

Protection and Recreation Application of Cultural Heritage in the Era of Artificial Intelligence—A Case Study of Ying Luo and Bi Chuan

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Abstract: Taking Ying Luo (jade and pearl jewelry) and Bi Chuan (arm bracelets) as examples, this paper discusses the protection and recreation application of traditional cultural heritage in the era of artificial intelligence. Firstly, it analyzes the status quo and problems existing in cultural heritage protection. Secondly, it discusses the application of digital technology to cultural heritage protection. Then, it cites Ying Luo and Bi Chuan as two examples to demonstrate the ways to use AI technology for the recreation application of cultural heritage. Lastly, it summarizes the opportunities and challenges brought by AI technology to cultural heritage protection and proposes relevant suggestions.

Keywords: era of AI; cultural heritage; protection; recreation

1 Introduction

Cultural heritage refers to the material and intangible heritage created by humans, which carry historical, cultural, artistic, scientific, and social values, and are of high significance for inheritance and protection. The cultural heritage from different regions and cultural backgrounds, as epitomes and memories of human history, serve as important imprints of advances in human civilization and are gems of human wisdom. As globalization deepens, national cultures and art that carry distinctive characteristics are of paramount significance and value for maintaining cultural diversity and facilitating the inheritance and development of human cultures.

As a major country with rich tangible cultural heritage, by 2022, China had a total of 43 items listed on the UNESCO Intangible Cultural Heritage list, with 3,057 inheritors and over 100,000 cumulative intangible cultural heritage projects.[1]

With the development of the nation, there has been an increase in the sense of national identity and pride among both groups and individuals. Consequently, there has been a growing attention to, dissemination of, and proactive protection of cultural heritage. According to the Cultural Tourism Industry Index Laboratory's "2022 Influence Report on Intangible Cultural Heritage on Overseas Short Video Platforms," the total views of intangible cultural heritage-related videos on TikTok alone exceeded 30.8 billion. Intangible cultural heritage videos are equally popular domestically, with public data showing that as of June 2022, the

coverage rate of national-level intangible cultural heritage projects on Douyin was 99.74%, and the total number of related video views reached 372.6 billion.[2][3]

While cultural heritage is eagerly being observed, its creation and preservation also face significant challenges. With the rapid development and revolutions of technology and society, fast-paced life has changed people's habits. On the one hand, due to the decrease in the number of inheritors, lots of cultural heritage that requires long-term learning and accumulation is at risk of being lost and forgotten. On the other hand, progress in digital technology and AI has brought more convenient means for acquiring and transmitting information. Correspondingly, more efficient digital technology and AI applications are creating new opportunities for the protection and recreation of cultural heritage.

In this context, based on the artistic characteristics of Ying Luo and Bi Chuan., this study aims to summarize their cultural connotations and artistic value.[4] The paper explores the status quo and future development of digital practices in cultural heritage and the application of AI to the protection and recreation application of cultural heritage.

2 Status Quo and Problems of Cultural Heritage Protection in the Era of AI

(1) Research Background

Over the past years, different countries have adopted a myriad of measures for protecting cultural heritage, including enacting laws on protection and inheriting traditions. For instance, France enacted the *French Law on Cultural Heritage*, stipulating specific measures for protecting cultural heritage, such as cultural relic protection and archaeological excavations. Besides, policies such as subsidizing and providing training programs for traditional handicraft artists have been introduced to encourage the inheritance and innovations of cultural heritage. Meanwhile, many traditional festivals and activities, including the International Artisan Exhibition in Paris and the Provence Equestrian Festival in Arles, are carried out to display and inherit traditional cultures.

Many traditional cultures of India have been incorporated into UNESCO's Cultural Heritage List, such as yoga, ancient mandalas, and traditional Indian medicine. Moreover, foundations are set up, and cultural festivals are organized to provide strong support for protecting cultural heritage.

China formulated the *State-Level Cultural Heritage List* and the *List of Cultural Protection Units* to provide special protection for cultural heritage included in these lists. Meanwhile, many other measures, including designating traditional skill inheritors, traditional craft masters, and other honorary titles, providing capital support, and supporting projects, are carried out to encourage and protect the inheritance and development of traditional skills.

The achievements attained in cultural heritage protection of different countries have not only proved the effectiveness of traditional protection means but also revealed a series of problems, including the slow inheritance of cultural heritage, the gradual deterioration of the inheritance environment, and the single, limited modes of conversion and dissemination. These problems become increasingly prominent and serious in the rapidly developing modern society.

On the other hand, the rapid development and application of AI technology in 3D screening, image recognition, and natural language processing provide technical support for the digital maintenance and inheritance of cultural heritage. Moreover, other technical means, such as virtual reality and augmented reality, are adopted to reappear cultural heritage, bringing new possibilities to the protection and recreation of cultural heritage.

However, cultural heritage protection still faces some problems in the AI realm. Firstly, the protection of cultural heritage requires digital technology, such as 3D screening and virtual reality. However, corresponding application systems, hardware and software equipment, and technology in China need to be developed and perfected. Secondly, several types of AI-related technology are involved in cultural heritage protection, yet few are applied and the actual technology levels are uneven. Hence, more efforts should be made in popularizing and mastering technical applications. Thirdly, AI-oriented realms are still developing rapidly and need a system that is upgraded, updated, optimized, and protected along with the times to achieve continuous improvement.

In summary, exploring traditional culture can enhance the deep integration of the "ancient" and the "modern." The practical transformation journey of cultural heritage, such as Ying Luo and Bi Chuan, under contemporary aesthetic standards, requires continuous exploration and experimentation.[5]

(2) Historical Value, Cultural Value, and Status Quo of Ying Luo and Bi Chuan

1. History and Evolution

Ying Luo and Bi Chuan are typically adornments worn by Bodhisattvas, and the term itself is a transliteration from Sanskrit. With the introduction and integration of Buddhism, these ornate ornaments were assimilated into Chinese culture.[6]

Ying Luo, also known as Hua Man, is a clothing accessory of the Han nationality. (Figure 1) It was commonly worn by women in the imperial court or by Buddhist figures, immortals, and heavenly maids in drawings, reflecting rich cultural connotations. In the long course of history, Ying Luo has gradually evolved into a cultural carrier with symbolic significance and become an important element of the imperial court culture and aesthetics.

Bi Chuan, is also known as Tiao Tuo. The one worn around the wrist is called Zhuo (bracelet), while that worn on the arm is named Chuan (armlet). Hence Chuan is also referred to as Bi Zhuo (armlet) and Bi Huan (armband). It can be worn by either men or women. As one of the earliest forms of ornaments, it changed from the simple copper style of the Han Dynasty and the exquisite gold and silver styles in the Tang and Song dynasties to diverse decoration styles in the Ming and Qing dynasties. Bi Chuan reflects the aesthetic interest and cultural characteristics of different eras and are critical components of ancient clothing cultures.



Figure 1. Agate and pure gold Ying Luo (Yuan Dynasty)

2. Cultural Value

Ying Luo and Bi Chuan could not only be worn in ancient life to symbolize the wearer's social status and family honor, but were also used as important accessories in everyday life. The auspicious patterns and lucky words engraved on Ying Luo symbolize virtues, love and feelings, belief, and protection, showing the wearer's ardent wish for and pursuit of a beautiful life, well-being, and good health. (Figure 2)



Figure 2. Yellow jade Bi Chuan (Western Han Dynasty)

3. Status Quo of Ying Luo and Bi Chuan

(1) The preservation of Ying Luo and Bi Chuan samples and data is dispersed. The Palace Museum holds 17 sets of multicolored Ying Luo from the Qianlong period; the Inner Mongolia Museum has Amber Ying Luo; the Capital Museum houses Shang dynasty gold Bi Chuan; the Anshun Museum contains bronze Bi Chuan of ethnic minorities; the Henan Museum possesses several Ming dynasty gold Bi Chuan; and the Shaanxi History Museum

keeps Tang dynasty gold and jade Bi Chuan. Currently, the preservation of these Ying Luo and Bi Chuan artifacts is fragmented, with data being relatively isolated. This dispersion and lack of integration complicate the compilation, analysis, and association of data across vertical categories, significantly hindering systematic protection and research efforts.

(2) The number of inheritors of traditional craftsmanship is dwindling, and the methods of transmission are limited. As fashion trends evolve, traditional culture is no longer the sole heritage young people are exposed to. The influx of diverse cultural influences poses significant challenges to the dissemination and preservation of traditional cultural heritage. Ceremonial necklaces and armlets, which require extensive learning, deep cultural understanding, and complex craftsmanship, face the risk of deterioration, loss, and oblivion in the fast-paced modern world.

(3) Abuse and arbitrary change in the dissemination process: Although the cultural heritage related to Ying Luo, Bi Chuan, and other clothing accessories have frequently appeared in court-based films and TV operas in recent years, abuse and arbitrary changes are not rare, which becomes a double-edged sword for disseminating and protecting such cultural heritage.

3 Application of AI Technology to Cultural Heritage Protection

Art and design disciplines have always been a complex relationship. It has been a symbiotic and evolving relationship with in the culture of technology.[7]Currently, explorations have been made in applying AI technology to protecting and preserving cultural heritage, including data gathering related to cultural heritage, digital management, online curation and dissemination, and many other aspects.

(1) Establishment of Digital Databases and Literature Digitalization

With the rapid development of AI technology, particularly the widespread adoption and application of large language models like ChatGPT, there has been a significant transformation in the integration of databases and artificial intelligence. Whether dealing with structured data in SQL traditional relational databases (RDBMS) through simplified CRUD operations, or handling semi-structured or unstructured data with more flexible data storage models like documents, key-value pairs, column families, and graphs in NoSQL databases, the enhancement and refinement provided by AI technology greatly improve the intelligence, adaptability, and user-friendliness of SQL databases. This enables them to better meet specific data needs and application goals within their respective use cases.

With the advent of the big data era and the rapid development of cloud computing technology, machine learning, which relies on large-scale model training and computation, and microsecond-level real-time intelligent decision systems, is reshaping the new generation of database infrastructure. This AI-driven approach can handle various complex and unknown scenarios effectively. With cloud deployment as the foundation, real-time stream computing as the mainstream, and hybrid cloud cluster architecture as the strategy, the open-source database NewSQL has emerged. The emergence of NewSQL is based on the concept of Lakehouse, encompassing both SQL and NoSQL big data models, aiming to eliminate data silos and ETL processes while unifying database collections. Simplifying the data engineering process, unified AI and BI can unlock the commercial value of all data, enabling data sharing and

coordination to achieve global availability of the cloud ecosystem. The development of AI-driven databases, through intelligent data (AI for Data), has enabled digital database intelligence in areas such as data quality, data governance, data lineage, metadata, semantics, as well as new data from analytics and AI. (Figure 3) [8]

The establishment of digital databases enables the recording and storage of a large number of cultural materials related to cultural heritage. Scattered historical literature, pictures, videos, and other related research findings are comprehensively and systematically arranged, gathered, classified, and stored to set up digital archives, providing comprehensive support for subsequent research, management, and protection of relevant cultural relics. The information includes but is not limited to the history, design, craftsmanship, usage and related stories of ceremonial necklaces and armlets.

The comprehensive and accurate information stored in databases allows for precise and flexible extraction. With the assistance of artificial intelligence in searching, cultural heritage such as Ying Luo and Bi Chuan can transcend geographical and language barriers, spreading to various parts of the world and promoting the recognition and respect of cultural diversity. Moreover, it can provide new creative inspiration and directions for cross-disciplinary artists who require it.

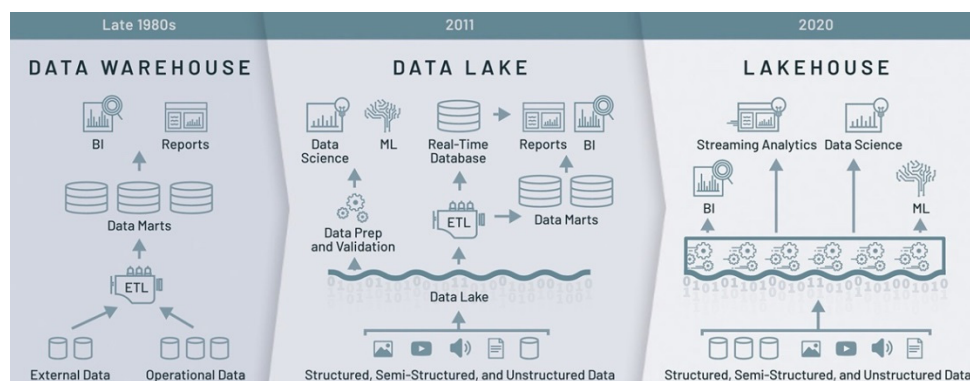


Figure 3. Evolution of data platform architectures to today's two-tier model (a-b) and the new Lakehouse model (c).[9]

(2) Application of 3D Scanning and Image AI Recognition Technology in Cultural Heritage Protection

Through 3D scanning, cultural heritage artifacts are transformed into corresponding point cloud models. Utilizing machine learning algorithms, the AI curve fitting technique accurately describes the size, shape, and position of objects by fitting the scanned discrete data points into continuous curves. (Figure 4) This enables the precise reconstruction of the three-dimensional details of Ying Luo and Bi Chuan.

Point cloud data and surface fitting three-dimensional scans typically generate a point cloud dataset ($\{P_i \mid i = 1, 2, \dots, N\}$), where each point (P_i) represents a three-dimensional coordinate point on the surface of Ying Luo and Bi Chuan. Applying surface fitting techniques, such as polynomial surface fitting, constructs continuous three-dimensional models: $[f(x, y) = \sum_{i=0}^n \sum_{j=0}^m a_{ij} x^i y^j]$. Here, $(f(x, y))$ is the fitting surface, and

(a_{ij}) is the fitting coefficient, which can be determined using the least squares method to minimize the error between the surface and the point cloud data.

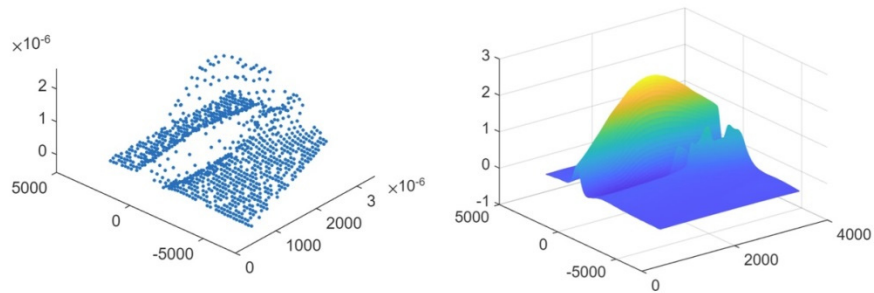


Figure 4. AI curve fitting technique

Through 3D scanning technology, cultural heritage artifacts are acquired as corresponding point cloud models. Following digital model construction and analysis through image recognition techniques, certain surface reconstruction algorithms (Alexa, 2001a; Carr, 2001a; Ohtake, 2003; Kazhdan, 2006) employ fitting methods to achieve noise reduction while obtaining smooth surfaces.[10] Subsequently, after normal adjustment, the high-precision details of Ying Luo and Bi Chuan are recognized and reproduced, enabling precise digital reconstruction and visual management of artifacts such as YingLuo and Bi Chuan. (Figure 5) This ensures accurate digitized presentation and long-term preservation.

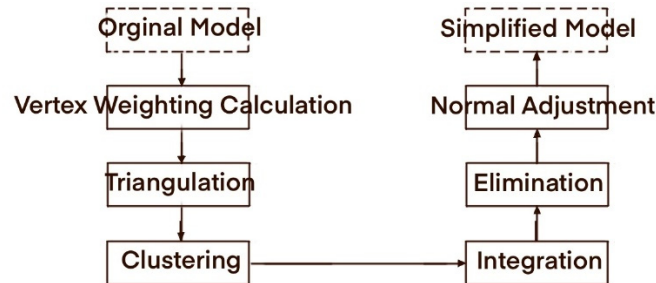


Figure 5. Simplification Process of 3D Scanning Models.

More specifically, AI technology is used to assist with recognizing and simulating the plans for repairing damaged or defective parts. In 2021, the Dunhuang Research Institute introduced Tencent Multimedia Laboratory's AI disease recognition technology to analyze data on the damage to Dunhuang murals. The system includes modules for image preprocessing, disease annotation, automatic restoration, image stitching, digital watermark embedding, query retrieval, and output display, achieving automated and efficient segmentation and identification of mural diseases. Meanwhile, Tencent provided immersive remote consultation technology, displaying cave interiors and artifact details in 4K ultra-high-definition 360-degree images, enabling barrier-free remote consultation on cultural relics. (Figure 6)



Figure 6. AI Tool for Identifying Mural Diseases (Source: Internet)

Beyond that, digitalized 3D models provide channels for disseminating Ying Luo and Bi Chuan culture. These models can be used in Digital Museums, online exhibitions, and education projects to enable more people to personally experience and learn the historical and cultural connotations of Ying Luo and Bi Chuan.

(3) Virtual Reality and AI Technology of Digital Museums

Virtual Reality (VR) technology utilizes computer simulation systems to replicate external environments, sensory devices, and perception, providing users with a multi-information, three-dimensional dynamic, and interactive simulation experience. Its three main characteristics are immersion, interactivity, and imagination, allowing individuals to explore and interact within digital environments as if they were physically present .(Figure 7)

VR technology is a synthesis of various techniques, including real-time 3D computer graphics (3D modeling and design, graphics rendering technologies such as OpenGL and Vulkan, programming languages such as C++ and JavaScript), wide-angle/wide-field stereoscopic display technology (stereoscopic glasses, active stereoscopic display, passive synchronized stereoscopic projection, 3D stereoscopic display technology), spatial audio,sensors (gyroscopes,accelerometers, magnetometers, etc.), and tracking technology (image recognition, object detection, SLAM), among others.

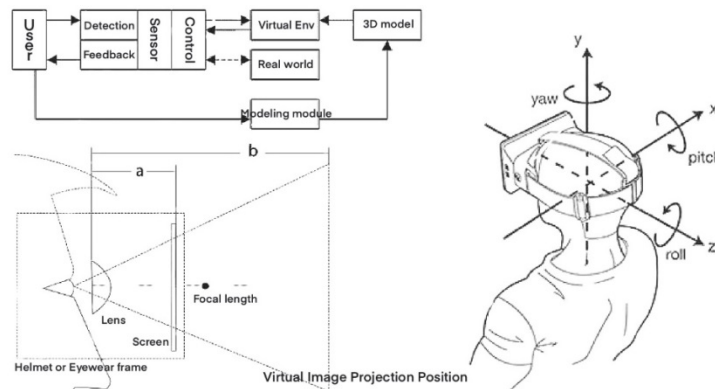


Figure 7.The foundational principles of VR technology.

Using VR technology to create a virtual palace environment, along with virtual replicas and scenes of Ying Luo and Bi Chuan, allows people to physically experience the appearance and wearing sensations of these artifacts, thereby enhancing their understanding of their historical and cultural significance. When combined with Augmented Reality (AR) technology, it further diversifies and enriches the virtual experience, enabling individuals to engage in interactive cultural displays and educational activities. Through virtual museums and online exhibitions, the historical and cultural significance of Ying Luo and Bi Chuan can be disseminated to audiences worldwide. Additionally, this provides scholars and cultural heritage experts with an important tool for researching and simulating the design and production processes of Ying Luo and Bi Chuan.

Virtual reality technology allows people to have immersive explorations and interactions in the digital environment, take the means and scenarios of wearing Ying Luo and Bi Chuan as examples. People can personally experience the appearances of Ying Luo and Bi Chuan, so as to better understand their historical and cultural values.

Thus, it can be seen that digital AI technology helps us better protect and inherit the cultural heritage of Ying Luo and Bi Chuan to continually display their important cultural values in modern society.

4 Application of AI Technology to Recreation Application of Ying Luo and Bi Chuan

(1) Characteristics of the modern creation of Ying Luo and Bi Chuan

Assisted by AI technology, AI image generation technology and intelligent algorithms can be used in the artistic creations and reappearances of Ying Luo and Bi Chuan to reappear and have derivative designs of their modeling and ornamentation, achieving the recreation and reconstruction of traditional art.

Meanwhile, AI technology helps to analyze and simulate the artistic styles and aesthetical characteristics of Ying Luo and Bi Chuan. Also, the diverse secondary creation of different modern cultures and styles provides artists with new creation inspiration and directions. In this way, the designs of Ying Luo and Bi Chuan have high artistic values and can complete the design creation and production manifestation more effectively.

(2) Cases for Applying AI Technology to Modernized Ying Luo and Bi Chuan Jewelry

1. Creation Thoughts: Based on referring to and extracting a large number of Ying Luo and Bi Chuan patterns from vast literature and cases, based on formal aesthetics, this study deconstructs the design elements of jewelry, extracts the primary elements, and uses them as the core to create an automated design generation system.[11] Keywords are input to retain the design styles and patterns of Ying Luo and Bi Chuan. Next, AI software and tools are used for derivative production and recreation. Efficient drawing output and effect representation enable creators to broaden their minds and assist with the implementation and completion of their creations and designs.

2. Pattern Analysis (Necklace Ornaments): ① Structure: Composed of U-shaped bead chains

combined with U-shaped short collars featuring pendants, as well as diagonally draped beaded necklaces. (Figure 8)



Figure 8. Bodhisattva from Cave 71 of the Early Tang Dynasty (left), Bodhisattva from Cave 26 of the Middle Tang Dynasty (center), Bodhisattva from Cave 158 of the Middle Tang Dynasty (right), and their sketch extractions.

②Patterns: Oval pendants, spiral designs, scroll motifs, and dot patterns. (Figure 9)

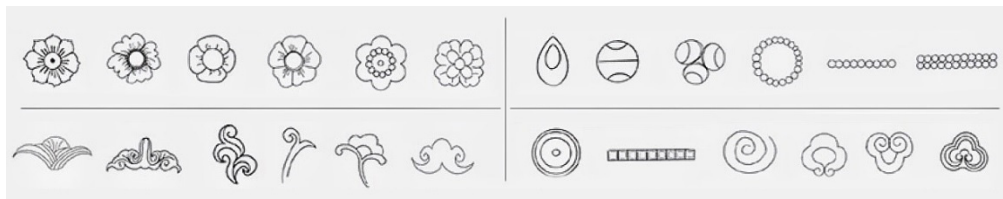


Figure 9. Ornament Patterns of Ying Luo and Bi Chuan.

3. Design instruments: Midjourney (Version 5.2). Midjourney is an AI drawing platform that can rapidly generate AI drawings and is open for public application. After referential pictures are uploaded or keywords are input, the AI algorithm rapidly generates relevant pictures through such functions as picture-generated picture, word-generated picture, and picture + word generated picture. Moreover, keywords are described to achieve distinctive artistic styles, such as Andy Warhol, Leonardo Da Vinci, Dali and Picasso. Lastly, specific shots or photography terms can be recognized to meet the creator’s creation needs.

4. Pattern Keywords :Stylize med,Public mode,Remix mode,High Variation Mode,Turbo mode.

5.Design procedures: ① Input/describe, import referential pictures, and generate four keywords; ② Upload referential pictures and copy links; ③ Input/ imagine, copy the links of the pictures in the prompt dialog box, and enter additional keyword: Buddhism,Dunhuang mural style jewelry; ④ Add the order of restoration “—iw 2” and press the return key to generate four keywords and referential pictures; ⑤Add the keywords through the v1~v4 commands according to the generated picture effect and have secondary generation until the satisfactory picture is generated; then execute the u1~u4 commands to optimize the quality of pictures. (Figures 10, Figures 11)



Figures 10. Ying Luo design drawings based on AI recreation



Figures 11. Design drawings of Bi Chuan generated by AI-based recreation

4. Production processes: 3D modeling and printing technology are used to achieve rapid conversion from numerals to material objects. Firstly, Rhino, Zbrush, and other modeling

software are used to convert design graphs from 2D versions into 3D structural data. Then, stereolithography and other 3D printing techniques are used to convert 3D structural data into highly accurate resin models. Afterward, roll-overs or lost-wax casting techniques are used to convert these models into silver, gold, and other rare metals. The seamless connection with traditional jewelry-making procedures greatly reduces the labor and cycles of the preliminary design and production. Meanwhile, digital modeling provides more accurate details for improving the product's quality with higher precision. (Figures12)



Figures12. 3D highly accurate resin models

5 Conclusions

(1) Status Quo

In the era of AI, digitalization, AI, and many other new technologies have been applied in the protection and redesign of cultural heritage, attaining noticeable achievements. Meanwhile, these technologies can effectively make up for the deficiency of protecting and inheriting traditional cultural heritage. On the other hand, a series of problems still exist, such as the imperfect cultural heritage protection system, uneven levels of digital technology application, and the need to develop and improve the understanding, operability, and depth of AI in fine cultures.

(2) Research Methods

Using literature review, technical theory learning, and case study, the paper systematically studies and deeply discusses the application of digitalization and AI technology to protecting and inheriting the Ying Luo and Bi Chuan culture.

(3) Research Objectives

Citing Ying Luo and Bi Chuan culture as two examples, this paper aims to demonstrate the capacity for protecting and recreating cultural heritage based on combining digitalization and AI in the era of AI. Meanwhile, it studies the degree and realization of converting the applied values of modernized jewelry, providing effective solutions and helpful references for the closed loop of protecting, inheriting, and transmitting China's traditional cultural heritage. Using cultural heritage to promote exchanges and mutual learning between Chinese civilization and other civilizations fosters cultural development, cultivates national spirit, enhances social governance and political development, and advances economic construction.[12]

(4) Suggestions

The paper proposes the following suggestions to solve the problems in cultural heritage protection in the era of AI: to improve the cultural heritage protection system and enhance the level of applying digital technology; to explore and study the redesign application of different cultural heritage; to deepen the international cooperation in heritage protection; In an environment where digital software and artificial intelligence are increasingly vital in artistic creation, inheritors of cultural heritage also need to adapt by continuously engaging with digitization and AI. Learning to use AI enables them to express themselves more efficiently, rather than being replaced by it.[13] Meanwhile, efforts should be made to facilitate the self-improvement and upgrading of digitalization and AI to protect and inherit cultural heritage, so as to attain the goal of cultural heritage protection and inheritance more conveniently.

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