14th Five-Year Plan for the Protection of Intangible Cultural Heritage provides programmatic guidance for the inheritance and development of ICH. Against this backdrop, ICH digitization, as an important branch of cultural digitization, is becoming a key driver for building a digital China and enhancing the communication power of Chinese civilization.

Digital communication is a new form of communication that takes computers as the main body and multimedia as a supplement, integrates multiple exchange functions for information such as language, text, audio, and video, and enables the interactive combination of various data, texts, diagrams, animations, music, languages, images, films, and video information through networks. “However, the communication of ICH in the digital age is not a simple copy or reorganization of traditional communication. Instead, based on the characteristics and current status of ICH content, and combined with the groundbreaking technological innovations of the digital age, it involves the reconstruction of brand-new communication content, communication processes, and communication strategies tailored to different target audience groups.” [1]

“The digital communication of ICH is a product of the organic integration of digital media and digital technology. On the one hand, digital media not only possesses the preservability and retrievability of print media, but also the freshness and timeliness of electronic media, as well as its own advantages in graphic reading and audio-visual experience. On the other hand, the development of digital technology and internet technology has further accelerated the comprehensive integration of different types of media.” [1] Therefore, it is of great significance to fully integrate the communication advantages of different media channels and creatively build a digital communication channel system for ICH.

2. Data Source and Statistical Analysis

2.1. Research Methods and Data Sources

This study employs the CiteSpace visualization analysis tool developed by Professor Chen Chaomei. By quantitatively analyzing the dynamic evolution of keywords in the field, it systematically sorts out the current status and trends of research on the digital display of China’s intangible cultural heritage (ICH). The data sources are restricted to the search results themed on “intangible cultural heritage” and “digitalization” in the CNKI database from 2005 to May 2025. After screening out invalid documents such as informal discussions and book reviews, a total of 367 core journal articles—including those from CSSCI, Peking University Core Journals, and EI Core Journals—are finally included as the analysis samples.

2.2. Analysis of Hot Keywords

CiteSpace was used to conduct a temporal analysis of keywords, which are displayed in descending order of occurrence frequency: “digitalization”, “ICH archives”, and “ICH” rank among the top due to the characteristics of thematic

retrieval; keywords such as “inheritance”, “digital humanities”, “artificial intelligence”, “dynamic inheritance”, “knowledge graph”, and “ICH protection” appear frequently, highlighting the current research focus on the digital protection and inheritance of ICH. (Table 1)

Table 1. Keyword Frequency Table.

Serial Number	Frequency	Keywords
1	53	Digitalization
2	13	ICH Archives
3	12	Intangible Cultural Heritage (ICH)
4	11	Inheritance
5	9	Digital Humanities (DH)
6	8	Artificial Intelligence(AI)
7	7	Dynamic Inheritance
8	7	Digital Technology
9	6	Big Data
10	6	Metaverse
11	5	Knowledge Graph
12	5	ICH Protection
13	5	Inheritor
14	4	Sports-Related ICH
15	4	Cultural Heritage
16	4	Cultural Heritage
17	4	Linked Data
18	4	Metadata
19	4	Protection and Inheritance
20	4	Communication Strategy

2.3. Analysis of Keyword Distribution by Time Zone

The keyword distribution map by time zone shows that the research context presents a phased characteristic of “digital recording of traditional craftsmanship - technological integration and innovation - reconstruction of cultural communication ecology”. Early research took specific projects such as “Qinghai embroidery” and “Guangzhou ivory carving” as carriers; the middle stage focused on the application of tools like “artificial intelligence” and “digital technology”; and the recent stage has shifted to the construction of immersive communication scenarios such as “metaverse” and “dynamic inheritance”. Among them, nodes with high centrality (e.g., “digitalization” and “dynamic inheritance”) have constituted the core directions of the field’s development. (Figure 1)

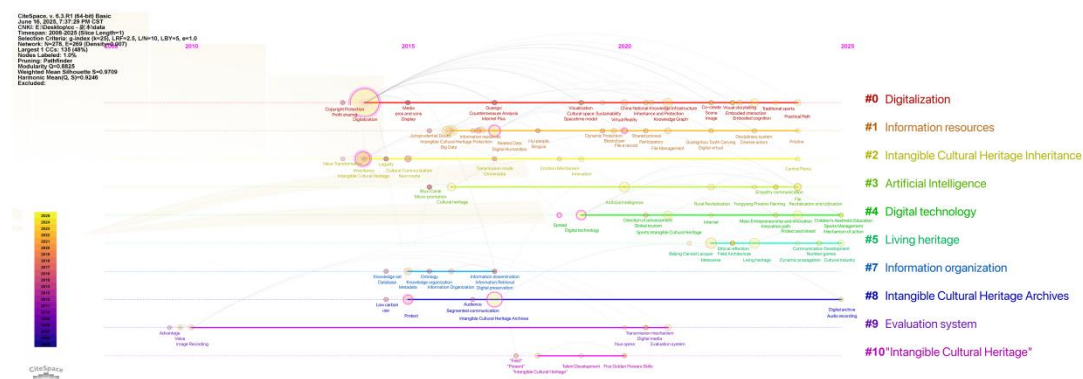


Figure 1. Distribution Map of Keywords by Time Zone.

2.4. Keyword Cluster Analysis

In the generated keyword cluster map, 10 cluster labels are summarized, as shown in Figure 1-3. The Q-value represents the significance of the network structure, and the S-value represents the average silhouette value of the clusters. In the map, $Q = 0.8825$ ($Q > 0.3$) and $S = 0.9246$ ($S > 0.5$), indicating that the clustering effect is relatively ideal. The smaller the cluster number, the more keywords it contains; the labels include "digitalization", "information resources", "ICH inheritance", "artificial intelligence", "digital technology", "dynamic inheritance", "information organization principles", "ICH archives", "evaluation system", and "ICH". (Figure 2) (Table 2)

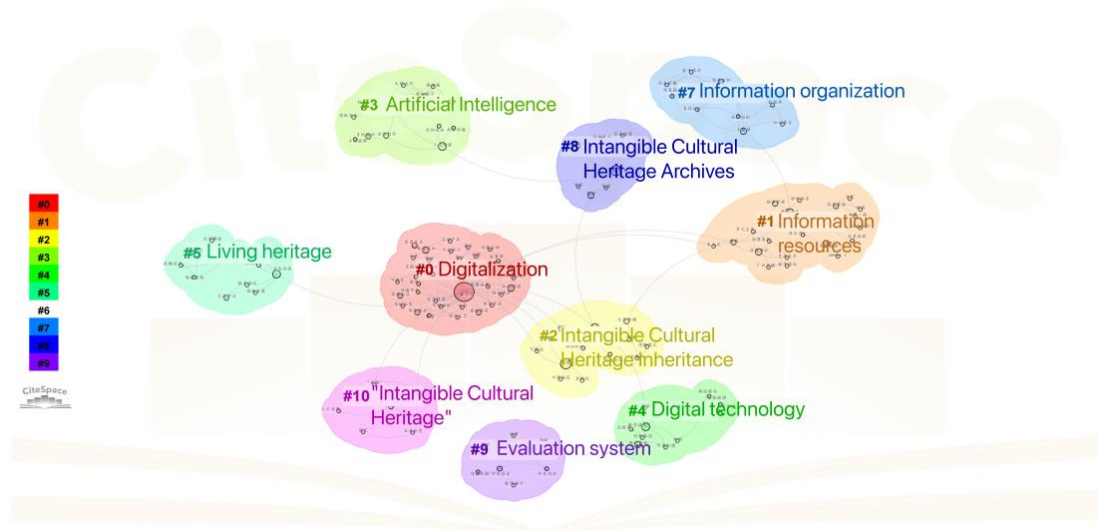


Figure 2. Keyword Clustering Map.

Table 2. Keyword Clustering LLR Algorithm Table.

Cluster Name	Keywords included under the LLR algorithm
Information Organization	Information Organization; Digital Preservation; Information Retrieval; Knowledge Organization; Information Dissemination
ICH Archives	Intangible Cultural Heritage (ICH) Archives; Protection; Digitization; Dissemination Audience; Utilization
Evaluation System	Evaluation System; Video Documentation; Copyright; Digitization of Intangible Cultural Heritage; Development and Utilization
ICH	Intangible Cultural Heritage (ICH); New Media; Inheritance; Performing Arts; Dissemination Model
Digitalization	Digitization; Inheritance and Protection; Intangible Cultural Heritage (ICH); Protection; Practical Path
Information Resources	Information Resources; Big Data; Digital Humanities; Archiving; Intangible Cultural Heritage (ICH) Protection
Artificial Intelligence	Artificial Intelligence (AI); Cultural Heritage; Rural Revitalization; Integration of Culture and Tourism; Rural Tourism
Digital Technology	Digital Technology; Protection and Inheritance; Mechanism of Action; Sports-related Intangible Cultural Heritage; Mass Entrepreneurship and Innovation (ME&I)
ICH Inheritance	“Intangible Cultural Heritage (ICH)”; “Presence”; Qinghai Embroidery; “Field” (sociological term)

	Referring to a specific social context); Intangible Cultural Heritage
Living Inheritance	Living Inheritance; Metaverse; Sports-related Intangible Cultural Heritage; Intangible Cultural Heritage (ICH); Static Protection

2.5. Evolution of Hot Topics in ICH Development

By applying the Burstness (burst node) function of CiteSpace, this study reveals the evolutionary characteristics of research frontiers in different periods through the burst analysis of keywords in the field of digital protection research on ICH craftsmanship. Among the top 20 keywords with the strongest burst intensity, “information space” stands out with the longest burst duration, demonstrating its sustained influence in this research field. “As an important extension of the information space theory, ICH information space constructs a dynamic and interactive protection system for ICH information through modern technological means such as digital collection, database construction, application of virtual reality (VR) and augmented reality (AR) technologies,” [14] as well as communication via social media and online platforms. This finding strongly verifies that ICH protection is highly dependent on modern information technology; digital, networked, and intelligent technologies have not only revolutionized the protection model of ICH craftsmanship but also become the core support for its contemporary inheritance and development.

In terms of burst intensity, “metaverse”, “dynamic inheritance”, “ICH protection”, “information resources”, and “new media” rank among the top five, with intensities of 2.38, 2.21, 1.86, 1.65, and 1.43 respectively, serving as the leaders of research hotspots. Among the top 20 bursting keywords, 18 have ceased to burst, and only 2 have emerged newly since 2023, reflecting the dynamic iterative characteristics of research hotspots.

There is a high degree of overall overlap between keyword frequency and burst ranking; terms such as “dynamic inheritance”, “digital resources”, and “new media” have always been academic focuses. From a temporal perspective, early ICH research focused on traditional development and inheritance; with the advancement of science and technology, the focus has gradually shifted to digital presentation, inheritance and protection, and sustainable development, showing an evolutionary trajectory from horizontal diversified expansion to vertical in-depth exploration.

Policy-driven forces and technological innovation have reshaped the research pattern of ICH protection. Since 2018, the improvement of China’s national ICH protection policy system has significantly promoted practical results. In the academic context, communication efficiency has become a key criterion for measuring protection effectiveness; online media and digital technologies are replacing traditional communication methods and becoming the core carriers for the inheritance and innovation of ICH.

Current research on ICH digitalization is deeply penetrating the field of “digital humanities”. This discipline integrates cutting-edge technologies with traditional humanistic research paradigms, and continuously expands the application boundaries of ICH digitalization in education, scientific research, services, and innovative practices. “To cultivate digital talents, many universities and institutions have launched majors such as ICH management and ICH digital protection, organically combining the latest digital technologies with ICH craftsmanship, adhering to the integration of theory and practice, and laying a talent foundation for the digital

protection of ICH.” [9] “The Chinese nation has a long history of outstanding traditional culture, and has long held a cultural vision of openness, inclusiveness, and absorption of diverse elements; Chinese civilization has always advocated mutual understanding and respect among different civilizations.” [10] Under the guidance of Xi Jinping’s cultural digitization strategy, ICH digitalization is developing in the direction of diversification, systematization, and in-depth advancement. “By integrating technologies such as digital twin, artificial intelligence, and blockchain, ICH can break through the limitations of time and space, integrate multi-party resources for innovative transformation and creative development, realize the global dissemination of China’s excellent traditional culture while continuing its inheritance, tell Chinese stories well to the world, and continuously expand the international communication power and influence of Chinese culture.” [7] (Figure 3)

Top 20 Keywords with the Strongest Citation Bursts

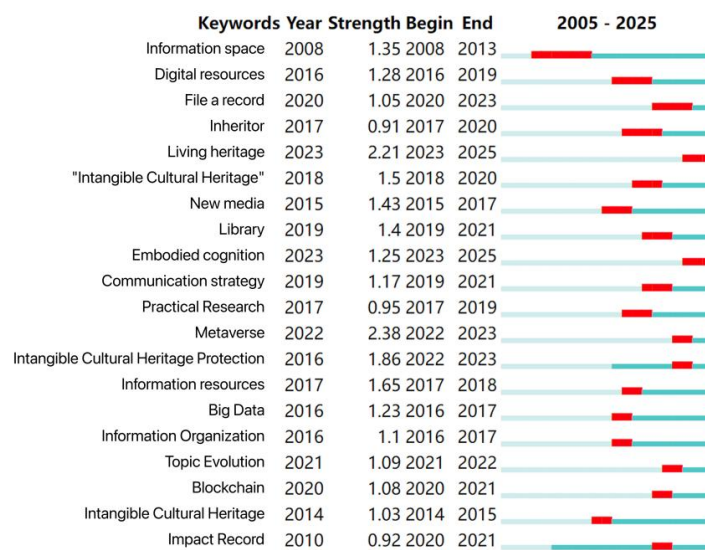


Figure 3. Keyword Emergence.

3. Main Content of ICH Digitalization Research

From the perspective of scientific and technological mapping analysis, the current research on ICH digitalization is in a stage of diversified exploration. However, there is still room to further clarify the correlation between the keywords clustered under the LLR algorithm and the core information indicated by the clusters (Table 3). Therefore, based on the existing cluster research on ICH digitalization, this study intends to re-organize the cluster information from the technical and practical levels to present the internal logic and interrelationships of the research more accurately (Table 4).

Table 3. Summary of Digitalization Technologies for Intangible Cultural Heritage Table.

ICH Digitalization Technology	
Technology	Interpretation
Image Recognition Technology	Rapidly identify the visual features of Intangible Cultural Heritage (ICH) artifacts and ICH scenarios to achieve automatic classification and retrieval of ICH digital resources.
Speech Recognition Technology	Convert audio recordings of interviews with ICH inheritors, traditional singing styles, and oral folk tales into text, preserve

	ICH audio archives, and assist in building an "ICH Audio Database" to facilitate subsequent review and research.
Optical Character Recognition Technology	Extract text from ICH ancient books, handwritten music scores, and traditional craftsmanship manuals, and convert it into editable digital text. This prevents information loss caused by the damage of paper materials and enables easier digital dissemination.
Computer Vision Technology	Conduct video analysis on ICH craftsmanship processes, decompose key action steps for digital recording, and restore digital images of damaged ICH artifacts.
Natural Language Processing Technology	Analyze ICH-related documents and legend texts to extract core information; build an intelligent ICH Q&A system to answer users' questions.
Big Data Technology	Integrate ICH resource data (such as inheritor information, craftsmanship distribution, and exhibition records), analyze the dissemination popularity and inheritance status of ICH, and provide data support for the formulation of ICH protection policies.
Knowledge Graph Technology	Construct an "ICH Entity Relationship Network" (e.g., "Kunqu Opera - Representative Repertoire - The Peony Pavilion - Inheritor") to clearly present the connections between various ICH elements and help users systematically understand ICH knowledge.
3D Laser Scanning Technology	Precisely scan ICH artifacts and traditional architectural components to obtain 3D point cloud data, preserve the details of artifacts, and lay a foundation for subsequent digital restoration and reproduction.
3D Modeling Technology	Build virtual 3D models of ICH artifacts (e.g., damaged ancient musical instruments) and traditional scenarios (e.g., ancient markets) based on scanning data or historical materials, for application in online exhibitions and teaching demonstrations.
Motion Capture Technology	Record the precise trajectories of ICH performance-based craftsmanship, convert them into digital animations, and realize the digital preservation of craftsmanship movements.
Virtual Reality Technology	Create immersive ICH experience scenarios—such as allowing users to "be present" in a virtual stage to watch Peking Opera and "enter" a virtual workshop to learn pottery making—to break the constraints of time and space and enhance the sense of engagement in ICH dissemination.
Augmented Reality (AR) Technology	Overlay ICH digital content in real scenarios: for example, scanning ICH paper-cutting with a mobile phone to display the folk stories behind it, or scanning traditional costumes to show the meanings of costume patterns and their production techniques.
Mixed Reality Technology	Enable users to interact with ICH virtual content in real environments. For instance, in physical ICH exhibitions, users can "touch" virtual artifacts and "communicate" with virtual inheritors via MR devices to improve the interactivity of the exhibition.
Microdisplay Technology	Provide high-definition small-sized screens for ICH digital devices (e.g., portable VR headsets, ICH cultural smart glasses), allowing users to clearly view ICH digital content in scenarios such as outdoor locations and exhibitions.
Cloud Computing Technology	Store massive ICH digital resources (e.g., high-definition videos, 3D models) in the cloud. Users can access them anytime via the Internet (e.g., watching ICH craftsmanship teaching videos online), reducing the storage and sharing costs of ICH digital resources.
Blockchain Technology	Upload ICH digital resources to the blockchain, record the ownership and circulation of resources, prevent tampering and

	misappropriation of ICH digital copyrights, and protect the rights and interests of inheritors.
Intelligent Interaction Technology	Enable users to naturally control ICH digital content through methods like gesture recognition and eye tracking—such as waving to switch virtual ICH exhibition scenarios and using eye movements to "browse" digital ICH classics—to enhance the convenience of the experience.
Artificial Intelligence Generated Content Technology	Generate auxiliary content according to ICH styles: for example, creating new digital illustrations in the style of a specific New Year painting, or generating ICH music segments by imitating traditional singing styles to provide materials for the innovative dissemination of ICH.
Holographic Projection Technology	Present holographic images of ICH inheritors and ICH performances in ICH exhibitions and shows to enhance the sense of technology and attractiveness of ICH displays.
Edge Computing Technology	Enable local devices to quickly process ICH digital content (e.g., real-time rendering of 3D models) in offline ICH exhibitions and outdoor experience scenarios, reducing reliance on the network and ensuring a smooth experience.
Quantum Computing Technology	Realize efficient processing of complex ICH data—such as quickly analyzing massive ICH "gene sequences" (e.g., style differences in embroidery techniques across different regions) and simulating the environmental impact of long-term preservation of ICH artifacts—to support in-depth ICH research.
Internet of Things Technology	Install sensors in the storage environment of ICH artifacts to monitor temperature, humidity, and light in real time, ensuring the physical safety of artifacts; it can also connect to equipment in ICH workshops to remotely monitor the production process of traditional craftsmanship and assist in the supervision of craftsmanship inheritance.
Digital Watermarking Technology	Embed copyright marks in ICH digital resources. Once the resources are misappropriated, the source can be traced through watermarks to protect the intellectual property rights of ICH digital content.

Table 4. *Digital Practice Applications of Intangible Cultural Heritage Table.*

Practical Application of Intangible Cultural Heritage (ICH) Digitalization		
Type of Technical Practice	Involved Technology	Role of Practice
Technical Practice of Collection and Storage	Image Recognition Technology Speech Recognition Technology Optical Character Recognition Technology 3D Laser Scanning Technology Big Data Technology Cloud Computing Technology Internet of Things Technology	It covers the collection of multi-dimensional information related to Intangible Cultural Heritage (ICH), including visual information (cultural relics, scenes), auditory information (singing styles, interviews), textual information (ancient books, manuscripts), and 3D structural information (cultural relics, components). Meanwhile, through big data integration, cloud computing-based storage, and IoT-enabled environmental monitoring, efficient management and secure preservation of ICH data are achieved.
Technical Practice of Exhibition and Dissemination	VR; AR; MR; Microdisplay Technology; Holographic Projection	Technologies including VR (Virtual Reality), AR (Augmented Reality), MR (Mixed Reality) and holographic projection create immersive and interactive exhibition scenarios. Combined with microdisplay

	Technology; Intelligent Interaction Technology; Blockchain Technology; Digital Watermarking Technology	technology, viewing scenarios are expanded, while intelligent interaction technology enhances the user experience. Additionally, blockchain and digital watermarking technologies protect the digital copyright of Intangible Cultural Heritage (ICH), ensuring the ownership of rights during the dissemination process.
Technical Practice of Form Transformation	Computer Vision Technology; Natural Language Processing Technology; Knowledge Graph Technology; 3D Modeling Technology; Motion Capture Technology; Artificial Intelligence Generated Content Technology Edge Computing Technology Quantum Computing Technology	The original ICH data (videos, texts, movements) is converted into structured content—for instance, extracting the core of texts via NLP (Natural Language Processing), building connections through knowledge graphs, and generating virtual models with 3D modeling. AIGC (Artificial Intelligence Generated Content) assists in the creation of innovative content, while edge computing/quantum computing provides efficient computing power support for the complex conversion process.

3.1. Main Content of ICH Digitalization Technology Research

In his book *Digitalization of Ethnic Cultural Heritage* (People's Publishing House, 2009 edition), Wang Yaoxi points out that the digitalization of cultural heritage refers to the adoption of digital technologies such as digital collection, digital storage, digital processing, digital display, and digital dissemination to convert, reproduce, and restore cultural heritage into a shareable and renewable digital form, [11] and then interpret it from new perspectives, preserve it in new ways, and utilize it in response to new needs. From a technical perspective, Tan Biyong argues that digital ICH (intangible cultural heritage) is “the application of digital information technology to the rescue and protection of ethnic and folk intangible cultural heritage; by virtue of technologies such as digital virtual reality, multimedia, and broadband network technology, a comprehensive digital system based on computer networks—integrating photography and 3D information acquisition—is established.” [2] Song Junhua holds that in the process of ICH digitalization, “as an information processing technology, digital technology serves as the foundation for computer technology, multimedia technology, intelligent technology, and information dissemination technology.” [3] Compared with tangible cultural heritage, when digital technology is applied to ICH protection, the focus should be placed on preserving, displaying, and disseminating cultural connotations, and integrating cultural elements and cultural values into the process.

“In the current ICH inheritance process, digital technology is regarded as a tool and an accessory for ICH inheritance, and the integration of digital technology and ICH is more reflected in the integration of surface-level techniques and technical applications. However, with the maturity and application of various new technologies, people's understanding of ICH will pay more attention to the spiritual level.” [4] At the technical application level, academic research on digital technologies for ICH protection, inheritance, and dissemination can be systematically divided into three major directions:

First is collection and storage. Technologies such as image recognition, speech recognition, optical character recognition (OCR), 3D laser scanning, big data, cloud computing, and the Internet of Things (IoT) are used to achieve systematic collection, structured classification, and permanent storage of ICH cultural resources. For example, Zhu Mingjie (2025) proposes that “by means of digital methods based on the acquired presentation of traditional media—such as digital images and high-definition digital audio-visual records—a digital archive of Kunqu opera art should be built to realize the systematic preservation and dissemination of traditional cultural heritage.” [8] Cai Wen (2021) points out that “digital collection and storage technologies can effectively integrate ICH information and data, store it in a visible form, and solve the problems that ICH itself is not easy to preserve and prone to loss.” [13]

Second is performance and dissemination. With the advancement of the third wave of artificial intelligence (AI) technology, intelligent interaction technologies represented by VR (Virtual Reality), AR (Augmented Reality), MR (Mixed Reality), micro-display technology, holographic projection technology, intelligent interaction technology, blockchain technology, and digital watermarking technology are reconstructing the ICH dissemination ecology. Through digital modeling to restore the original appearance of ICH projects, immersive and interactive cross-temporal performance scenarios are constructed; meanwhile, mobile Internet technology further breaks through geographical limitations, forming a dissemination closed loop of “technology empowerment—scenario reconstruction—experience upgrading,” which fully demonstrates the “rational creation” characteristic of digital technology in cultural inheritance. Zhang Xu (2015) argues that “the digital display media of ICH make full use of various imaging and Internet technologies to display ICH on digital terminal devices in a visualized and contextualized manner, endowing ICH with new attributes of interactivity and experience, and realizing rapid and effective dissemination and display, thus achieving the ultimate goal of ICH inheritance and protection.” [15] He also emphasizes the adaptability of different media to ICH dissemination and analyzes their applicable scenarios in ICH dissemination—for instance, by comparing the dissemination effects of different platforms, it provides a basis for the selection of ICH dissemination channels. Li Jingya, Wang Zhuo’er, and Yi Xiao (2023) linked physical Nuo masks with virtual puzzle-solving mechanisms to design a game that combines virtual and real elements, thereby attracting young people to participate in ICH experiences and expanding the integration boundary between ICH and the entertainment industry. For example, the Nuo culture game (integrating virtual and real elements) allows players to experience the charm of ICH while entertaining.

Third is form transformation. This field utilizes technologies such as computer vision, natural language processing (NLP), knowledge graph, 3D modeling, motion capture, AI-generated content (AIGC), edge computing, and quantum computing. In addition to realizing the digital transformation of ICH forms, it also focuses on the development of market-oriented value. “Digital collectibles and cultural and creative products based on blockchain technology are becoming innovative hotspots in the field of ICH digitalization; through technology empowerment, they activate the economic attributes of ICH and promote the creative transformation of traditional cultural resources into cultural capital.” [12] Bai Jiansong (2011) proposes “digital reproduction and value-added services, cultural product development, audio-visual product development, and theme product development. On the basis of research

results, creative reprocessing and re-creation should be carried out to make them more in line with consumers' cultural needs. This part belongs to the commercial product development category; research results related to ICH can participate in cooperation in the form of shares, so as to organically integrate business, industry, academia, and research.” [16] Liu Yang (2024) explores a rural revitalization model of “ICH digitalization + forestry and forest product industry,” converting traditional patterns into product design elements; Chen Guoqiang (2021) takes Lujin (Shandong brocade) as an example to analyze the role of digital technology in protecting traditional weaving techniques and promoting industrial upgrading—such as establishing a digital pattern database of Lujin to empower cultural and creative design.

In addition, “the innovative technology in ICH digital protection is mainly manifested in the application of 'multimodality,' which refers to a complex composed of comprehensive information forms such as text, images, audio, and video.” [5] “This innovative technical form originates from the support of technical ‘affordance.’ The sociologist Danah Boyd points out that in the digital environment, affordance refers to the potential possibilities that digital products or systems can stimulate users to operate, explore, and experience through technical functions.” [6]

To sum up, academic research on ICH digitalization technology proceeds as follows: first, starting from conceptual definition, it clarifies the core connotation and technical composition of digital ICH, emphasizing that ICH digitalization should be distinguished from tangible cultural heritage and focus on the transmission of cultural connotations and values; second, it has formed three core directions around technical application: collection and storage technology provides a systematic preservation and management solution for ICH resources, performance and dissemination technology reconstructs ICH dissemination scenarios relying on intelligent interaction methods, and form transformation technology promotes the conversion of ICH into cultural capital. At the same time, the concept of “multimodality” is innovatively proposed to provide support for technical application.

3.2. Figures and Tables

Against the backdrop of the advancement of China's national cultural digitalization strategy, the practical application of intangible cultural heritage (ICH) digitalization follows a full chain of “collection and storage – performance and dissemination – form transformation”. Among these links, collection and storage technology serves as the fundamental support, undertaking the key functions of permanently preserving ICH cultural resources and managing them efficiently. In practice, the application of such technology features “precision” and “systematization”:

Precision is reflected in the use of technologies like 3D scanning, motion capture, and high-fidelity recording to document details, such as the joint movement trajectories of Kunqu opera postures and the color layers of Zhuxianzhen woodblock New Year paintings.

Systematization achieves resource integration through database construction and metadata annotation. For example, Xu Xin's team built a framework based on the Dublin Core (DC) metadata standard, linking “craftsmanship processes – cultural connotations – inheritor information”; meanwhile, machine learning algorithms have further improved the efficiency of resource retrieval and cultural connotation exploration.

The value of these technologies lies in breaking the temporal and spatial limitations of traditional inheritance, establishing an ICH “digital gene bank”, and realizing the permanent preservation of craftsmanship.

Performance and dissemination technology focuses on the digital display and dissemination of ICH. It aims to reconstruct ICH dissemination scenarios through technological innovation and achieve the goals of “breaking temporal and spatial barriers – upgrading experiences – expanding audiences”. From a technical perspective, Tan Biyong proposes that digital ICH needs to rely on “virtual reality (VR), multimedia, and broadband network technologies” to build a comprehensive digital system. This concept has evolved in practice into an immersive dissemination model centered on VR/AR (Augmented Reality) and supported by the mobile Internet. Specifically:

VR technology can reconstruct the original scenarios of ICH; for instance, Hefei Cultural Center used it to restore Huizhou bamboo weaving workshops, allowing users to “experience” the craftsmanship process firsthand.

AR technology enables “virtual-real integration”; in AR Peking opera applications, for example, users can scan patterns to watch virtual characters perform, breaking the limitations of stage space.

The mobile Internet and social media have established a model of “fragmented dissemination + community interaction”. Douyin’s “ICH Partner” program uses short videos combined with algorithmic recommendations to reach young audiences, forming a closed loop of “technology empowerment – user participation – cultural diffusion”.

The breakthrough of these technologies lies in transforming ICH from “static viewing” to “dynamic experience”: In 2024, the “Revitalized Traditional Opera” live broadcast adopted 6 Degrees of Freedom (6DoF) technology, allowing audiences to observe Kunqu opera details from a 360-degree perspective; the “Suzhou Has Opera” APP developed by Suzhou Kunqu Opera Theater realized the regular online dissemination of Kunqu opera through digital performances. Both initiatives significantly enhanced the depth of ICH dissemination and audience stickiness.

As an extended direction of ICH digitalization, form transformation focuses on realizing the conversion of ICH from cultural resources to cultural capital through technological innovation, with the core being the exploration of ICH’s economic attributes and contemporary value. For example, Zhang Yan (2018) studied the “dynamic inheritance + industrialization” path of Tianjin’s ICH, stating that it is necessary to “conduct a hierarchical analysis of intangible cultural heritage, separate the parts applicable to industrial development, and develop an industrial development model for Tianjin folk custom products based on intangible cultural heritage protection in response to the protection and inheritance of ICH and different market demands, so as to promote development through inheritance and sustain inheritance through development”. [17]

Song Junhua emphasizes that ICH digitalization needs to “integrate cultural elements and cultural values into it” – this concept is reflected in form transformation technology as the logic of “technology empowering creativity, and creativity activating the market”. Current practices focus on the integration of digital collectibles and cultural and creative products: On one hand, blockchain technology is used to create ICH digital collectibles; for example, Jiangsu Kunqu Opera Theater

launched “Kunqu Opera Digital Collectibles”, converting clips of classic plays into unique digital assets and expanding the channels for ICH value realization and dissemination. On the other hand, digital technology is used to extract ICH cultural symbols and integrate them into modern cultural and creative design; for instance, auspicious patterns are extracted from Zhuxianzhen woodblock New Year paintings and applied to products such as clothing and stationery through digital modeling, realizing the conversion of “traditional symbols – modern design – market consumption”.

Lv Yun (2024) proposes a dissemination matrix of “ICH + e-commerce” and “ICH + cultural tourism”, pointing out that it is necessary to “comply with the needs of the times, rely on big data and digital technologies, use social media, online shopping, short videos and other methods for dissemination and application, build ICH IPs, and enable ICH to better embrace digital development”. [18]

4. Review of Research on the Digitalization of Intangible Cultural Heritage

4.1. Review of Research on Digital Information in ICH Digitalization

This study employs the CiteSpace visualization tool to systematically analyze the current status and trends of research on the digitalization of intangible cultural heritage (ICH) in China from the dimensions of keyword temporal sequence, time zone distribution, clustering, and burstiness. From the perspective of research hotspots, keyword frequency analysis highlights the core concerns of the field. Terms such as “digitalization”, “ICH archives”, and “ICH” rank among the top due to the characteristics of thematic retrieval. Meanwhile, high-frequency keywords including “digital humanities”, “artificial intelligence”, “dynamic inheritance”, and “knowledge graph” accurately point to the core focus of ICH digital protection and inheritance. This reflects the academic community’s high attention to the integration of technology and cultural inheritance, with research content closely aligned with the practical needs of the dynamic inheritance of ICH. The time zone distribution of keywords outlines the evolutionary context of the research, presenting phased characteristics of “resource preservation – performance and dissemination – value transformation”. In the early stage, research took specific projects as carriers, focusing on the digital preservation of craftsmanship; in the middle stage, it shifted to the exploration of applications of tools such as “artificial intelligence” and “digital technology”, emphasizing the support of technology for ICH protection; in the recent stage, it has focused on the construction of immersive communication scenarios such as “metaverse” and “dynamic inheritance”, marking the in-depth expansion of research from technological application to cultural ecological reconstruction. Among them, nodes with high centrality, such as “digitalization” and “dynamic inheritance”, constitute the core directions of the field’s development. Cluster analysis identifies 10 cluster labels including “digitalization”, “information resources”, and “ICH inheritance”, covering key fields such as technological application, resource management, and inheritance practice. Among these, emerging explorations such as digital preservation, information dissemination, metaverse, and static protection demonstrate a three-dimensional pattern of interdisciplinary research and multi-scenario application. In the burstiness analysis, “information space” has the longest burst duration, confirming its core supporting role in the construction of the dynamic interactive protection system for ICH; “metaverse” and “dynamic inheritance” have

become current hotspots with high burst intensity, reflecting the academic community's attention to the integration of emerging technologies and dynamic inheritance. The research focus has gradually shifted from the early traditional development and inheritance model to topics such as digital presentation, inheritance and protection, and sustainable development, showing the characteristics of expanding from horizontal extension to vertical deepening. Overall, the quantitative analysis intuitively presents the development status of this field and reveals that under the dual driving forces of policy and technological innovation, the research is deeply penetrating into "digital humanities" and moving towards diversification and systematization. This finding not only verifies the core value of digital technology in ICH protection and inheritance but also provides an academic reference for subsequent research to focus on the in-depth integration of technology and culture and promote the innovative transformation and dissemination of ICH.

4.2. Review of Research on Digital Technology in ICH Digitalization

Research on ICH digitalization technology has transcended the perception that "technology serves merely as a storage tool" and expanded its functional boundaries. Collection and storage technology not only enables the systematic preservation of multi-dimensional ICH information (including visual, auditory, and textual data) but also constructs a shareable "digital gene bank" through big data and cloud computing, laying the foundation for dynamic inheritance. Relying on immersive technologies such as VR/AR/MR, performance and dissemination technology reconstructs scenarios, breaks temporal and spatial limitations, and transforms ICH from "niche appreciation" to "mass experience," enhancing the breadth of dissemination and audience stickiness. Form transformation technology, on the other hand, promotes the conversion of ICH into cultural capital; applications such as AIGC (AI-Generated Content) and knowledge graphs open up new pathways for innovative dissemination and industrial integration. Particularly crucially, the technical concept of "multimodality" integrates diverse information forms, providing support for exploring cultural connotations and advancing research from "technological application" to in-depth "cultural interpretation."

"From the perspective of technology itself, as a carrier for ICH cultural performances, the development of digital technology has provided more ways to showcase ICH, restored the original form of ICH to the greatest extent, and while presenting the complete form of ICH, also conveys the unique cultural connotations of ICH to the public, thereby realizing the dissemination and development of ICH culture in the era of intelligent media." [4] However, while technology expands the scope of dissemination and enhances awareness, it also gives rise to in-depth contradictions: fragmented dissemination easily leads to one-sided interpretations of cultural connotations, hindering the public from forming a holistic understanding; the tendency toward excessive entertainment places technological display above culture, deviating from the core of protection. The academic community's emphasis on the "authenticity" of ICH, rooted in the static protection concept of "preserving the original flavor," is in fact contradictory to the inherent nature of ICH as a "dynamically inherited" practice. From the perspective of cultural communication studies, digital conversion is inherently a creative reproduction mediated by technology, and the digital form of ICH has become a new type of cultural construct integrated with technical logic. The current bias of "prioritizing technological

presentation over cultural interpretation” further underscores the urgency of balancing the instrumental role of technology and the ontological status of culture.

In summary, research on ICH digitalization technology has established an application system adapted to the characteristics of ICH, achieving a functional upgrade from “resource preservation” to “value activation.” Nevertheless, breakthroughs are still needed in areas such as the in-depth integration of technology and culture, the holistic construction of dissemination, and the accurate grasp of the essence of inheritance. Future research should focus on the core proposition of “technology adapting to culture,” strengthen technical empowerment pathways for cultural interpretation, explore methods for constructing holistic cognition in the context of fragmented dissemination, and balance “authenticity” and “innovation” in dynamic inheritance—ultimately enabling technology to truly become a sustainable support for the dynamic inheritance of ICH.

4.3. Review of Research on Digital Practical Applications in ICH Digitalization

In the field of ICH (Intangible Cultural Heritage) digitalization research, technology and practical applications have yielded rich outcomes and achieved positive progress. The practice of ICH digitalization has evolved from the application of a single technology to a systematic project encompassing “resource preservation – performance and dissemination – value transformation”.

In terms of collection and storage, multimodal technologies are employed to accurately capture ICH information and build an ICH “digital gene bank”. In performance and dissemination, immersive communication models centered on VR/AR (Virtual Reality/Augmented Reality) and supported by the mobile Internet are widely applied. For instance, VR is used to recreate the environment of Huizhou bamboo weaving workshops, AR enables the virtual performance of Peking opera characters, and social media platforms are leveraged to disseminate ICH-related short videos. These practices have significantly enhanced the effectiveness of ICH dissemination. In the practice of form transformation, ICH digital collectibles and cultural and creative products are constantly emerging, and the “ICH + industry” model has initially demonstrated positive results.

However, there is a lack of refinement in research on the technical adaptability for different types of ICH. ICH covers a wide range of categories, including performance-based, craftsmanship-based, and folk custom-based ICH, which have distinct needs during the digitalization process. Currently, there is a dearth of systematic research to identify the most suitable technology combinations and application methods for various ICH categories in links such as collection, storage, performance, and transformation. As a result, no refined technical application guidelines tailored to the differences between ICH types have been developed.

In terms of research on the in-depth exploration and presentation of cultural connotations, current digitalization practices mostly focus on the display of ICH’s external forms. The means to explore and present the in-depth cultural connotations behind ICH – such as its cultural origins, aesthetic implications, and folk custom backgrounds – are limited. In the construction of digital resources, there is relatively little research on how to comprehensively and in-depth interpret the cultural connotations of ICH through innovative approaches, so as to enhance users’ understanding and perception of ICH culture.

This not only defines the core areas for the R&D and application of ICH digitalization technologies but also points out the key issues that need to be addressed in subsequent practices, preventing technical logic from overriding cultural logic.

5. Conclusion and Outlook

Over the past two decades, research on the digitalization of Intangible Cultural Heritage (ICH) has evolved in three phases: starting with the “digital recording of traditional craftsmanship” centered on specific projects in the early stage, transitioning to “technological integration and innovation” featuring the application of tools like “artificial intelligence” and “digital technology” in the middle stage, and now focusing on “the reconstruction of cultural communication ecology” with an emphasis on “metaverse” and “dynamic inheritance” in the recent stage. Throughout this process, the research focus has consistently revolved around “technology empowering cultural inheritance,” and three core directions have taken shape: “collection and storage – performance and dissemination – form transformation.” However, challenges remain, such as insufficient collaboration among research institutions, the weakening of cultural connotations in technology application, and the occasional prioritization of economic goals over cultural values.

Looking ahead, research on ICH digitalization technology needs to reconstruct its development path based on the logic of “culture as the foundation and technology as the means.”

At the theoretical level, efforts should be made to deepen research on the “technology-culture” interaction mechanism, establish a theoretical framework for the technical translation of ICH cultural connotations, and address the practical bias of “prioritizing technological presentation over cultural interpretation.”

At the technical level, it is necessary to explore pathways for constructing holistic cognition in the context of fragmented dissemination. By leveraging knowledge graph and multimodal fusion technologies, we can achieve the complete digital presentation of ICH cultural systems and balance the dialectical relationship between “authenticity” and “innovation” in dynamic inheritance.

At the practical level, steps should be taken to promote the downscaling and balanced allocation of technical resources, develop adaptable technical solutions that are low-cost and easy to operate, strengthen technical support for endangered and niche ICH, and narrow the gap in technology application across regions.

Meanwhile, it is essential to further improve the collaborative mechanism involving “ICH inheritors – technical teams – academic circles – governments.” By leveraging inclusive technology to energize inheritance vitality and relying on in-depth cultural interpretation to consolidate the foundation of inheritance, we will ultimately achieve the symbiotic development of technology empowerment and cultural inheritance, injecting sustainable digital momentum into the dynamic inheritance of ICH.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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