RESEARCH-ARTICLE

Systematic Review of Empowering Intangible Cultural Heritage with Metaverse Technology

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Systematic Review of Empowering Intangible Cultural Heritage with Metaverse Technology

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The metaverse is a virtual society capable of mapping the real world, bringing new opportunities and innovations for the transmission and development of Intangible Cultural Heritage (ICH). However, nowadays, the research on metaverse technology in the field of ICH needs to be more cohesive. Therefore, a comprehensive systematic review was conducted through an extensive search of ICH and metaverse-related technologies. The scope of the search is based on the studies from January 2019 to September 2023 of the three major databases of Web of Science, IEEE Xplore, and Scopus covering the keyword. This article provides a general overview of the use of metaverse technologies in ICH and its categories over 5 years. It explains the characteristics, features, and scope of varying metaverse technologies applied to different ICHs in detail. It also explores the prospects of using metaverse to empower ICH and finally discusses the effectiveness of using metaverse technologies to empower ICH and presents the current resistance. In this way, it provides a new direction for the ICH in meeting and integrating into the new era of the metaverse.

CCS Concepts: • **General and reference** → **Surveys and overviews**; • **Applied computing** → *Media arts*;

Additional Key Words and Phrases: Intangible Cultural Heritage (ICH), Metaverse, Extended Reality, Artificial Intelligence (AI), Digital Twins (DT), Internet of Things (loT)

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1 Introduction

The world's cultural heritage is a valuable asset that needs to be preserved and passed on. Some heritage comes in tangible forms, such as buildings or artistic creations. Another kind of heritage transmitted in intangible ways, such as music, folklore, dance, theatre, and crafts [1]. **Intangible Cultural Heritage (ICH)** is an essential

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pillar of cultural diversity and guarantees sustainable development. In 2001, the **United Nations Educational, Scientific and Cultural Organization (UNESCO)** issued a declaration and a convention which that ICH is an important pillar of cultural diversity and a guarantee of sustainable development [2]. In addition to facilitating access, interpretation, survival, and mitigating the risks to which heritage is exposed, humankind bears the primary responsibility for its preservation and protection [3]. However, as the social environment continues to transform, the environment in which ICH survives has also changed dramatically, with young people unable to recognize and understand ICH poses a significant challenge to the transmission and development of ICH. The arrival of the Big Data era and the continuous development of digital technology have exacerbated the difference between the current social environment and the original environment of ICH [4]. In 1992, the UNESCO launched the "Memory of the World" project to further promote the digital preservation of cultural heritage around the world [5]. The purpose of digitization of ICH is to preserve them for future generation. The digitization of ICH also allows people to understand and know their own culture to achieve the transmission and development of intangible culture. However, ICH cannot be effectively passed on due to the lack of practical methods, a small audience, and a single application scenario [6].

In recent years, the concept of metaverse has been widely used in cultural heritage, industry, commerce, healthcare, and other fields [7]. It has also become the focus of attention of the global tech community, with major tech companies joining the metaverse industry, focusing on digital research and development), building digital communication platforms, investing in other metaverse companies, and so on. The first metaverse company, Roblox, was listed on the New York Stock Exchange as the first metaverse stock. In the same year, Facebook, the leading social media company in the U.S., announced that it would usher in the next digital revolution through the metaverse and renamed the company "Meta." Search for the term metaverse skyrocketed on the Internet, reaching a peak at one point. We can venture to speculate that the metaverse is one of the inevitable trends in the development of digital society [8]. The actual term "metaverse" appeared as early as 1992 in the science fiction novel *Snow Crash* by American author Neal Stephenson [9], where users interacted in a virtual parallel universe called metaverse in digitalized bodies. In a World where users interact digitally, they can work and behave as if they were in the real physical world. The metaverse is considered the next disruptive technology that will merge the physical and digital worlds by enabling immersive experiences in both virtual and physical environments, allowing users to traverse seamlessly [10]. Its technology is the core foundation in the early stages of metaverse development [11]. Metaverse involves critical technologies such as the **Internet of Things (IoT)**, **Virtual Reality (VR)**, **5th Generation Mobile Communication Technology (5G)**, AI, blockchain technology, and **Digital Twins (DT)** are also key technologies of the metaverse. Digitizing cultural heritage using metaverse technology will help the promotion, dissemination, and transmission of cultural heritage [12] and is an effective way to deeply integrate ICH into the highly digitalized world, which can enrich its preservation forms, display methods, and application scenarios [13].

Based on the above situation, metaverse technology has become popular for activating ICH. However, the research on the metaverse to empower ICH is relatively scattered, and there is no systematic research. Therefore, this article focuses on the application situation and prospect of metaverse technology in ICH to achieve the following aims:

(1) Demonstrate results and discussion of articles retrieved from three reliable databases and the filtering process.
(2) Demonstrate the type of literature, number of publications, and geographic distribution of ICH papers empowered with metaverse technology.
(3) Overview of ICH that uses metaverse and type of metaverse technology in the context of metaverse empowerment of ICH.
(4) Prospects for the use of metaverse-empowered ICH.

Table 1. Keywords, Database, and Database Refinement Filtering

Keywords	Database	Database Refinement Filtering
ALL=((“Intangible cultural heritage” OR “ICH”) AND (“metaverse”OR “VR” OR “Virtual Reality” OR “MR” OR “mixed reality” OR “AR” OR “Augmented Reality” OR “AI” OR “Artificial Intelligence” OR “digital twins” OR“DT” OR “Blockchain” OR “NFT” OR “5G” OR “loT”))	Web of Science	1. Publication Date: January 2019– September 2023; 2. Language: English; 3. Field: computer science, social science, arts and humanities-related fields; 4. Type: articles, review papers
(“Intangible cultural heritage” OR “ICH”) AND (“metaverse” OR “VR” OR “Virtual Reality” OR “MR” OR “mixed reality” OR “AR” OR “Augmented Reality” OR “AI” OR “Artificial Intelligence” OR “digital twins” OR “DT” OR “Blockchain” OR “NFT” OR “5G” OR “loT”)	Scopus	1. Publication Date: January 2019– September 2023; 2. Language: English; 3. Field: computer science, social science, arts and humanities-related fields; 4. Type: conference papers, articles, review
(“Intangible cultural heritage ” OR “ICH”) AND (“metaverse” OR “VR” OR “Virtual Reality” OR “MR” OR “mixed reality” OR “AR” OR “Augmented Reality” OR “AI” OR “Artificial Intelligence” OR “digital twins” OR “DT” OR “Blockchain” OR “NFT” OR “5G” OR “loT”)	IEEE Xplore	Publication Date: January 2019– September 2023

2 Material and Method

2.1 Data Sources and Retrieval Methods

The methodology of this study is divided into the following stages:

(1) Formulating research objectives.
(2) Determining search terms for relevant fields according to the research objectives.
(3) Selecting literature databases with high credibility.
(4) Implementing the search and refining the filtering according to the functions of the databases as well as the peer review.
(5) Executing the research: reading the relevant literature in full text and summarizing and organizing the ideas by the research objectives.
(6) Extracting the data.
(7) Analyzing the data.
(8) Researching the results.

The research selection centers on important terms such as metaverse, metaverse technology, and ICH. As shown in Table 1, the main literature was sourced from three famous library databases, namely Web of Science, IEEE Xplore, and Scopus, to ensure the credibility of the retrieval using exact search or expert mode. The keywords are derived from the terms related to metaverse, metaverse technology, ICH or terms of similar concepts. The advanced arithmetic mnemonics of “OR” and “AND” were used for extensive searching, and the related concepts of metaverse and ICH were grouped and linked using “AND,” and the terms of the same or similar concepts were linked using “OR.” Since the functions of different databases are not the same, the scope of articles is restricted and filtered in the available functions of the databases. For example, the publication time is limited to relevant literature within the last 5 years, from January 2019 to September 2023.

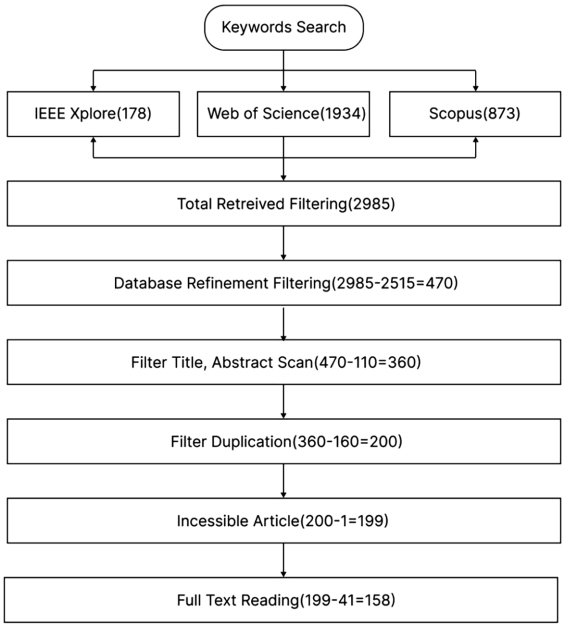

Fig. 1. Search flow.

In addition, restrictions were placed on the language and research areas of the articles as well as the type of literature.

2.2 Data Collection and Filtering

Figure 1 shows the search flow chart. The total number of articles retrieved through the keywords was 2,985, followed by 470 articles obtained by filtering based on the filtering functions available in the database, such as publication date, language, field, and type. All these articles were put into an Excel sheet, and the titles and abstracts were scanned; papers not related to metaverse technology-empowered ICH were excluded, yielding 360 articles, and then the work of weeding out these articles was carried out, and the inaccessible articles were also excluded from the study. Subsequently, the full text of the articles was read in depth. Ultimately, the final scope of the literature for this study was determined after full-text reading screening in conjunction with the inclusion and exclusion criteria (Table 2).

3 Results

3.1 Types of Literature

This study provides 158 documents published between January 2019 and September 2023. Among all publications, 104 journal articles (66%) and 54 conference papers (34%) were the main contributors. These two main categories dominated the database searches, with other less important outputs such as editorial material, books, and book chapters being excluded.

3.2 Number of Publications

Figure 2 depicts the evolution of the number of published articles in the last 5 years and shows that the relevant research started to grow significantly after 2020 and peaked in 2022 with 51 articles. This is partly due to the accelerated virtualization of society by the COVID-19 epidemic and partly due to the rapid development of

Table 2. Inclusion and Exclusion Criteria

Type of Criteria	Explicit Reference
Inclusion criteria	1. From three major literature databases: journals, conference papers, and reviews. 2. The articles will be published from January 2019 to September 2023. 3. Language: English. 4. Related fields: computer science, social science, arts and humanities-related fields. 5. Review articles in the research areas of related fields that use metaverse-related technologies to act on ICH. 6. To propose theoretical support and practical methodological guidance for the metaverse to act on ICH in related fields.
Exclusion criteria	1. Only research related to the metaverse is covered. 2. Only involves research related to ICH. 3. Research that cannot act on ICH. 4. Research that only refers to cultural heritage-related research. 5. Excluding research on digitization of ICH with metaverse-related technologies. 6. Excluding articles in fields not related to computer science, social science, arts, and humanities. 7. Retracted articles.

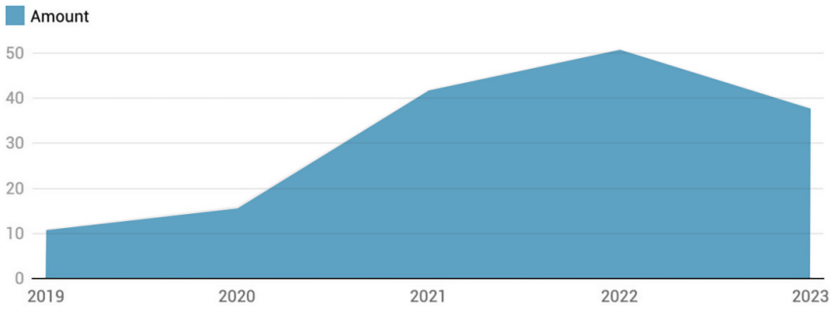

Fig. 2. Distribution of number of publications by year.

technologies such as blockchain, IoT, and VR. Currently, 38 articles have been published as of September 2023. In summary, it can be found that the use of metaverse technologies to empower ICH is still evolving and still maintains a strong trend.

3.3 Geographical Distribution

From the countries to which the first-author institutions of the published articles belong, it can be found that 22 countries are interested in the study, mainly in the Southeast Asian and European regions. Among them, China has the largest number of distributions, with a total of 100 articles, accounting for about 63% of the total distribution area. China is an ancient civilization with a long history of rich ICH and is also committed to the protection and transmission of ICH. Greece comes in second place with 16 articles, accounting for about 10% of the total. The history of Greece can be traced back thousands of years, and it is considered one of the origins

Fig. 3. Geographical distribution of number of publications.

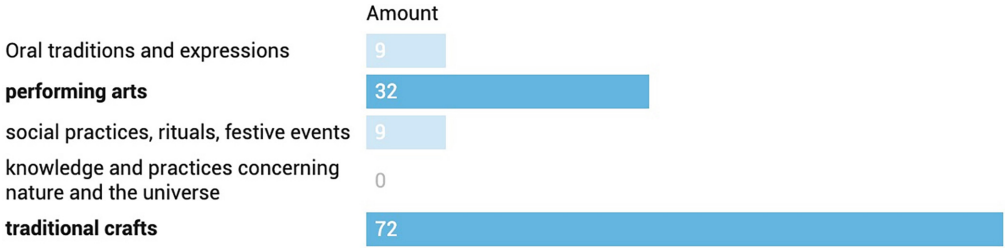

Fig. 4. Overview of the categories of ICH.

of Western civilization. This ancient country has left many vital relics and legends in its history. It is closely followed by Malaysia, Japan, Denmark, Italy, and France (Figure 3).

4 Detailed Literature Study

4.1 The Type of ICH with the Use of Metaverse Technology

ICH consists of five categories of intangible elements: traditional craftsmanship, performing arts, oral traditions and expressions, language as a medium of ICH, social practices, rituals, festivals, knowledge and practices about nature and the universe [14]. However, 36 articles (23%) did not explicitly refer to a particular category or item of ICH in the literature covered, including 21 articles that only referred to ICH with no explicit content and 15 articles that referred to both ICH and tangible cultural heritage. A total of 122 articles (77%) explicitly referred to specific elements of the ICH, with the category of traditional craftsmanship accounting for the largest number of articles, with 72 (59%) (Figure 4). Six articles focused on the ICH of Thangka, which are religious scroll paintings mounted on colored satin and hung for worship. The research focuses mainly on the field of AI. Li and Liu [15] proposed a dataset of Thangka sketches and studied the matching rules between Thangka images and sketches using deep learning techniques. Wang et al. [16] proposed a fine-grained classification method for Thangka images based on Squeeze-and-Excitation Networks (SENet). Wang et al. [17] constructed a Thangka multi-object image dataset and further proposed an improved model. Weaving traditional craftsmanship such as Batik, tie-dye, embroidery, and ceramics manufacturing crafts are also of wide interest. Ji et al. [18] and Zhong et al. [19] both seek to preserve and reinvent Cantonese porcelain using VR, along with Dai ceramics [20] and Longquan-fired porcelain [21].

In second place is performing arts, in which there is with a strong focus on dance, with 32 papers, or about 26% of the performing arts category. Belabbes et al. [22] propose an ontology that can be represented in the language of descriptive logic in order to capture the knowledge conveyed by the "Tamia đwa buk", a traditional Vietnamese dance, and develops tools that can annotate the video and query the content automatically. Pistola et al. [23] sought to develop a web platform "CHROMATA" that provides 3D pose prediction, folk dance recognition, and text analysis, with the aim of creating to create a more complete and inspiring immersive experience to promote the revival of Greek cultural practices and dances. Liu and Yan [24] used **Augmented Reality (AR)** to build scenarios to promote the dissemination and development of the "Dance of Durms". Cai et al. [25] proposed a method for generating extended Laban annotations for ICH dance videos based on 3D human gesture estimation.

Tied for third place are oral traditions and expression and social practices, rituals, and festive events, accounting for about 7% of the total, including poetry, texts, festivals, and customs. However, there is a temporary lack of focus on knowledge and practices concerning nature and the universe.

4.2 The Type of Metaverse Technology Applied to ICH

The metaverse combines almost all current advanced software and hardware technologies and is an entirely new stage in information technology and digitalization development. Nalbant and Aydin [26] focus on the impact of AI technology on digital marketing and branding. The impact of AI technology on digital marketing and branding is also examined along with related digital technologies, including metaverse, AI, blockchain, VR, and AR. Huang et al. [27] also mentioned DT and multi-modal networks in their research foundation. Bibri and Allam [28] more specifically mentioned core technologies such as AI, Big Data, IoT, blockchain, DT, VR, AR, **Mixed Reality (MR)**, and 5G. Among them, VR, AR and MR are all extended reality technologies. Synthesizing the views of experts and scholars, it can be found that their views on selecting core technologies for the metaverse have certain commonalities. The key technologies of the metaverse include extended reality, AI, blockchain, IoT, DT, and 5G (Table 3). There are 94 articles that use extended reality technologies in ICH in this study: 56 articles focus on AI, 11 articles focus on blockchain, 4 articles focus on 5G and IoT, and only 1 article related to DT. Sometimes, two or more technologies are used to integrate into the same article, commonly there are six articles combining AI and extended reality technologies, two articles combining AI and blockchain, one article integrating extended reality technologies and 5G, and one article integrating blockchain and DT. On the whole, there is an inevitable trend for core technologies to intermingle and use each other. However, there is a great demand for researchers' ability, so most articles focus on one core technology to revitalize and innovate the ICH.

4.2.1 Extended Reality. Extended reality technologies integrate digital content with the real world to create immersive and augmented experiences through the interaction of the virtual and the real, and mainly contain three forms of VR, AR, and MR. These three technologies are often combined with 3D modeling techniques to create 3D models of ICH, which are then used to build immersive experiences [4]. Sixty articles in this study use VR to empower ICH, 30 in AR, and 8 in MR. Among them, Liu et al. [29] used three technologies, AR, VR, and MR, to complete the Thangka scene display. Yiyi and Lingxuan [30] used AR and VR to transmit the Putian wood carving craftsmanship as a way of lifting the dilemma of ICH. However, most researchers choose one of them and combine it with other technologies or hardware devices to innovate, the technologies include 3D, gesture tracking, motion capture, visualization, animation, and so on, and hardware devices such as VR helmets and AR headsets. Extended reality technologies demonstrate a powerful ability to enhance experiences in a variety of usage contexts. They can be well used to augment physical objects and spaces or information about physical entities [31]. Therefore, extended reality technologies are of great help in showing the formation process of ICH, which allows people to feel the charm of the ICH production process in an immersive way and enhances the sense of interactivity and participation. The following is a detailed overview of relevant studies that use extended reality technologies as the main focus.

Table 3. The Characteristics, Functions, and ICH Application Scope of Metaverse Technology

Technology	Characteristic	Feature	Scope
VR	Virtual	Immersion	ICH with a procedural or performative nature
AR	Reality + virtual	Semi-immersion	ICH with narrative or display characteristics
MR	Reality × virtual	Immersion or semi-immersion	ICH in the museum display
AI	Algorithms, computing power, and data	Intelligent recognition, extraction, classification, generation	ICH with text, images, sounds, and actions
DT and blockchain	Digital solid model, decentralization	Digital modeling transparent transactions, traceability	ICH with a digital model that has transactional attributes
loT	Sensor monitoring and control	Real-time monitoring	ICH with monitoring properties and highly real-time interaction properties
5G	High speed, low latency	Real-time data transmission	ICH with require high-speed data transmission

VR is an interactive digital technology that simulates real or fictional environments, enabling immersive experiences and exploration of virtual worlds by applying perceptual devices and computer graphics. In the integration of ICH and VR, the main focus is on design and practice, such as building platforms and systems. Tai Chi is a traditional Chinese martial art that uses VR technology to break through the limitations of insufficient teachers, training hours, and inconsistent movement gestures. The establishment of a VR online learning platform can help to get rid of the limitations of teaching content and practice time, stimulate interest in learning, and expand the participation of the population [32]. In a cloud-based multi-user VR Chinese glove puppetry system, the user can have a unique perception of the virtual environment and interact remotely through the control of the glove puppet [33]. VR systems have also been applied to the learning and experience of musical instruments, which can enhance the learners' interest and experience through fun somatic interactions, but its drawback may lie in the fact that too much gamification can lead to distraction [34]. The digital preservation and inheritance of the "Wu Leno" weaving technique is a lightweight silk fabric with warp and weft threads interlaced to form patterned holes. A loom simulation library was established using VR to redesign and recreate fabric patterns digitally. At the same time, a library of garment effect models and interactive experiences of different loom principles were developed. The digital preservation and inheritance of the "Wu Leno" weaving technique and the digital innovation of fabric patterns were realized [35]. Beer brewing in South Africa uses VR to immerse participants in the community to learn about brewing practices, allowing beginners to quickly learn the cultural aspects of the heritage as well as the hands-on techniques of beer brewing. This method that can also increase participant motivation [36]. VR technology is also often used in interactive installations. The "Dance of Drums" is an interactive installation of traditional Chinese dance, which combines the movements and ethnic elements of the copper drum dance to create a VR virtual scene and then displays the history and culture of the copper drum dance as well as its expression in the real world, which is an innovative static expression of traditional dance [24]. In addition, there is also the virtual museum of "Jiao Shan Stele Forest," which uses VR to create an emotional and spatial unity, allowing the experiencer to experience the environment of the stele forest in a 360-degree view, and to interpret the art of calligraphy in depth [37]. VR has also been applied to the performing arts, providing a universal design methodology and ideas for the artistic creation and artistic expression of

ICH and, at the same time, increasing the expressive power of the arts. It can be seen that VR technology has gradually matured, through which culture and heritage can be experienced to achieve sustainable protection of ICH [38].

AR technology that enables users to perceive and experience the real world and virtual elements by superimposing virtual information in the real environment. AR technology seamlessly combines virtual content with real scenes through computer vision, perception technology and display technology, thus creating an AR perception experience. AR can be applied to a variety of devices, such as smartphones, tablets, and AR glasses. Through these devices, users can view real-world scenes and superimpose virtual 3D images, text, video, audio, and other content, creating interaction and fusion between the virtual and the real. He et al. [39] argued that AR can be applied to packaging design, which is different from traditional packaging design in that it can significantly improve the layout space, interactive experience, and brand memory of consumers. He explains this with the example of "Ya'an" Tibetan Tea. Yan et al. [40] designed the folktale "Xishi Dance" as an AR illustrated book, superimposing virtual character animation on the scenes of a paper book, thus increasing the user experience and immersion. Ntagiantas et al. [41] also used AR in children's books, creating an AR book app based on the theme of the idyllic life of Psiloritis, which allows readers to bring the life scenes and heroes of the book to life. Kazanidis et al. [42] designed an AR system to promote cultural heritage, which also combines interactive technology, sensing technology, and multimedia technology, and designed a transparent interactive box that displays information about ICH on the box screen when the user approaches it. Clarizia et al. [43] believe that AR can bring people closer to cultural heritage and that AR combined with games and digital storytelling, it can be an effective communication tool.

MR is an experience that integrates VR and AR technologies, a technology that has been applied relatively often in museums of ICH. The Olive Oil Museum in Lesvos Island, Greece, allows virtual workers to present the museum's interior in virtually reconstructed landscapes and machinery and uses a rotating screen as an MR setup for disseminating ICH [44]. Spatial Augmented Reality is also part of MR, which allows museum artifacts on display to be superimposed with virtual information content, to expand the museum's display space and content and enhance interactivity and interest [45].

4.2.2 AI. With the application of AI technology, people worldwide are using various means and methods of AI technology to remember to preserve, innovate, and disseminate ICH. The digital world can transform elements, texts, sounds, and images into a universal programming language [46]. AI can enable the digital networking of ICH and information intelligence [47], and "Computational Museology" is now introduced to bring about a fully coded environment [48]. The current use of AI technologies to empower ICH is mainly through algorithms that recognize, extract, classify, and generate information and content related to ICH, where the purpose of recognition is to collect and store data, and extraction, classification, and generation are to analyze and recreate the data (Table 4). The techniques used include computer vision, deep learning, machine learning, ontology technology, and so on. These techniques are suitable for application to types of ICH that focus on the visual and auditory senses, such as those with gorgeous patterns, beautiful dances, and lovely music.

ICH Empowered by AI: Recognition and Extraction. Li and Liu [15] researched Thangka in image recognition and extraction and proposed a sketch image dataset, which can facilitate the subsequent retrieval of Thangka images by assembling the Thangka images into a database after sufficient dataset training. Hu [49] carried out image recognition and tracking alignment of clay sculptures based on an algorithmic model. Image recognition technology is also applied to the search system of tie-dye, which is combined with a guidance system and database to create an online community for the transmission of ICH [50]. The **Convolutional Neural Network (CNN)** model based on deep learning carries out image recognition on the Chinese folk song "Hua'er" in the field of performing arts, realizing the inheritance and development of ICH [51]. However, Han [52] argued that extracting image contours is a key step for digital design and can be widely applied to various scenes in life. Combining the

Table 4. Key Expressions of ICH Empowered by AI

Key Expression	Papers	Author
Recognition and extraction	Sketch Based Thangka Image Retrieval	[15]
	Research on the Digital Protection Technology of Intangible Cultural Heritage Information under Computer Artificial Intelligence	[49]
	An Online Community Applying CNN Technology for ICH Craftsmanship Inheritance and Preservation	[50]
	Intangible Cultural Heritage Management Using Machine Learning Model: A Case Study of Northwest Folk Song Hua'er	[51]
	Computer Image Processing Technology on Reconstruction of Shadow Puppets in Jianghan Plain	[52]
Recognition and classification	Choreographic pose identification using convolutional neural networks	[53]
	The Sustainable Development of Intangible Cultural Heritage with AI: Cantonese Opera Singing Genre Classification Based on CoGCNet Model in China	[54]
	Music sheet score recognition of Chinese Gong-che notation based on Deep Learning	[55]
	Classification of Batik Authenticity Using Convolutional Neural Network Algorithm with Transfer Learning Method	[56]
	Nantong Blue Calico Image Dataset and Its Recognition	[57]
	Research on Computer Image Recognition and Intelligent Analysis Technology of Water and Land Painting Clothing	[58]
Recognition and generation	Innovative Design of Artificial Intelligence in Intangible Cultural Heritage	[59]
	Research on Wickerwork Patterns Creative Design and Development Based on Style Transfer Technology	[60]
	Machine Learning in Intangible Cultural Analytics: The Case of Greek Songs' Lyrics	[61]
	Digital Style Design of Nanjing Brocade Based on Deep Learning	[62]

visual characteristics of prop patterns in shadow puppetry, an algorithm was designed to extract the shape and color of shadow patterns.

ICH Empowered by AI: Identification and Classification. Bakalos et al. [53] used deep CNNs in AI to recognize of movement trajectory and kinematic theme data of three traditional dances in Greece and further processed the obtained data by analyzing the dataset to classify the original gestures of different dances. As a famous ICH of China, Cantonese opera has various singing genres. Chen et al. [54] collected and identified 10 singing genre audios as a dataset and proposed a model based on Cantonese opera Genre Classification Networks based on the characteristics of different singing genres. In the experimental test, it is found that the accuracy of this model can be as high as 95% or more, which can practically solve the dilemma that Cantonese opera genres cannot be effectively classified and preserved. Chinese Gone-Che notation which recognizes and classifies information in a musical score, is relatively complicated, including the score, tune, lyrics, author, and so on. Therefore, a multi-layer set classification model was adopted, further proposing a method for preserving and disseminating traditional music [55]. There is also involvement in the field of traditional craftsmanship. Putra et al. [56] used the CNN algorithm with a transfer learning approach for machine learning to classify the authenticity of batik

and developed it into a mobile application. Nantong blue fabric is also a traditional craftsmanship in China. To fill the gap in the public dataset of blue fabric, by comparing four commonly used CNNs, it was found that ResNet-50, as a deep learning model, has a higher recognition accuracy than the other three and is more suitable for classifying blue fabric patterns [57]. Effective storage is required after recognition and classification. Meng et al. [58] proposed an intelligent database technique based on AI and image recognition technology to achieve intelligent analysis and storage classification of "Water and Land Painting Clothing."

ICH Empowered by AI: Recognition and Generation. AI technologies are also often used as tools for automatic generation and innovation. An analysis atlas is constructed by analyzing the visual elements and compositional forms of ICH collated into data for recognition. The elements are then extracted using shape syntax to automatically generate many innovative atlases and schemes, which can also be iterated and optimized [59]. Based on AI technology, a creative design method for Chinese wickerwork patterns based on a style migration algorithm is proposed, which can cater to the user's preference for design. First, a recognition model is established to extract the feature information of the wickerwork pattern style. Then, an innovation generation model is established based on Cycle-Consistent Adversarial Networks to generate a large number of innovative patterns using wickerwork weaving styles. Finally, the final pattern can also be formed by human intervention and adjustment. This innovative approach is deeply rooted in the content of ICH itself for transmission, which is a sustainable method [60]. Generated patterns can further create databases, and a large number of databases and datasets are available for the effective preservation, analysis, and management of ICH [61]. Xuelin et al. [62] start from the pain point of the lack of innovation in the Nanjing brocade patterns and use deep learning and computer-assisted techniques to innovate the generated pattern's style and further construct a pattern database, which facilitates the material query as well as innovative reconstruction of the research pattern afterwards.

4.2.3 DT and Blockchain. DT technology is a mirror image of physical processes that can match exactly with the physical phenomena, processes, and operations that occur in real-time [63]. DT technology is now currently used in a wide range of industrial, architectural, and other fields. In the protection of Miao silver, a traditional craft, a digital virtual product is created based on DT and **Non-Fungible Token (NFT)** technology in blockchain, and real-time data sharing with the Miao silver product in the physical world is achieved. In addition, NFT protects the ownership of the creator, who can also earn revenue from it. Protection of intellectual property rights is difficult to achieve in traditional craftsmanship, but NFT is now often widely recognized as having a unique value and role in protecting the originality and authenticity of ICH [13]. At present, Jingdezhen ceramics as traditional craftsmanship is facing the problem of being destroyed and improperly developed. The reasonable use of blockchain technology's decentralization, traceability, openness, and other characteristics can effectively achieve the integration of ceramic information, create a digital world of Jingdezhen ceramics, and improve its data information, which can ensure the uniqueness and value of Jingdezhen ceramics [63, 64]. The use of blockchain technology has become a key part of the archival information resource management platform of musical ICH, constructing the archival information resource management platform of musical ICH in Jiangxi, improving the tracking and tracing of information, and thus reducing the risk and cost of the management of ICH [65].

4.2.4 IoT and 5G. Of the three papers that use 5G and IoT to empower ICH, two use extension technologies in addition to 5G and IoT technologies. They are a fusion of 5G, IoT, and extended reality technologies. Shen [66] uses 5G and VR technology to propose a protection and innovation method that integrates computer VR technology and uses "Xiuzhou Farmer's Painting" as an example to excavate the inheritance and development strategies further. Qu et al. [67], on the other hand, use 5G in combination with VR, AR, MR, and holographic projection technology to construct an interactive narrative environment model for ICH exhibitions. Sun [68] explored the management and protection strategies of traditional sports in the context of IoT combined with Geographic Information System and VR technologies. Dong et al. [69] used IoT devices to apply deep learning

techniques in AI to the puppets in the Japanese traditional performing art of "Jo-Ha-Kyu Mechanism," and the speed of movement and the rhythm of the music are modulated.

4.3 The Application Field of Metaverse Technology Empowering ICH

Metaverse technology has been widely used in education, entertainment, social tools, and other fields. Technological innovation promotes the change of ideas and methods.

4.3.1 Education. The development of technology is driving changes in education [70]. With the advancement and application of various new technologies, people now have access to diverse multi-modal learning opportunities, fostering innovation in educational delivery methods and teaching methods [71]. Extended reality technology provides an immersive and interactive learning method for ICH in the field of education, which can effectively improve users' understanding and acceptance of ICH. This includes the creation of a virtual classroom to provide ICH skills courses, and students experience the making process of Guangdong porcelain through "hands-on" in the virtual environment [18]. The AR Lantern experience system, AR books [41], and virtual museum [72, 73] also add interest to learning. These methods have changed the traditional concept of culture and education and broken the restrictions of time and space. Let learners enter the virtual classroom anytime and anywhere, contact rich cultural resources and diversified learning scenes, and realize natural edutainment [74]. Learners can deeply experience the connotation of ICH, enhance cultural identity, and discover the diversification and individuation of education.

4.3.2 Entertainment. In the field of entertainment enabled by ICH, metaverse technology can show ICH through innovative interactive ways, digital content, and virtual experience. Interactive installation would allow users to experience intangible cultural arts or festivals in a virtual world. The Tinian Marble Museum in Greece has designed an installation that puts visitors in the role of a crane operator in a virtual reconstruction of a historic quarry. It lets players operate a crane with non-player characters and move marbles safely [75]. The construction of virtual scenes through VR technology, such as the construction of the virtual stage of Suona [76] and Dance of Drums [24], provides a scene beyond regional restrictions and provides a new idea and effective practice plan for the dissemination of ICH. DT, blockchain, and NFT technologies can create and sell ICH digital collections, which will help expand the use scenario of ICH and improve its the commercial value. In addition, VR and AI technology can also be applied to cultural tourism and other entertainment scenes. For example, VR technology can provide a reference for the shape design of the Yixing teapot [77], and AI technology can provide strategies for the tourism product design and brand value of Grass Cloth Embroidery [78]. Compared with VR, AR can improve the social dimension and experience of the virtual world [79].

The wide application of metaverse technology in the field of entertainment not only enriches People's Daily life experiences but also dramatically broadens the boundaries of culture and content transmission. Diversified forms of entertainment provide unlimited possibilities, make people's entertainment more diversified and personalized, and give digital entertainment a new depth and breadth.

4.3.3 Tools. The platform [80], system [81], and database [82] provided by the metaverse technology build a comprehensive and effective tool system for the digital preservation of ICH. Through these digital means, the skills, stories, scenes, and performances of ICH can be meticulously recorded, archived, and reproduced. The metaverse has realized the long-term preservation of ICH, and this digital preservation method has injected new momentum into the protection of ICH, enabling traditional culture to be inherited and disseminated in the virtual world and laying a solid foundation for future cultural education, research, and dissemination.

5 Prospects of Metaverse Empowering ICH

Relying on digital technology and mapping the physical world, the metaverse used to authentically record and preserve ICH and apply it to various fields and interactive media, broaden the inheritance paths, lead sustainable

development, and further promote industrial integration and cultural diversity to a broader market. As a digital technology, the metaverse can play a game-changing role in helping ICH enter a new era of service, management, and preservation [12]. In a sense, the metaverse is the embodiment and carrier of the evolution of social technology [83].

5.1 Virtual Immersion Experience Broadens the Inheritance Pathway

The metaverse is a virtual multidimensional space that allows users to enter and interact with other people, objects, and environments as a digital identity. In this digital world, people can experience unprecedented immersive experiences through technologies such as VR and AR [29]. This technology has not only changed the cultural, tourism, and education industries but also brought new possibilities for the transmission and interpretation of ICH. Traditional transmission of ICH lacks a spatio-temporal context and is not attractive enough in the colorful contemporary society. However, in the metaverse, we can break through the limitations of time and space, complete the flow of time and space, feel the history and culture in real-time, travel through ancient and modern space, and bring a sense of science and technology, a sense of the future, and a sense of excitement to the ancient excellent culture, so that people can fully feel the real charm of ICH, which is undoubtedly a piece of intense attraction to the new generation of young people. In addition, the interpretation of the metaverse can narrow the communication space and break the geographical limitations of ICH so that people all over the world can interact and communicate in the same virtual space.

5.2 Leading the Sustainable Development of ICH

The digital characteristics of metaverse technology provide new means for preserving and inheriting ICH. The traditional meaning of preservation for ICH is just to put beautiful things into the silent dust, which will fly away with time. However, through the metaverse, static preservation can be made dynamic and active, and elements such as traditional skills, dances, and music can be digitally recorded and preserved without being affected by natural disasters [84], which prolongs ICH indefinitely. Preservation using metaverse technology not only provides a solid foundation for the transmission of cultural heritage but also lays an important foundation for the sustainable development of intangible culture [85].

5.3 Creative Industry Integration Helps Intangible Culture Innovation

The fusion of metaverse technologies with ICH industries has spawned a range of creative industries [6]. Virtual exhibitions, virtual tours, virtual performances, and other projects featuring ICH are emerging as a new economic growth point. The development of these creative industries has injected new commercial value into the intangible culture, stimulated consumers' purchase intention, and further promoted innovation and development [86].

5.4 Global Exchange Promotes Cultural Diversity

Metaverse technology breaks the geographical and linguistic limitations of ICH, allowing global barrier-free communication to promote cultural diversity [2]. Different countries and regions have large differences in their ICH due to different cultures and environments, and metaverse can break down the barriers of information transmission and create a model of real-time display of vertical communication so that people around the globe can better understand and pass on ICH.

6 Discussion

The intervention of the metaverse does not mean that ICH people or processes will be completely replaced by digital tools, but rather that they can choose to use it in the conceptual, design, and production phases to enhance the innovation of ICH content, dissemination, and other form of use. However, these sustainable digital assets made of code are questionable at this stage. Research in the last 5 years has found that the core technologies of

the metaverse have been used in ICH, proving that it is feasible and effective to use the metaverse to empower ICH. The current social environment and technological development have not yet ushered in the metaverse in its heyday, and there are still some significant factors. For example, constructing a metaverse requires a lot of technical support. Due to insufficient awareness and understanding, many ICH workers need more awareness and knowledge of the metaverse. The conversion cost needs to be lowered, the initial capital investment is very high, and it may not bring significant economic benefits in the short term. In addition, the application of ICH often involves complex copyright and intellectual property issues. These legal and ethical obstacles may hinder the application of intangible cultural heritage in the metaverse. However, with the enhancement of technology and the development of society, these problems can be solved gradually. Then, the ICH, dissemination, and inheritance through metaverse will be better awakened, the purpose of which is not to be replaced but to be preserved and presented better.

7 Conclusion

This article presents a systematic literature review of metaverse-empowered ICH. According to the study's objectives, it was shown that the most critical themes in the study are ICH, metaverse, and metaverse technologies. Under the great wave of the metaverse, this article summarizes how different technologies adapt to different categories of ICH, which will help ICH researchers choose one or more metaverse technologies for application. The most popular metaverse technologies for ICH are AI and extended reality technologies. Extended reality technologies can bring interactivity to ICH, enabling interaction with users, consumers, and visitors through the interaction of systems, platforms, and devices. Not to be a static narrative, extended reality technologies allow ICH to communicate and interact with humans through multiple dimensions, such as vision, hearing, smell, and touch, providing a two-way perception process. Immersion can be further achieved through interactivity, allowing people to immerse themselves in a virtual environment as if it were the real world, creating an immersive experience. AI algorithms can create ICH datasets and build a systematic platform to identify, classify, and automatically generate ICH. Blockchain and DT technologies can model ICH and carry out effective digital management and detection. Many studies found that using metaverse technology to empower ICH aims at better protection, inheritance, dissemination, and development to make ICH rich in modernity. Metaverse technology is precious for the digitization of ICH, which can broaden the channels of dissemination, lead to sustainable development, and help integrate industrial innovation and global cultural diversity.

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