

Research on the Application of Digital Light and Shadow Technology in the Visualization of Husa Silverware Forging Skills of the Achang Ethnic Group

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Abstract: The Husa silverware forging skill of the Achang ethnic group is a provincial-level intangible cultural heritage in Yunnan. At present, it faces problems such as narrow dissemination scope and low recognition among young groups. Taking this skill as the research object, this paper extracts core craftsmanship and cultural symbols through 338 audience surveys and field visits, and constructs an intangible cultural heritage visualization communication system featuring "craftsmanship restoration - symbol visualization - scene immersion" by using digital light and shadow technologies such as light and shadow animation production and light and shadow scene modeling. Design practice is completed combining three scenarios: intangible cultural heritage inheritance hall, online platform and rural cultural tourism. Verification results indicate that 91% of young audiences are willing to share the visualized content, and the rural cultural tourism scenario has covered more than 500 tourists. The research shows that digital light and shadow technology can present intangible cultural heritage in a more intuitive and vivid form, effectively expand the dissemination scope, improve the acceptance of young groups, and provide a feasible path for the innovative communication of traditional skills of ethnic minorities.

1. Introduction

The state is promoting the strategy for the digital protection of intangible cultural heritage. Yunnan Provincial Department of Culture and Tourism has issued the Yunnan Development Report on Digital Protection of Intangible Cultural Heritage, clearly proposing the integrated communication path of "intangible cultural heritage + technology", which provides a good policy environment for the communication of traditional skills[1]. The Husa silverware forging skill has been handed down in Husa Township, Longchuan County, Dehong Prefecture since the Ming Dynasty, with a history of over 600 years. It was included in the list of Yunnan provincial intangible cultural heritage in 2022. Inherited in the form of family workshops, its products cover hundreds of ethnic ornaments, carrying the cultural memory and aesthetic pursuit of the Achang

ethnic group. At present, this skill relies on a single form of communication, mostly offline exhibitions and word-of-mouth, with its dissemination scope limited to western Yunnan. The recognition rate among young groups is less than 30%, and the communication power of its cultural symbols is gradually weakening.

There have been existing application cases of digital light and shadow technology in the visualization of intangible cultural heritage at home and abroad. Digital technology provides effective support for the visual communication of traditional crafts, but existing researches lack pertinence to the small-scale traditional skills of ethnic minorities, and the adaptability between technology and cultural communication needs to be improved[2]. Focusing on the application of digital light and shadow technology in the communication of Husa silverware forging skills, this paper constructs a visualization communication system adapted to multiple scenarios. Through field visits to 5 core silverware workshops in Husa Township and interviews with 3 provincial-level inheritors of intangible cultural heritage, this paper collects craftsmanship details and cultural background data. Combined with the "uses and gratifications" communication theory, this study aims to solve the practical dilemmas in the communication of this skill and expand its dissemination scope and influence.

2. Core Characteristics and Communication Needs of Husa Silverware Forging Skills

2.1 Analysis of Core Craftsmanship and Cultural Symbols

The Husa silverware forging involves multiple distinctive processes, including core steps such as silver melting, rough forging, carving, polishing and cleaning. In the silver melting stage, silver materials are melted into liquid state for shaping. Rough forging gives the silver materials basic forms through repeated hammering. Carving is the most distinctive process, where craftsmen hold special carving chisels to engrave patterns on the silverware surface. After polishing, the silverware presents a smooth and moist luster. The dynamic processes and manual texture of these procedures have strong value for visual communication.

The cultural symbols are rich and ethnic characteristic. In terms of patterns, there are auspicious designs like dragon and phoenix dancing, tiger roaring, as well as ethnic characteristic patterns such as Jingpo ethnic group's silver bubble patterns and geometric patterns, integrating cultural elements of the Achang and surrounding ethnic groups. Tool symbols include special iron hammers, carving chisels, melting furnaces and other traditional forging tools, with unique shapes adapted to craftsmanship needs. Folk scene symbols are reflected in the usage scenarios such as wedding silver ornaments and festival ritual vessels, carrying the folk cultural connotation of the Achang ethnic group. These distinctive cultural symbols are the core attraction in communication.

2.2 Practical Needs for Visual Communication

Based on the "uses and gratifications" theory[3], young groups nowadays are more receptive to digital information, while traditional communication methods are difficult to reach target audiences. The communication of intangible cultural heritage needs to break geographical and generational barriers. Different scenarios have different demands for communication content: the intangible cultural heritage inheritance hall requires professional and accurate exhibition content; online platforms need concise and shareable short video content; rural cultural tourism scenarios demand interactive and easy-to-understand forms. Targeted visual design can improve the breadth and depth of communication.

3. Adaptability and Communication Paths of Digital Light and Shadow Technology and Husa Silverware Forging Skills

3.1 Core Technical Characteristics and Adaptation Logic

3.1.1 Technical Characteristics and Adaptation Logic of Light and Shadow Animation Production

The production of light and shadow animation is based on After Effects software, with core technologies focusing on three modules: keyframe animation, expression control and effect plug-ins, to achieve precise adaptation to the dynamic communication needs of Husa silverware forging skills. Keyframe animation sets the timeline rhythm according to the 1:12 compression ratio of the actual craftsmanship duration. For example, the silver melting process, which actually takes 3 minutes, is condensed into 15 seconds in the animation, ensuring both information integrity and compliance with the fragmented viewing habits of audiences. By recording the morphological changes of silver materials from solid grayish-white to liquid bright white and the extension deformation trajectory of silver materials during hammering frame by frame, the dynamic characteristics of the craftsmanship are accurately restored. Expression control writes cycle functions for the repetitive actions in the carving process, controlling the vertical displacement range of carving chisels (3-5cm) and hammering frequency (2 times per second), simulating the uniform hammering rhythm of craftsmen, and avoiding action lag caused by manual keyframe setting. The effect plug-in Trapcode Particular is selected to create spark particle effects when silver materials melt, combined with the Optical Flares plug-in to simulate the light and shadow of furnace flames, with colors gradient from orange-red to yellow, enhancing the visual impact of the images[4].

The core of the adaptation between this technology and the skill lies in solving the pain point of "difficult to present dynamic details" in traditional communication. For the details that are hard to capture with the naked eye, such as the liquid flow state of silver materials during melting, the stress deformation of silver materials during forging, and the gradual formation of patterns during carving, the contact angle between carving chisels and silverware (30-45 °) and the pattern depth difference caused by hammering force (0.2-0.5mm) are clearly presented through slow motion and detail amplification functions. At the same time, lightweight craftsmanship annotations are embedded in the animation, such as "Carving requires uniform hammering force to avoid uneven pattern depth", which not only does not interfere with the visual experience, but also helps audiences understand the core of the craftsmanship. Surveys show that most young audiences feedback that "dynamic animations are easier to remember craftsmanship characteristics than static pictures", verifying the effectiveness of technical adaptation. To further improve communication adaptability, the animation also reserves multi-language subtitle interfaces, including Chinese, English and Dai languages, to adapt to the communication needs of multi-ethnic and multi-lingual audiences in border areas of Yunnan.

3.1.2 Technical Characteristics and Adaptation Logic of Light and Shadow Scene Modeling

Light and shadow scene modeling relies on C4D software, with core technologies of polygonal modeling, material rendering and lighting arrangement, to construct a virtual carrier adapted to scene-based communication. Polygonal modeling adopts the quadrilateral surface modeling method, restoring the traditional silverware workshop space in Husa Township at a 1:1 scale. The modeling accuracy of core tools reaches 0.1cm. Details such as the hammer marks on the surface of iron hammers and the radian of carving chisel edges are restored according to field measurement data. The number of modeling faces is controlled within 50,000 to 80,000 to balance model accuracy and

operation fluency. Material rendering adopts the Physical Render renderer, setting metallic materials for silver to restore the smooth and moist texture of handcrafted silverware; natural wood grain materials are used for wood tool racks; soil materials are adopted for walls, fitting the original environmental characteristics of rural workshops. Lighting arrangement adopts the three-point lighting method: the main light simulates natural light entering through windows; fill lights supplement the brightness of shadow areas; contour lights highlight the outlines of tools and silverware, combined with volume light effects to simulate light beams passing through window lattice, creating an immersive atmosphere.

The adaptive value of scene-based communication is reflected in three aspects. First, it restores the real communication context. Details such as the arrangement of tool racks in the workshop and the distance between the anvil and the melting furnace make audiences feel as if they are on the scene, enhancing the sense of substitution. Second, it adapts to the demand for multi-angle observation. The scene model supports 360-degree rotation, allowing audiences to switch different perspectives to clearly view the operating angle of craftsmen's hands during carving and the working state of the melting furnace, making up for the limitation of single perspective in traditional communication. Third, it strengthens the transmission of cultural atmosphere. By restoring details such as ethnic pattern fabrics hanging in the workshop and traditional farm tools in the corner, the living culture of the Achang ethnic group is indirectly conveyed, making the communication content more layered. In addition, the scene model also supports lightweight export, which can be embedded in WeChat mini-programs or H5 pages to realize online immersive browsing, breaking the geographical limitations of offline scenarios.

3.1.3 Technical Adaptation Principles

The application of technology strictly follows the dual principles of "prioritizing cultural authenticity and taking scene adaptation as the core". In terms of cultural authenticity, no exaggerated special effects are added in animation production, and the original environment of the workshop is not beautified in scene modeling. The usage traces on the surface of tools and the natural mottling of walls are retained to ensure that audiences receive authentic intangible cultural heritage information. Referring to the application specifications of digital light and shadow technology in traditional craft exhibitions, excessive digitalization is avoided to prevent the distortion of craftsmanship texture. In terms of scene adaptation, technical parameters are optimized according to the hardware conditions and audience needs of different communication scenarios[5].

3.2 Design of Specific Communication Paths

3.2.1 Visual Communication Path of Craftsmanship Process

The visualization of the craftsmanship process produces 12 core shot animations according to the core procedures, with each shot focusing on one craftsmanship highlight. The silver melting shot shows the process of silver materials changing from solid to liquid state; the rough forging shot presents the dynamic process of silver materials gradually taking shape; the carving shot highlights the characteristics of pattern engraving; the polishing shot displays the formation process of silverware luster. In animation production, keyframe animation, effect plug-ins and other technologies are used to enhance the visual impact of the images.

After the animation is completed, concise voice-over explanations and subtitles are added to form a three-dimensional visual communication form of "dynamic images + voice commentary + text subtitles", which is not only suitable for loop playback in the intangible cultural heritage inheritance hall, but also can be edited into short videos for communication on social platforms,

improving communication efficiency.

3.2.2 Visual Communication Path of Cultural Symbols

The visualization of cultural symbols constructs a three-level light and shadow model system of "patterns - tools - scenes" to realize the figurative communication of abstract symbols[6]. The pattern models select three types of core symbols: Jingpo silver bubble patterns, geometric patterns and dragon-phoenix patterns, which are built into three-dimensional models through C4D, added with metallic materials and light and shadow effects, supporting 360-degree rotation display; tool models are built at a 1:1 scale, added with usage trace details; scene models restore the usage scenarios and cultural atmosphere of silverware.

The three-level models are integrated and designed as a "symbol light and shadow wall", displayed on a transparent LED screen, allowing audiences to switch model types through touch interaction. Meanwhile, the models are made into downloadable digital materials for users to share and re-create on social platforms, expanding the dissemination scope of cultural symbols.

3.2.3 Integrated Communication Paths for Multiple Scenarios

In the intangible cultural heritage inheritance hall scenario, laser projectors are used to project three-dimensional scenes onto walls and floors to form an immersive space, combined with infrared sensor interaction technology, setting 3 induction areas. When audiences enter the areas, the light and shadow animations of corresponding procedures are automatically triggered. After interactive experience, audiences are more likely to take the initiative to spread the content.

In the online communication scenario, the visualized content is edited into 2-3 minute short videos, extracting core craftsmanship and characteristic cultural symbols, adding topic tags and communication copy, adapted to platforms such as Douyin and Kuaishou. Meanwhile, a series of graphic posters are produced for communication on platforms such as WeChat official accounts and Weibo, forming a multi-channel communication matrix.

In the rural cultural tourism scenario, movable projection stands are adopted, equipped with portable laser projectors, simplifying the interactive function to trigger process demonstrations by waving hands, facilitating tourists to quickly experience and shoot for sharing. By scanning the QR code to follow the official account, audiences can obtain complete visualized content, realizing the linkage between offline experience and online communication.

4. Design Practice and Effect Verification of Visual Communication for Husa Silverware Forging Skills

4.1 Design Practice Scheme

4.1.1 Scene-specific Design Details

Exhibition Version: 4K resolution, 24 frames per second, MOV video format, with a total duration of 8 minutes, including complete process animations, cultural symbol model displays and interactive scene demonstrations, supporting manual switching of shots and models.

Online Communication Version: 1080P resolution, 30 frames per second, MP4 video format, with a total duration of 2-3 minutes, extracting core craftsmanship and characteristic cultural symbols, highlighting dynamic visual effects and accelerating content rhythm.

Rural Cultural Tourism Version: The interactive design is simplified, using a portable laser projector with a brightness of 3000 lumens and a battery life of 4 hours, with an interactive response time of 0.2 seconds, supporting outdoor mobile display.

4.1.2 Technical Implementation Parameters

Light and Shadow Animation Production: The canvas size is set according to the resolution, with RGB color mode; the keyframe interpolation type is Bezier curve; the number of Trapcode Particular particles is 500 per frame, with a speed of 10-15px per second; the brightness of Optical Flares is 150, with colors gradient from orange-red to yellow.

Light and Shadow Scene Modeling: The model unit is centimeter, with a precision control of 0.1cm and a material sampling rate of 16x; the main light color temperature is 5500K with an intensity of 800cd; the fill light color temperature is 4500K with an intensity of 400cd; the contour light color temperature is 6000K with an intensity of 300cd; the infrared sensor induction distance is 0.5-3m, with a response time of 0.2 seconds, supporting simultaneous interaction of multiple people.

4.1.3 Implementation Process

To clearly present the project implementation process, this paper summarizes the stages, durations, and core tasks as shown in Table 1.

Table 1 Implementation Process

Stage	Duration	Core Tasks
Phase 1	2 weeks	Field research and data collection: Visit 5 core silverware workshops in Husa Township, record the visual characteristics of core craftsmanship and details of cultural symbols, shoot craftsmanship videos, collect physical photos of silverware, and measure tool specifications.
Phase 2	4 weeks	Digital content production: Use After Effects to make process animations, C4D to build scene and symbol models, and Premiere for post-editing and dubbing.
Phase 3	2 weeks	Interactive system construction: Purchase infrared sensor equipment and projection equipment, complete hardware installation and debugging, and realize the linkage between light and shadow content and interactive equipment.
Phase 4	1 week	Multi-scenario deployment and testing: Deploy equipment in the intangible cultural heritage inheritance hall and rural cultural tourism demonstration sites, launch online communication content simultaneously, and test equipment operation and preliminary communication effects.

4.2 Communication Effect Verification and Optimization

This survey covers 338 audiences, including 100 young groups, 200 cultural tourists and 38 intangible cultural heritage communication practitioners, with an effective recovery rate of 96.6%. Verification results indicate that the visualized communication form has outstanding performance in attractiveness and comprehensibility. 91% of young audiences are willing to share the visualized content, 89% of tourists say they can quickly understand the characteristics of the skill, and 86% of communication practitioners recognize the popularization potential of the scheme, but there is still room for optimization[7].

The improvement suggestions mainly include three aspects: first, at the content level, supplement 3 sets of re-creation material packages of cultural symbols, launch 3 series of online

short videos including craftsmanship highlights, symbol interpretation and scene experience, forming continuous communication; second, at the technical level, increase the brightness of the rural cultural tourism version projection equipment to 4000 lumens to adapt to outdoor light, and add subtitle special effects to the online communication version to highlight core information; third, at the communication channel level, cooperate with intangible cultural heritage bloggers to create promotional videos, set up check-in walls in exhibition scenarios, and encourage audiences to shoot and share.

The verification conclusion shows that the visual communication system based on digital light and shadow technology can effectively improve the communication effect of HUSA silverware forging skills, stimulate audiences' willingness to communicate, and provide a feasible practical scheme for the extensive communication of traditional skills of ethnic minorities.

5. Conclusion and Prospect

This study constructs a visual communication system for HUSA silverware forging skills based on light and shadow animation and scene modeling. Through the precise adaptation of technology and multiple scenarios, the core craftsmanship and cultural symbols are transformed into intuitive and vivid communication content. Practice shows that this system can effectively improve the attractiveness and coverage of intangible cultural heritage communication, break geographical and generational limitations, and its replicability can provide reference for the digital communication of similar traditional skills of ethnic minorities.

The deep integration of digital technology and intangible cultural heritage communication lies in balancing cultural authenticity and communication effects, presenting intangible cultural heritage in a form popular with audiences while retaining its core cultural connotation. In the future, we can further expand communication forms, develop virtual experience content combined with VR technology; deepen the interactivity of online communication, develop interactive mini-programs of intangible cultural heritage cultural symbols; strengthen cooperation with more communication platforms and bloggers to form a broader communication matrix, so that the traditional skills of ethnic minorities can be known and loved by more people, realizing the sustainable development of cultural communication.

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