

Research on the Protection Strategy of Weifang's Antique Copper Intangible Cultural Heritage Technology Enabled by Digital Technology

Lei Zhang*

Qingdao Binhai University, Qingdao, 266555, Shandong, China

**Corresponding author: Lei Zhang.*

Abstract

On the ancient bronze artifacts unearthed in Weifang, there are a large number of decorative patterns with distinct local styles, which are important visual records of local craft traditions. In the face of the outstanding problems exposed in the actual inheritance of such traditional skills at present-such as the scattered distribution of bronze pattern data, the difficulty of systematic access, the excessive emphasis on digital collection in the research work and the neglect of the production process and skill core, and the difficulty of the existing digital resources to truly transform into productivity that can be used for creative design, this study starts from the basic position of digital empowerment and transformation and innovation, combined with a number of practical application projects, and systematically sorts out the specific operation processes of a series of technical links such as three-dimensional scanning, photographic measurement, pattern vector reconstruction, immersive interactive experience, and cultural and creative development based on digital printing. On this basis, a three-layer progressive application path of "collection-communication-transformation" is built. The design of this path integrates the process ontology, inheritance people, digital platform and industrial subjects into the overall consideration. In the actual promotion, this article digitally restores the whole process of ancient bronze artifacts, covering high-precision collection modeling, extraction and classification of decorative symbols, visual translation and redesign of patterns, until the final development of printed cultural products. Through this complete chain, the digital data that was originally in the collection stage is gradually transformed into effective design assets that can be put into production and have market value. At the same time, this article also clearly divides the boundaries of the use of digital tools in process intervention to prevent the risk of alienation caused by excessive technical intervention. In the end, this set of methods provides a set of practical references with replication and promotion value for the digital preservation of traditional metal crafts, immersive visual communication, and the physical transformation of cultural and creative products.

Keywords

Weifang antique copper technology, digital empowerment, cultural and creative transformation

1. Introduction

With the continuous deepening of the digital construction of China's intangible cultural heritage, a number of technical means such as digital collection and 3D modeling have been gradually introduced to build a resource database covering the process, thereby promoting the integration and interaction between traditional

craft elements and the modern design industry. The 14th Five-Year Plan for the Protection of Intangible Cultural Heritage clearly states that projects related to the digital recording of intangible cultural heritage should be carried out, and the use of digital media technology should be encouraged to carry out innovative transformation of traditional crafts. This kind of policy orientation provides a clear development framework and action basis for the development and utilization of traditional craft image resources [1].

Weifang antique copper technology can be traced back to the Qing Dynasty. After more than a hundred years of inheritance and evolution, it has formed a complete technical system with lost wax casting, wax relief techniques, hand-carving and multi-layer chemical aging as the core, and thus derived a large number of exquisitely constructed and rich bronze decorative patterns. However, most of these high-quality pattern resources are still attached to physical artifacts, and the lack of standardized digital image materials limits their secondary use in the field of modern cultural and creative design and print development. The dissemination of this process has long relied mainly on offline exhibitions and antique trading channels. There is an obvious tendency to homogenize cultural and creative products, and the development progress of pattern resources is relatively lagging behind. The traditional master-apprentice system inheritance and static museum display methods make it difficult to fully unleash the design potential contained in ancient bronze patterns. The previously carried out digitalization work is mostly limited to the basic links such as photo archiving and three-dimensional scanning, and has not yet formed a complete implementation link from digital materials to physical cultural and creative products [2]. Based on the operation experience of actual projects, this article carries out a systematic practical discussion on the digital collection and processing of artifact patterns, immersive visual presentation, and the final transformation and application of printed cultural and creative products.

2. The Challenges in the Preservation of Weifang Antique Copper Technology and the Digitalization Dilemma

2.1 The Structural Crisis of Skill Inheritance

One of the outstanding problems facing Weifang antique copper technology in the inheritance is the obvious fault in the talent echelon. At present, the representative inheritance of mastering core skills has been high for many years. Its technology of restoring old patterns and making new decorations is highly dependent on personal experience and intuitive judgment. It has obvious implicit knowledge characteristics and is difficult to teach through standardized processes. The younger generation generally faces practical difficulties such as long learning cycles, large physical consumption, and limited short-term economic returns, and few people take the initiative to learn from art. A large number of operational essentials and judgment criteria that only exist in the minds of inheritors have not been systematically sorted out and recorded so far. At the same time, the existing resource records are also quite scattered, mostly photos or short video clips, lacking key contents such as complete process images, high-precision three-dimensional models of artifacts, historical information of inheritance, process parameter files, and tool atlas. These scattered materials are kept in the hands of individual inheritors, research institutions and museums respectively. They use different recording methods, lack of unified archiving standards, and the preservation conditions are uneven, and there is a risk of damage or loss of materials.

2.2 The Simplification of Communication Models and Digital Practices

In terms of communication, Weifang antique copper technology has long relied on traditional channels such as offline exhibitions and antique markets, and the degree of intervention in new media is not high. The communication content is mainly about the display of finished products, and rarely involves popular science interpretation of the production process, which is not easy to attract the attention of young audiences. What's more prominent is that the public often regards ancient bronze directly as "man-made imitations" and lacks further understanding of its artistic value and cultural connotation as an independent craft category.

In the current digital exploration, some workshops have tried to promote with the help of short videos, but most of them are still in the shallow stage of marketing and publicity, and have not carried out systematic digital collection of the process. These digital resources have not been effectively transformed into teaching materials, interactive exhibition content or cultural and creative design assets. At the same time, there are two

more extreme cognitive attitudes within the inheritance group. Some inheritors are worried that digital technology will weaken the original value of manual skills, so they are resistant to digitalization. The other part overly pursues large-scale production methods such as 3D printing, which dilutes the core characteristics of handicrafts themselves. There is a lack of effective connection between digital collection and industrial transformation. After scanning and modeling, relevant data are often put on hold, which fails to form a complete closed loop from digital resources to cultural and creative products.

2.3 The Systematic Deficiency in Digital Protection

From a deeper perspective, the digital protection of Weifang antique copper technology faces four systemic shortcomings. The first short board lies in heavy products and light technology. The existing digital materials are mostly developed around the final artifacts, and the records of dynamic core processes such as casting, carving, and layer-by-layer molding are seriously insufficient. Inheriting the experience, judgment basis, material ratio and a large amount of implicit knowledge in the population are almost not included in the scope of collection, resulting in the integrity of digital files but lack of substantive connotation. The second shortcoming is the convergence of technical schemes. Most non-heritage digital projects directly apply general shooting and modeling templates, and do not customize the collection process according to the high-temperature operation environment of metal casting, the complexity of the surface of the artifact, and the texture characteristics of surface rust. The cost of obtaining high-precision three-dimensional data is high, and it is difficult for a single inheritor to bear it independently. The third short board is that the data island problem is prominent. Inheritors, cultural and tourism institutions, and universities produce their own digital resources, and there is no unified archiving standard and a lack of sharing platforms. Digital achievements are often put on hold after completion. There is a lack of authorized use mechanism to serve teaching, exhibition and cultural and creative development, and it is difficult to transform the early investment into long-term inheritance value. The fourth shortcoming is the disconnection between protection and industry. Digital archiving, online communication and cultural and creative development have not yet formed a virtuous cycle. The most fundamental lack is the intermediate link of digital empowerment to industrial transformation. Digital assets have not really become design materials, virtual experience products or online course resources. It is difficult to establish a sustainable endogenous operation model, and long-term operation can only rely on external project funding.

3. Construction of a Digital Conservation System for Weifang Antique Copper Technology under a Digital Empowerment-oriented Approach

The digital protection work of Weifang antique copper technology mainly revolves around the three goals of storage, dissemination and transformation of digital resources, thus building a “three-layer and four-dimensional” protection structure. The three-layer structure is composed of the basic digital archive layer, the intermediate communication experience layer, and the innovation transformation and development layer of the upper layer, showing a trend of advancing from basic information accumulation to practical application step by step. The four dimensions correspond to the process ontology, inheritance people, digital platform and industrial ecology, which together constitute the core supporting elements of the whole protection system. The three layers follow the progressive logic of “collection-dissemination-empowering transformation”, and pay attention to supplementing practical operation cases in each layer, and strive to restore the complete path of digital resources from primitive artifacts to cultural and creative products step by step. The four dimensions run through each level, providing corresponding support for the work of each level.

3.1 First Layer: Emergency Digital Archiving—the Practical Data Collection Process for Decorative Digital Materials

Digital archives are the foundation for the promotion of digital empowerment and innovation transformation. In terms of collection concept, we adopt the comprehensive principle of “static objects, dynamic processes and oral historical materials”, and strive to retain the core information of the process as completely as possible. Weifang’s representative ancient bronze inlay artifact “curled pattern bronze vase” (Figure 1) is the specific collection object. The surface of the artifact is obviously curved and undulating, with weathered rust and mottled texture. Routine shooting is easy to produce reflections, resulting in the loss of

texture details. For this reason, this project jointly adopts two methods: 3D laser scanning and close-up photography: first, use a 3D laser scanner to conduct a 360-degree surround scan of the object to obtain the overall modeling and macro pattern; and then use photographic measurement equipment to partially reshoot the animal face pattern, cloud and thunder pattern and curly carving pattern of the bottle body. More than 280 to 350 multi-angle fine photos were taken for each artifact to make up for the lack of engraving line details in the scan. After the data acquisition is completed, the point cloud data is imported into the modeling software for noise reduction, splicing and grid repair to generate a high-precision three-dimensional model. Enter the metadata file synchronously, annotate the copy of the artifact, the engraving process, the old process and the information of the inheritor. For copper rust and stains attached to the surface of the model, they are treated by layered peeling in the software to extract the traditional bronze patterns attached to the curved surface of the artifact separately. Finally, image extraction, distortion correction and contour outline are carried out in turn, complete the vectorization processing, and output editable vector pattern files in AI and EPS formats, which can be directly used to create products and packaging design source files.

Figure 1: Antique-style bronze engraved artifact patterns

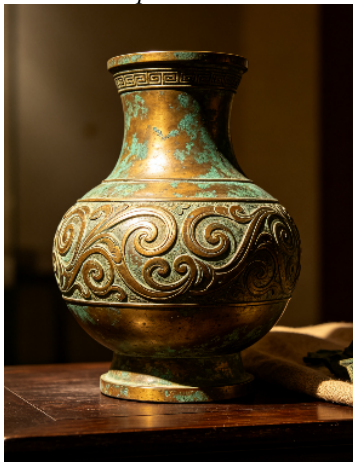


Figure 2: Cultural and creative products featuring antique bronze patterns



In terms of dynamic recording, in cooperation with the inheritor, the image of the complete process was collected on the spot, and the complete operation of key links such as sand casting, wax loss molding, manual carving and multi-layer chemical aging was recorded. At the same time, in-depth interviews were carried out with the inheritors, and the oral historical materials were systematically summarized. Convert experiential operating tips, copper ratio, experience in preparing old pharmaceutical preparations, and risk control points into searchable text and audio materials.

3.2 Second Layer: Digital Communication and Immersive Experiences—Implementation of Interactive Scenarios

Based on the three-dimensional models, vector patterns and process image materials produced by the digital resource library, a multi-level communication matrix is built to form a cognitive and experience channel for online and offline linkage. The chisel tools and old craft physical materials collected in the inheritance workshop will be disassembled and presented after editing and processing. On the short video platform, release a process deconstruction video with the theme of “How to chisel bronze patterns”, and cooperate with craftsman documentaries and pattern appreciation short films to form three types of content combinations [3]. The content adopts a dual-version layered push strategy: the popular science version weakens technical terms and focuses on interpreting the cultural connotation behind the animal face pattern and the Qilu scroll pattern, so as to reverse the public impression that “ancient bronze replicas are equivalent to forgery”; the professional in-depth version is aimed at art and craft enthusiasts, and fully displays the whole flow of lost wax casting. Strive to rebuild the artistic value recognition of the process in the professional circle.

During the implementation stage of digital communication, three-dimensional model displays of representative cultural relics such as “animal face vase” were added to the online virtual exhibition hall, and an AR interactive guide system was deployed offline in the intangible cultural heritage workshop. The

audience scanned the physical bronze artifacts with the help of mobile phones, and the screen presented the three-dimensional model disassembly animation, showing the complete process of mold molding, pattern carving and old processing in turn [4]. At the same time, a lightweight VR experience module has been developed. After wearing a simple VR device, users can simulate the basic operation of carving and polishing patterns, and actually feel the generation process of bronze patterns. This setting effectively lowers the cognitive threshold of the public's access to traditional skills, and also provides feasible conditions for the experiential dissemination of skills.

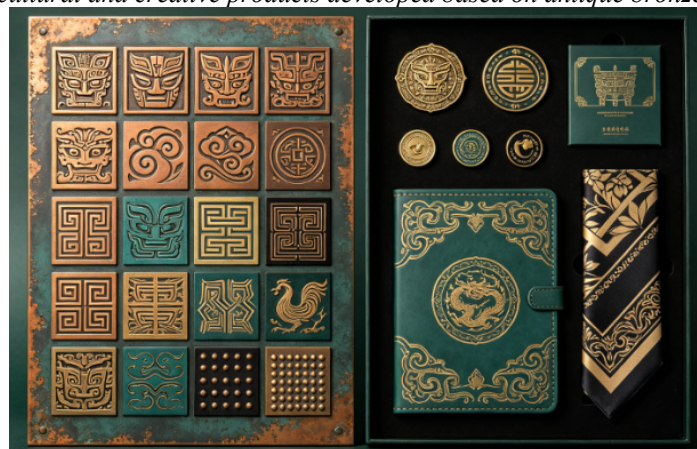
3.3 Third Layer: Digital Empowerment for Innovation Transformation—a Full-process Implementation from Digital Patterns to Printed Cultural and Creative Products

The foothold of digital protection is to promote the active inheritance and long-term continuation of traditional crafts. This level is at the core of the whole system. It focuses on converting digital resources into actual productivity and market revenue, and at the same time completely opening up the transformation chain from vector patterns to physical cultural and creative products.

Step 1: Carry out pattern screening and parameterization redesign. Select traditional patterns with distinct regional characteristics from the ancient bronze digital model library, such as beast face patterns, cloud and thunder patterns and Qilu scroll patterns. When redesigning, the composition logic of the original pattern, the decorative base and the aesthetic characteristics of Qilu technology should be retained, and the parameters should be adapted according to the size specifications and carrier materials of the target cultural and creative products. Take bookmarks and gift box packaging as an example. The bronze pattern on the original object is curved, which fits the curved surface of the copperware. If it is directly transferred to flat paper, it will stretch and deform. Therefore, designers need to make corresponding adjustments to the pattern proportion, line density and unit layout according to the vector source file, eliminate those structures that are too complicated and not suitable for modern printing technology, complete the flat reorganization of traditional patterns, and finally output typesetting documents suitable for paper carriers.

Step 2: Cross-carrier process adaptation output, printing text creation landing case. When implementing the transformation of printing cultural and creative products, according to different printing process standards, the flattened vector patterns are output as corresponding versions to complete the conversion from metalware table decorative patterns to modern paper visual language. Specifically for the bronze pattern series of paper cultural creations, such as bookmarks and gift boxes, it is necessary to layer the pattern and color positioning according to the requirements of printing production to generate silk-screen printing plate-making files. In the design, the beast face pattern is selected as the border decoration of the gift box, and the scroll pattern is used as the main picture of the bookmark. It is printed on special card paper by screen printing technology, and finally forms a set of molded cultural tourism gift boxes (Figure 3).

Figure 3: Printed cultural and creative products developed based on antique bronze decorative patterns



Throughout the process of cultural and creative development, the scope of intervention of digital tools in cultural and creative development is clearly defined. 3D models and AI vector patterns are limited to the early scheme conception and rendering production. If you want to produce copper solid derivatives, the processes

from pouring molding, pattern carving, and coloring to bronze greening, which reflect the core process of ancient bronze, are all handed over to craftsmen to complete by hand. Digital technology only plays an auxiliary role in the creative process and should not replace the core position of manual operation.

In the whole process of cultural and creative development, the scope of use of digital tools has been clearly limited: 3D models and AI vector patterns are only used for early scheme conception and rendering production. If copper solid derivative products are produced, from casting molding, pattern carving, coloring to bronze green appearance and other processes that reflect the core technology of ancient bronze, all are completed manually by non-genetic inheritors, and digital technology only acts as an auxiliary role and does not replace the manual process. At the same time, we will carry out supporting construction around the confirmation of digital assets and industrial cooperation, and use blockchain technology to carry out digital storage of 3D models and vector patterns to ensure that the digital copyright of the inheritor is effectively protected. On this basis, an authorized use mechanism for pattern resources is established, allowing cultural and creative enterprises to use the patterns in the resource library for commercial development according to the agreement, and distribute copyright income to the inheritors as agreed, so as to achieve benefit sharing [5]. In addition, digital literacy training is carried out for inheritors, so that they can master basic operations such as pattern preview and retrieval calls, so that inheritors can deeply participate in all aspects of digital transformation, and avoid the disconnection of “technology outsourcing and absence of craftsmen”.

4. Implementation Support Measures for Weifang Antique Copper Technology

4.1 Multi-party Collaborative Coordination Mechanism

In response to the dynamic inheritance needs of ancient bronze crafts, the local area has formed a multi-party cooperative operation mechanism, with the participation of the competent departments of culture and tourism, scientific research teams of colleges and universities, non-genetic inheritors and their workshops, museums and other subjects. The cultural and tourism department is responsible for policy coordination and financial security, and at the same time builds a resource docking platform; the college team undertakes technical research and development tasks, covering digital collection, database construction, pattern analysis and redesign and other links; the inheritor controls the process core and cultural connotation of the pattern; the workshop focuses on the trial production of cultural and creative samples, small-batch production and product incubation; museums provide offline digital display and public education services. The division of labor of each subject is clear and coordinated, and the whole process of collection, design, sampling to mass production is connected in series, breaking through the limitation of independent operation of a single subject.

4.2 Uphold the Authenticity of Craftsmanship and Prevent Technological Alienation

When carrying out digital practice, it is necessary to clearly distinguish between the two concepts of “digital recording” and “digital production”. Digital molding methods such as 3D printing can only be used as auxiliary proofing tools in the early stage, and cannot replace the core processes such as traditional casting, hand carving and old. The communication content should continue to highlight the humanity of the craftsman group and handicrafts, so as to avoid the wrong impression that “ancient bronze craft can be completely replaced by machines” [6]. The positioning of technologies such as digital collection, pattern reconstruction and artificial intelligence-assisted design has always been an auxiliary means to serve craft inheritance, not a substitute for the value of manual skills.

5. Conclusion

The key to the innovation and transformation of Weifang ancient copper technology with the help of digital empowerment is to fully present the whole process from data acquisition, processing, pattern redesign to printing output and cultural creation based on multiple actual projects. The digital practice framework of “three layers and four dimensions” is constructed, and the complete path of “acquisition-transmission-empowerment transformation” is formed. This path considers the four core elements of process ontology, inheritance group, digital platform and industrial ecology as a whole, and to a considerable extent responds to the current outstanding problems in the field of intangible cultural heritage digitization, such as “emphasis on collection and light application, emphasis on finished products and light process”. Facing the future development, it is

necessary to continuously improve the authorization and sharing mechanism of pattern materials in the digital resource library, and constantly optimize the whole chain workflow from physical scanning collection to printing product output. In particular, it is necessary to pay attention to improving the digital literacy of the inheritance group, so that it has stronger ability to use in practical operation and design application. Through these efforts, it is expected to promote the deeper integration of Weifang ancient bronze traditional pattern language and modern printing culture design, and also provide a set of practical reference paths for domestic similar traditional crafts in image archiving, pattern digital translation and cultural and creative derivative development.

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Conflicts of Interest

The authors declare no conflict of interest.

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