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Towards Deep Experience in Living Heritage: A Study on the Digital Translation System for Cultural Genes of the Hexi Corridor

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Abstract: This study focuses on the predicament of living inheritance of intangible cultural heritage in the Hexi Corridor and proposes a new "deep experience"-oriented approach to digital translation. By analyzing the cultural gene connotations of multi-minzu integration in this region, a comprehensive methodological framework is constructed, spanning from gene extraction and digital representation to systematic translation. The research explores how to transform typical intangible cultural heritage projects into perceptible and interactive digital forms, and builds an immersive experience system with the aid of key technologies. Furthermore, it investigates sustainable inheritance mechanisms within the digital ecosystem, emphasizing that digital innovation must be rooted in cultural ontology, and advocates for the establishment of a diverse and collaborative co-creation network. The study aims to provide a practical solution that combines technological support and humanistic care for the preservation and development of intangible cultural heritage in contemporary times.

Keywords: Hexi Corridor; Intangible Cultural Heritage; Cultural Genes; Digital Translation; Deep Experience; Living Inheritance

1. Introduction

As a historical corridor of multi-minzu civilization convergence, the Hexi Corridor has nurtured diverse and profound intangible cultural heritage. These cultural treasures carry the collective memory and spiritual identity of local

communities, serving as living historical genes. However, under the impact of modernity, their inheritance commonly faces practical challenges such as a shrinking audience, fading cultural contexts, and rigid forms of expression. While digital technologies provide new tools for safeguarding intangible cultural



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heritage, current practices often remain limited to superficial documentation and static displays, failing to delve into its living essence or stimulate cultural resonance and deep engagement among the public, particularly the younger generation. Therefore, this study argues that the contemporary inheritance of intangible cultural heritage must move beyond "archival" preservation toward a living and sustainable approach centered on "deep experience." The key lies in regarding intangible cultural heritage as an organic "cultural living entity," interpreting and translating its intrinsic "cultural genes," and leveraging digital means to construct a new cultural context that is perceptible, interactive, and immersive. Focusing on the Hexi Corridor, this paper aims to explore a systematic digital translation framework and practical pathways, striving to revitalize the cultural vitality of intangible cultural heritage in digital spaces, safeguard its spiritual roots through innovative expressions, and provide theoretical references and practical solutions for its preservation and development in the digital era.

2. Research Background and Significance

Currently, the protection of intangible cultural heritage in the Hexi Corridor is at a critical turning point. On the one hand, the national "Cultural Digitalization" strategy and related policy advancements have created unprecedented opportunities for the inheritance of intangible cultural heritage, with technological conditions becoming increasingly mature. On the other hand, most existing practices remain limited to digital documentation and superficial displays, resulting in a disjointed relationship between culture and technology: digital applications often focus on formalistic technological presentations, yet struggle to penetrate the deeper core and cultural context of the living inheritance of intangible cultural heritage; while academic research emphasizes cultural value, it lacks effective pathways for translating it into experiential digital forms. This disconnection leads to digital outcomes that often remain superficial, failing to convey the emotional memory and artisanal essence embedded in intangible cultural heritage, resulting in low public engagement and limited effectiveness in inheritance.

Against this backdrop, this study holds clear practical value and theoretical significance. Practically,

it aims to provide a systematic methodology for the digital protection of intangible cultural heritage in the Hexi Corridor, spanning from cultural analysis to the construction of experiences. By bridging cultural genes and digital translation, it seeks to produce more impactful and participatory digital outcomes, directly contributing to the modern revitalization of intangible cultural heritage. Theoretically, the research attempts to transcend a purely technological application perspective, exploring a new paradigm of digital translation guided by deep experience and rooted in cultural heritage. It aims to provide a new analytical framework and an interdisciplinary foundation for understanding how the living inheritance and reproduction of meaning of intangible cultural heritage can be achieved in the digital era.

3. Digital Analysis Paths of the Intangible Cultural Heritage Cultural Genes in the Hexi Corridor

3.1 Connotation of Cultural Genes and Digital Decoding Methods

To understand the intangible cultural heritage (ICH) of the Hexi Corridor, we cannot merely stop at documenting their superficial forms. The key to achieving their in-depth digital inheritance lies in analyzing the core internal elements that, like genetic codes of life, define the cultural features and spiritual traits of the heritage. These elements can be referred to as "cultural genes". On the historical stage of the Hexi Corridor, cultural genes are the crystallization of the life wisdom, aesthetic concepts and spiritual beliefs of multiple minzu over the millennia. They are deeply embedded in the melodic transitions of a piece of Hua'er folk song, implied in the pattern collocations of a folk embroidery work, or embodied in the ethical narratives of a section of Baojuan storytelling and singing.

Digital decoding of these cultural genes is essentially a process of "understanding and translation", aiming to convert the tacit knowledge contained in craftsmanship, rituals and oral traditions into explicit data and logical relationships that can be recognized, analyzed and reconstructed by computers. This endeavor relies on technology, but more importantly, on humanistic insights.

Decoding starts with sophisticated on-site capture.

We adopt technologies such as 3D scanning, high-precision motion capture and spatial sound field recording not for simple archiving, but to capture the fleeting moments of artistic inspiration: the cadence and rhythm of a paper-cutter's scissor movements, the tacit understanding in eye contact and body positioning during the interactive performance of shehuo folk customs, or the seamless rhythmic connection between the reciter's singing, the beats of gongs and drums, and the movements of shadow puppets in a shadow puppetry show. These multi-dimensional raw data form the "raw materials" for decoding.

Subsequently, we move on to the more critical stage of rule extraction and knowledge modeling. Just as linguists analyze grammar, we need to interpret the "cultural grammar" underlying ICH phenomena. For example, in the folk songs of the Hexi Corridor, we analyze how their scales and modes are dually influenced by Persian music and the palace modes of the Central Plains; in the facial masks of local operas, we summarize the fixed character traits and fates represented by specific color and pattern combinations. By applying knowledge graph technology, we construct a structured relational network of basic elements such as patterns, sounds, movements and narrative units, as well as their combination rules, taboos and symbolic meanings. This network is the "digital atlas" of cultural genes, revealing the stable logical structure beneath cultural manifestations.

Finally, the extracted genes must be examined in the dynamic historical context. No cultural gene exists in isolation. By means of the Geographic Information System (GIS) and digital timelines, we overlay ICH projects with the historical layers of the Hexi Corridor, including the evolution of trade routes, minzu migrations, wars and marriage alliances. For instance, when examining an embroidery pattern, the database can simultaneously present its early form on Tuyuhun artifacts, its variant forms on Tubo textiles, and how it stabilized into its present style during the Ming and Qing dynasties. Such dynamic correlations reveal how cultural genes are inherited, mutated and integrated in the flow of time and space, thus decoding the essential attribute of Hexi culture as a "hybrid creation".

3.2 Gene Extraction of Typical Projects and Digital Representation of Multi-minzu Integration

To practice the above decoding methods, we select

representative ICH projects in the Hexi Corridor that fully embody the characteristics of multi-minzu integration for in-depth case analysis.

The gene extraction of Hexi Baojuan focuses on three levels: narrative ethics and structural genes form its spiritual core. The digital analysis work centers on dissecting its fixed formula of "combining storytelling and singing": how the prosaic "spoken narration" unfolds the story, and how the metrical "chanting" expresses emotions and deepens moral education. The core is to extract the enduring ethical paradigms such as upholding virtue and punishing vice, karma and reincarnation, as well as their recurring narrative models.

Genes of vocal performance formulas are related to its artistic appeal. Through meticulous musicological analysis, we decompose the melodic frameworks and rhythmic patterns of its commonly used tune patterns, and how the Baojuan reciter shapes characters and creates atmospheres through changes in timbre, volume and speed in different story sections.

Genes of community rituals and interaction form the foundation of its living inheritance. We record the fixed formulas and interjections chanted collectively by the audience at specific sections during Baojuan preaching activities, as well as the solemn or compassionate emotional atmosphere formed on site—these interaction modes are the key to the realization of its social functions.

For Liangzhou Gongguzi (a traditional drum dance in Liangzhou), the extraction of its digital genes focuses on three aspects: first, genes of movements and formation tactics. Through motion capture technology, we decompose and extract the dynamic curves, peak force values and rhythmic patterns of iconic dance moves such as "Eagle Spreading Its Wings" and "Steed Galloping"; we analyze the geometric transformation rules and group coordination logic followed by its formation tactics such as "Two Dragons Wagging Their Tails" and "Fighting Enemies at the Four Gates". Second, genes of sound and rhythm. We conduct precise analysis of the complex sequences of drum beat combinations (e.g., the urgent drum roll and the slow long beat), timbre changes (the differences between hitting the drum center and the drum edge), and their seamless correspondence with dance steps. Third, genes of spirit and imagery. Combining oral history and

local documents, we trace its possible connections with ancient military formation Nuo dances and Shaman sacrifices, and decode the collective spiritual imagery such as expedition, blessing and exorcism symbolized in its movements and formations.

The cultural genes embodied in Yugur costumes, especially the female headwear and ornaments, are concentrated in the visual symbol system and ecological wisdom. Ultra-high-definition digital collection not only preserves their physical forms, but also aims to interpret the deep semantic meaning of their color genes: red agate may be associated with the veneration of the Fire God, blue silk backgrounds may stem from the awe for the firmament, and white shell ornaments may retain the aesthetic memories of ancient grassland minzus.

The analysis of pattern genes reveals richer stories of cultural integration: the interlocking branch patterns on the plackets share the same origin with the art of the Central Plains, while some abstract geometric patterns have a genealogical connection with the patterns on Tibetan pulu woolen fabrics. Genes of shape and craftsmanship reflect adaptive wisdom: the loose robe design, the segmented structure facilitating riding, and the selection of materials such as fur and felt are all direct reflections of high-cold nomadic life.

Digital representation of multi-minzu integration is the key to animating these static cultural genes. We will build an Interactive Mapping Platform for Cultural Genes. When researchers or users click on a certain tune pattern melody of Hexi Baojuan, the platform can not only play the audio, but also display in parallel the singing of Liangzhou Xianxiao (a folk ballad) and even rhythm fragments of Dunhuang Bianwen (transformative texts) that may have origin or influence relationships with it in the form of voiceprint spectrograms, enabling comparison through visualized audio spectra. Similarly, when observing a Yungdrung symbol on Yugur headwear and ornaments, the platform can dynamically demonstrate on a map the possible transmission path of this symbol from ancient Zhangzhung to the Hexi Corridor via Tubo, and display its different variants on Tibetan jewelry and Mongolian horse harnesses.

4. Construction and Practice of a Digital Translation System for In-depth Experience

After completing the in-depth analysis of the cultural

genes of intangible cultural heritage (ICH) in the Hexi Corridor, the core challenge we face is how to reweave these structured "cultural source codes" into in-depth experiences that can arouse physical resonance, emotional engagement and cultural understanding. This means we must construct a brand-new digital translation system. Far from a mere display platform or database, this system should serve as a "Cultural Reconstruction Engine" that can comprehend cultural logic and create immersive meaning-making spaces accordingly. Its ultimate goal is to transform participants from passive onlookers into active embodied experiencers and co-creators of meaning in the digital context.

4.1 Core Framework and Principles of the Digital Translation System

Translation is neither literal replication nor unfettered fabrication. It requires the system to strictly take the decoded "cultural genes" as the inviolable blueprint—the so-called "cultural grammar"—whether they are the ethical structure of narratives, the formal rules of music, or the symbolic system of patterns. Within this constraint, the system encourages creative expression by leveraging the unique possibilities of digital media, such as time-space compression, perspective shift and perceptual extension. For example, in translating Hexi Baojuan, its narrative gene of "the combination of verse and prose" and ethical core of "upholding virtue and punishing vice" must be preserved, yet its presentation can evolve from the traditional form of "solo sitting recitation and singing" into a multi-threaded interactive narrative network that allows users to engage from the perspectives of different roles (the virtuous, the wicked, or the observing deities). A user's choices may influence the presentation order of the plot and the emotional tone, but all paths ultimately lead to the inherent ethical ending, enabling participants to deeply perceive the force of cultural discipline through interaction.

The emergence of in-depth experience relies on a multi-sensory, meaning-laden "context". The system's mission is to use digital technology to reconstruct a condensed, perceptible "fragment of the world". This contextual reconstruction should consist of three levels:

Physical context: For instance, reproducing the light, temperature, and the scents of leather and spices

inside a tent when Yugur women make headwear and ornaments;

Social context: For example, simulating the seating arrangement of community members gathering for a Baojuan recitation, the murmur of their whispered discussions, and the collective emotional fluctuations that ebb and flow with the plot;

Spiritual context: Such as implying the sacred atmosphere of a ritual or the invisible presence of ancestral spirits through visual metaphors and sound design.

Only when participants are placed in such a three-dimensional context filled with the "texture of life" and "spiritual ambiance" can cultural genes be truly "experienced" rather than merely "viewed".

The interactions designed by the system should not be simple interface operations like clicking and dragging, but elaborately crafted, culturally metaphorical "ritualized actions". The purpose of interaction is to guide participants to "discover" and "comprehend" cultural rules through their own operations. For example, in the digital translation experience of Yugur costumes, participants do not directly "put on" a pre-made digital costume; instead, they need to select and match elements from a "cultural color palette" and a "pattern gene bank" in accordance with specific rules (such as color symbolism, generational hierarchy and occasional taboos). If a participant mistakenly uses patterns symbolizing unmarried maidens for a simulated costume of an elderly woman, the system will not issue a blunt error message. Instead, it will prompt the participant through a sense of visual dissonance or a gentle correction from a digital "elder" (a piece of pre-recorded, wise oral narration). Through this trial-feedback-comprehension process, the social identity, age-based ethics and aesthetic norms behind the costumes are internalized as the participant's active cognition.

4.2 Translation Paths of the System and Integration of Key Technologies

The translation path begins with the semantic retrieval and dynamic assembly of the "Cultural Gene Bank". The system's back end is connected to the preliminarily constructed structured gene atlas. After an experience theme is set (e.g., "Sound Memories on the Silk Road"), the system intelligently extracts relevant gene clusters

from the atlas based on semantic relevance—these may include melodic fragment genes of Dunhuang musical scores, dialectical lyric genes of Hexi folk songs, and audio sample genes of camel caravan bells. Natural Language Processing (NLP) and knowledge graph technology work in deep collaboration here to ensure the system can comprehend the multi-layered relationships between the abstract concept of "sound memories" and these specific voiceprint and textual data.

Subsequently, these discrete genetic elements are not mechanically spliced together; instead, they are placed into a fundamental cultural context framework generated by game engines or real-time rendering technology in accordance with their inherent cultural logic (e.g., ritual occasions, emotional categories and geographical origins), completing the initial transformation from static data to a dynamic contextual embryo.

Key technologies then undergo in-depth integration around two goals: immersive generation and participatory deepening.

At the level of immersive generation, Virtual Reality (VR), high-fidelity spatial audio and wearable sensing devices work in synergy to construct an all-embracing sensory field for the body and mind. For example, in reconstructing the folk shehuo context at an ancient beacon tower site: VR head-mounted displays provide a 360° visual restoration of the historical scene; spatial audio technology precisely localizes the drum and music sounds, cheers of the crowd and howl of sand and wind coming from different directions, creating an authentic soundscape immersion; wearable devices can simulate the cold night air currents or vibrations that sync with the rhythm of drum beats. All parameters of these multi-sensory stimuli are driven and modulated by the back-end cultural gene models (e.g., the rhythmic patterns of shehuo performances and the emotional tones of specific occasions), ensuring the technical presentation has a clear cultural orientation.

At the level of participatory deepening, the system's interaction design collaborates seamlessly with the AI narrative engine. Interactions are designed as culturally metaphorical "action language": for example, in the Hexi Baojuan experience, users need to perform a series of ritualized virtual gestures such as "grinding cinnabar" and "unfolding a scripture scroll" to awaken

and advance the story. Every choice and action of the user is captured by real-time emotion computing and the narrative AI. Within the scope of the preset "cultural grammar" (i.e., the core narrative genes and ethical frameworks), the AI system dynamically adjusts plot details, non-player character (NPC) responses and even environmental ambiance, endowing the experience path with both individuality and cultural normativity.

Ultimately, based on the user's complete experience trajectory, the system generates a unique "digital token" (e.g., a melody "composed" by the user's behaviors, or a virtual embroidery piece integrating the patterns they selected). This extends the offline digital experience into a preservable and shareable mark of cultural identity, completing the closed loop of meaning generation.

5. Living Inheritance Mechanisms in the Digital Ecosystem

5.1 Balancing Digital Innovation and Cultural Roots

Any discussion of innovation in the field of cultural heritage must begin with a profound reverence for its roots. The relationship between digital innovation and cultural roots is not a mere one of technological application versus traditional materials, but a creative dialogue fraught with tension. True balance does not mean shackling innovation or confining tradition to stagnation; rather, it entails building an organic process where the two inspire and calibrate each other.

The cornerstone of such balance lies in transforming the inheritors—the artisans, elders and community members who master craftsmanship, comprehend rituals deeply and bear collective memories—from observed "objects" into the "interpreters and arbiters" of the entire digital process. Their role is not to passively provide materials, but to endow all digital creations with the fundamental "cultural legitimacy" and "meaning calibration". For example, the narrative core, character relationships and even key imagery of an immersive theater developed based on the creation myth of the Yugur minzu must undergo repeated deliberation and validation by authoritative narrators within the minzu. This validation is not a one-time approval, but a continuous dialogue throughout the creative process. Digital creators need to learn to listen to the inherent logic rooted in life and tradition, rather than crudely applying prevalent narrative templates.

Innovation only truly touches the cultural roots when digital works make the inheritors themselves feel that "this is indeed the spirit of our stories, even if told in a new way".

Conversely, the cultural roots safeguarded with rigor precisely provide the profound foundation and unique direction for the boldest innovations. The magic of digital technology should be harnessed to illuminate the "invisible" dimensions in daily inheritance: it can create a digital counterpoint between the melody of an ancient Hua'er folk song, the wind in the Qilian Mountains and the camel bell chimes of historical caravans, thus auralizing the deep connections between ballads and geography, as well as livelihoods; it can use dynamic data visualization to present how a traditional pattern has undergone subtle yet distinct evolutions over hundreds of years alongside tribal migrations and marital exchanges. Such innovation is not for technical showboating, but to provide a brand-new cognitive lens, enabling people—including the younger generation within the communities—to gain an unprecedented insight into and wonder at their own familiar culture. Hence, digital innovation ceases to be a threat to tradition and instead becomes a powerful medium that helps tradition achieve self-discovery and self-expression, allowing cultural roots to unfurl more rich and three-dimensional growth rings in the digital age.

5.2 Constructing a Collaborative Co-creation Digital Network for Living Inheritance

The essence of living inheritance lies in its sociality. If digital technology only produces isolated, exquisitely crafted cultural products, it will ultimately be fragile. Sustainable vitality stems from weaving a collaborative network that connects diverse stakeholders and fosters extensive participation. The goal of this network is to transform the digitalization of cultural heritage from a professional project led by a small number of institutions into a social practice of cultural rejuvenation.

The core of the network must be empowering local communities. This means technology needs to bend down to embrace daily life. Instead of designing complex and large-scale central systems, it is better to develop a series of lightweight, user-friendly and modular "digital toolkits"—for instance, enabling

embroidery artisans to conveniently build digital archives of their pattern works with the high-definition macro function of smart phones; providing storytelling artisans with simple audio processing applications to assist them in recording, annotating and sharing vocal segments. The purpose of these tools is to enhance the inheritors' own capabilities, making them the primary subjects of the digitalization of their own culture. At the same time, clear and equitable rules must be established to ensure that any value generated from these digital resources—whether academic influence, artistic prestige or commercial benefits—can be reciprocated to the communities and inheritors through sound mechanisms, forming a tangible positive cycle. Only when inheritors truly feel that digitalization is helping their craftsmanship be seen, understood and cherished by more people, and even improving their lives, will they embrace such changes from the bottom of their hearts, and the network will have its sturdiest nodes.

Around these solid nodes, various forces including museums, universities, tech enterprises, cultural institutions and media platforms can find their appropriate and irreplaceable roles. They should not be leaders, but rather servants, connectors and amplifiers. For example, university researchers can collaborate with inheritors to jointly complete the academic interpretation of cultural genes, providing in-depth nourishment for innovation; tech enterprises can iteratively develop more adaptive tools based on the actual needs of communities; museums can exhibit digital innovative achievements alongside traditional physical artifacts, elucidating the changes and continuities of culture through comparison; media platforms can tell the touching stories and human emotions behind these digital explorations. These roles interlock with one another, forming an ecosystem characterized by resource sharing, complementary capabilities and risk sharing.

6. Conclusion

This study takes the Hexi Corridor as the specific research context and explores a path for the digital living inheritance of intangible cultural heritage (ICH) oriented towards in-depth experience. It commences with the prudent analysis of cultural genes, then constructs a digital translation system that bridges

the traditional core and contemporary perceptual experiences, and ultimately focuses on building a sustainable digital inheritance ecosystem. The core proposition of this exploration is to demonstrate that the vitality of ICH in the digital age does not stem from rigid adherence to its external forms, but from our ability to creatively interpret and convey its inherent spiritual genes and cultural logic through the new language of media. Only when technology is rooted in the soil of humanistic spirit and integrated into an open social collaboration network can it truly become an enabler of cultural inheritance, allowing the ancient heritage to grow new branches in contemporary life—branches that both carry forward the cultural roots and embrace the future.

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