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The Digital Preservation and Ecological Reconstruction of Pipa Art from the Perspective of Cultural Ecology

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ABSTRACT

Against the backdrop of China's national digital strategy, the pipa art is undergoing an ecological transformation from "physical preservation" to "digital existence." Grounded in cultural ecology theory, this paper examines the ecological evolution and restructuring mechanisms of pipa art in the digital environment. The study reveals that while the pervasive integration of digital technologies has reshaped resource preservation and dissemination systems, it has also disrupted traditional ecological equilibrium, giving rise to structural crises such as "information silos," aesthetic alienation, and lagging industrial mechanisms. In response, the paper proposes establishing a new digital ecosystem characterized by synergy among technology, culture, and market: breaking down data barriers through interdisciplinary standardization, implementing targeted dissemination strategies to balance traffic dynamics with artistic essence, and fostering industry-academia-research collaboration to achieve a value closed-loop. The aim is to explore a dynamic inheritance pathway that preserves cultural heritage while adapting to the digital landscape.

Keywords: pipa art; cultural ecology; digital existence; ecological reconstruction; living inheritance

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1. Introduction

As a treasure of Chinese musical culture and a national intangible cultural heritage, the pipa art has developed a unique artistic style and rich cultural significance through over two millennia of historical evolution, serving as a vital vehicle for China's cultural soft power. Since the 18th National Congress of the Communist Party of China, the Party Central Committee with Comrade Xi Jinping at its core has placed high priority on intangible cultural heritage preservation. President Xi Jinping has repeatedly emphasized: "We must bring to life the cultural relics housed in museums, the heritage sites spread across the land, and the texts preserved in ancient books." During the 2024 National People's Congress sessions, the government work report explicitly called for "deepening the national cultural digitalization strategy, strengthening the protection and utilization of cultural relics and the preservation of intangible cultural heritage," while stressing the need to foster deep integration between culture and technology. These pivotal statements and policy directives have charted the course and provided robust momentum for the protection and development of pipa art in the new era.

However, with the acceleration of modernization and globalization coupled with rapid advancements in digital technologies, the cultural ecosystem of human society is undergoing unprecedented transformations. The digital revolution sweeping across the globe—through innovations like the internet, big data, artificial intelligence, and virtual reality—has fundamentally reshaped information dissemination methods, lifestyles, and patterns of cultural production and consumption. Against this sweeping historical backdrop, traditional pipa artistry faces dual challenges: existential survival pressures and rare developmental opportunities. The traditional master-apprentice "oral transmission and mental instruction" model has become constrained, while shifting aesthetic preferences among younger generations have left the cultural foundation of pipa art increasingly barren in modern society. Meanwhile, digital technologies—through their transcendent spatial-temporal dissemination capabilities, immersive experiential formats, and robust data processing power—are creating groundbreaking possibilities for the preservation, global outreach, and innovative evolution of pipa art.

This study introduces the Cultural Ecology theory proposed by American anthropologist J.H. Steward, conceptualizing pipa art as an organic cultural ecosystem in dynamic equilibrium with its environment—including natural settings, social contexts, and particularly the current digital landscape. Within this framework, pipa craftsmanship, inheritors, audiences, media platforms, and related industries form interdependent ecological components. The research examines how digitalization, as a dominant environmental factor, disrupts the traditional ecological balance of pipa art, triggers ecological chain restructuring, and explores pathways to establish a virtuous digital ecosystem for its living heritage preservation and sustainable development. This study not only investigates a specific intangible cultural heritage project but also provides valuable insights

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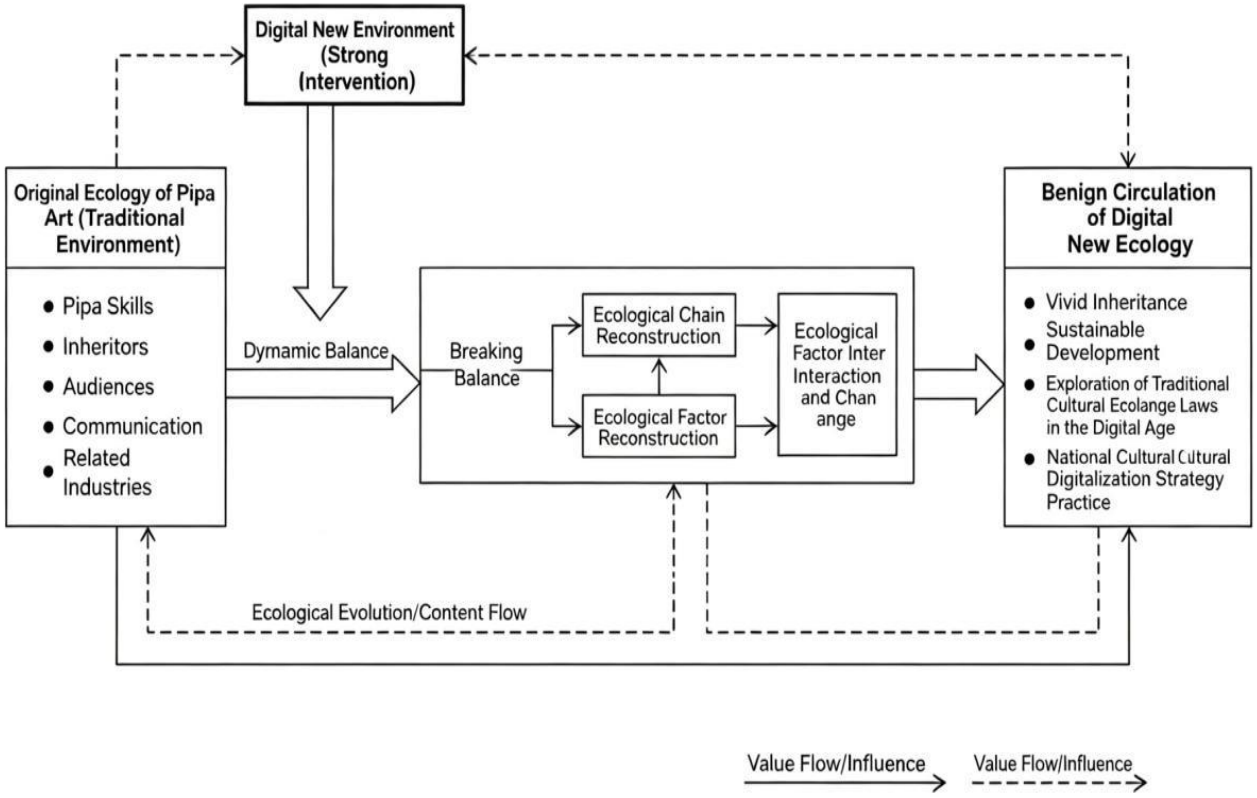
into traditional cultural ecological transformations in the digital era, serving as a proactive response and practical demonstration of China's national cultural digitalization strategy.

Figure 1: Mechanism Diagram of Digital Evolution and Ecological Reconstruction of Intangible Cultural Heritage Pipa Based on Cultural Ecology



2. The Current Status of Pipa Art's Ecological Adaptation in the Digital Environment

Under the strong influence of the new digital environment, the original ecological balance of pipa art has been disrupted, entering the 'evolution of ecological factor interactions' stage depicted in Figure 1. This stage is characterized primarily by the initial adaptation of three core factors—resources, dissemination, and industry—to the digital ecosystem.

2.1 The shortcomings in building an ecosystem for digitizing core technical resources are becoming increasingly apparent

From the perspective of cultural ecology, the core techniques and musical score literature of the pipa art form constitute its essential "cultural gene pool." As time passes and physical carriers

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naturally age, the pipa art must find new spaces for survival to sustain its vitality. Currently, digital technology has created a new "digital niche" for the pipa art, enabling its core resources to successfully transition and adapt from the physical to the digital environment.

This adaptation process is first manifested in the rescue-based preservation of endangered cultural resources. Historically, the transmission of significant schools such as the Pudong School relied heavily on paper musical scores and tapes—physical media vulnerable to damage and deterioration in natural environments. Leveraging the National Special Fund for Intangible Cultural Heritage Protection, digital scanning and restoration technologies have established a stable "digital storage space." For instance, precious rare editions like the *Jushi Lin Pipa Score* have been digitally restored through high-precision scanning, ensuring the integrity and security of these cultural treasures.

Deeper adaptation is manifested in the documentation of tacit knowledge. The traditional "oral and mental transmission" approach is often constrained by the inheritor's physical capabilities and geographical distance. The integration of motion capture and 3D modeling technologies enables precise recording of the inheritor's millisecond-level finger movements and body postures. This technological approach overcomes physiological limitations, transforming those "physical memories" that are difficult to fully articulate into quantifiable and reproducible data assets. Such digital transformation at the genetic level not only mitigates the risk of extinction in natural environments but also lays a solid foundation for the survival and development of pipa art in the information age, establishing its central role in the digital landscape.

2.2 Expansion of the Symbiotic Network in the Communication Community

The digital environment has fundamentally transformed the dissemination of pipa art, shifting it from the traditional, closed "master-apprentice inheritance" and offline theater performances to an open "omni-media matrix" communication network. This expanded dissemination framework has significantly enhanced the circulation efficiency of pipa culture and facilitated its extensive integration with modern mass media.

In this new ecosystem, algorithmic recommendation mechanisms serve as an efficient intermediary, reshaping the way art interacts with its audience. Short-video platforms like TikTok and Bilibili leverage big data technology to accurately profile users and deliver tailored content. Take Chinese music maestro Fang Jinlong as an example: during the Bilibili "Most Beautiful Night" New Year's Eve gala, he used the pipa to mimic the tones of electric guitars, Western pop instruments, and even Indian musical instruments. This 11-minute "cross-genre musical performance" video quickly amassed over 15 million views, with interactive bullet-screen comments exceeding 200,000. This communication strategy—combining "masterful

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craftsmanship with playful humor" —effectively broke down the cultural barriers associated with traditional Chinese music's perceived "elegance," enabling classic pieces like "Ten-Faced Ambush" to reach Generation Z in a more digitally resonant format.

Meanwhile, the application of VR and AR technologies has created immersive "virtual experience spaces," transforming the relationship between audiences and performers. Taking the Central Conservatory of Music's "Digital Museum of Pipa Art" as an example, this platform not only recreates historical performance settings but also employs technical means to deeply analyze musical structures, enabling audiences to gain an experience that surpasses that of live attendance. This digital connection breaks down geographical and cultural barriers, allowing the pipa—a cultural symbol—to transcend physical constraints and facilitate efficient cross-cultural exchange worldwide. The establishment of this new communication network signifies that pipa art has successfully adapted to the complex environment of globalization and digitalization, significantly enhancing its social influence and cultural reach.

2.3 Cross-boundary Integration of Artistic Forms and Industrial Restructuring

In cultural ecosystems, sustained economic value flow is crucial for maintaining system vitality. Digital technologies have not only transformed the survival paradigm of pipa art but also optimized its mechanism for deriving economic benefits from external environments by restructuring industrial value chains, thereby achieving an evolution from pure reliance on public welfare protection to acquiring "self-sustaining" capabilities.

The widespread adoption of digital music production technology has broken down barriers between different cultural forms, fostering a mutually beneficial symbiosis between pipa art and other popular cultures. For instance, in phenomenon-level games like Genshin Impact, the deep integration of pipa elements with anime and manga culture not only preserves its traditional characteristics but also leverages the game's massive user base to generate substantial traffic and attention. This cross-cultural integration strategy has successfully transformed the attention of younger audiences into tangible cultural consumption.

More crucially, the integration of blockchain and NFT technologies has opened up entirely new monetization channels for pipa art. By issuing digital collectibles and virtual musical instrument merchandise, pipa art has established a comprehensive digital industrial chain encompassing "creation—dissemination—transaction." This mechanism addresses the longstanding challenges of rights confirmation and monetization for traditional intangible cultural heritage products, enabling cultural value to be efficiently converted into economic value while further supporting artistic creation and preservation. From online concert ticket revenues to copyright income from digital cultural products, diversified revenue streams are emerging. This virtuous commercial

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cycle demonstrates the pipa art's strong adaptability and development potential in the digital business environment, providing a continuous internal driving force for its sustainable growth.

3. Ecological Imbalance Crisis of Pipa Art in Digital Evolution

As shown in Figure 1, the aggressive intervention of the digital environment has disrupted the original dynamic equilibrium of pipa art. Although the system is evolving toward a "new digital ecosystem," during the processes of "interactional changes among ecological factors" and "reconstruction of the ecological chain," it has exhibited pronounced negative feedback regulation due to failures in the integration of technology and culture. This chapter will conduct an in-depth analysis of the pathological manifestations inherent in this reconstruction process—the imbalance crisis arising during the system's adaptation.

3.1 The fragmentation of digital habitats creates barriers

Although the pipa art has initially established a digital presence, the current digital environment exhibits pronounced fragmentation, hindering interoperability within the system. Due to the absence of unified top-level planning, various stakeholders often operate in silos when developing digital platforms, resulting in numerous incompatible, isolated components.

This fragmentation is primarily manifested in the chaos of data standards and closed interfaces. When establishing the pipa art database, universities, museums, and research institutions adopted varying audio sampling rates, video resolutions, and data recording protocols. These technical barriers hinder the free flow and sharing of data resources across platforms, creating a typical "information silo" effect. This significantly reduces the system's overall efficiency, leaving the vast amount of collected data confined to a basic storage stage and preventing its integration into knowledge assets with substantial research value.

Furthermore, disciplinary barriers have exacerbated this divide. Current digital preservation efforts are predominantly led by art disciplines, lacking deep integration with STEM fields such as computer science and information management. This results in difficulties in implementing advanced functionalities like data mining and knowledge mapping. Such physical and conceptual barriers not only lead to redundant waste of valuable resources but also hinder the development of pipa art in digital spaces. Consequently, digital preservation efforts often remain superficial, failing to establish an organic, unified, and sustainable ecosystem for healthy development.

3.2 Adaptive Alienation of Cultural Species

In adapting to digital traffic logic, pipa art is facing the risk of "alienation." To compete for attention in the highly competitive online environment, some disseminated content has shown a

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tendency to excessively cater to audiences at the expense of artistic integrity, thereby threatening the purity of pipa art.

In the digital age, audiences often prefer information that is "short, straightforward, and fast-paced" with high sensory stimulation—a tendency that inherently conflicts with the traditional principles of pipa art, which emphasize "elegance, restraint, and artistic conception." Guided by algorithmic recommendation systems and driven by the pursuit of click-through rates and attention, some creators overemphasize visual spectacle and entertainment effects in their digital presentations, resulting in performances that become vulgar and fast-food-like. This context-free dissemination strategy often strips pipa art of its deep cultural roots—such as literati gatherings or folk traditions—and reduces it to mere auditory symbols or even mere entertainment gimmicks.

For example, in some cross-disciplinary performances that rely excessively on electronic effects, the technology overshadows the instrument itself, masking the pipa's inherently delicate timbre and sophisticated techniques. Over time, audiences are exposed to a distorted "pseudo-pipa culture," leading to misconceptions. Such excessive catering to short-term popularity essentially dilutes the core cultural essence of pipa art, undermines the "authenticity" of intangible cultural heritage, and leaves this traditional art facing a crisis of being "formal but devoid of spirit."

3.3 Energy Stagnation in the Industrial Ecosystem Chain

Although digitalization demonstrates the potential for industrialization, the digital industrial chain of pipa art still exhibits severe "bottlenecks" in practical operations. The lag in market mechanisms and insufficient talent reserves result in the inability of the entire system to form an efficient commercial closed loop, thereby limiting its capacity for "self-sustaining development."

From the perspective of market mechanisms, current digital promotion strategies have not fully established the critical pathway for transforming "cultural value" into "economic value." Many digital projects remain public welfare initiatives reliant on government funding, lacking mature business models aligned with market principles. Meanwhile, due to inadequate copyright protection mechanisms in the digital environment, low-cost replication and infringement activities are rampant, severely infringing upon the rights of creators and cultural heritage bearers and hindering the flow of economic benefits back to the production sector. This one-way model of "investment without returns" makes it difficult for the industrial ecosystem to maintain long-term dynamic equilibrium.

In terms of talent, a severe gap has emerged between veteran and younger inheritors. The older generation possesses core artistic skills but faces a "digital divide," struggling to effectively utilize new media tools; whereas the younger generation, though proficient in digital technology,

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often fails to inherit profound cultural literacy through rapid digital education, easily falling into the trap of "emphasizing technology over cultural depth." This imbalance in talent structure results in a lack of "multi-skilled professionals" who are both artistically and technologically competent within the industry, causing the digital development of pipa art to remain at a low level and failing to generate robust, sustainable growth momentum.

4. Strategies for Constructing a Digital Ecosystem for Collaborative Evolution of Pipa Art

In response to the aforementioned imbalance, this chapter proposes establishing a 'synergistic evolution' mechanism aimed at restoring fragmented habitats, conserving species genes, and optimizing energy flows, thereby driving the system toward the 'virtuous cycle of a digitalized new ecosystem' depicted at the endpoint in Figure 1.

4.1 Standardized Construction of Connected Digital Habitats

To address the current issue of "fragmentation" in digital resources, the key solution lies in breaking down barriers and establishing a unified, interoperable "integrated digital platform." This requires top-level design at the national level, involving the adoption of standardized technical languages and management protocols to consolidate dispersed resources and enable seamless data flow.

Specifically, the cultural authorities should take the lead in collaborating with research institutions and technology enterprises to establish a unified standard system for the digital preservation of pipa art. This system should encompass comprehensive specifications covering the entire process—from data collection parameters such as sampling rates and storage formats to classification and retrieval mechanisms—ensuring compatibility and interoperability among data from diverse sources within a unified framework. Building on this foundation, it is recommended to draw on the proven experience of the "Digital Dunhuang" resource repository and leverage cloud computing technologies to develop the "China Pipa Art Cloud Platform."

For instance, establishing unified standards for audio sampling (e.g., no lower than 96kHz/24-bit) and musical notation formats (such as adopting MusicXML standards), while integrating geographically dispersed databases into a centralized hub to achieve "distributed storage with centralized management." This connectivity will completely eliminate "information silos," enabling researchers and the public to analyze the developmental patterns of pipa art through big data perspectives. Simultaneously, it is essential to break down disciplinary barriers, establish interdisciplinary collaboration mechanisms, and leverage advanced technologies like artificial intelligence and knowledge graphs for in-depth data mining. By creating an open, shared, and intelligent digital ecosystem, we can provide pipa art with a resource-rich and efficient operational foundation, transforming digital resources into a powerful catalyst for academic

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advancement and societal dissemination.

4.2 Authentic Conservation of Cultural Species Genes

In addressing the potential risk of "alienation" during digitalization, the core of preservation efforts lies in establishing a "authenticity protection mechanism" to ensure that the pipa art retains its essential cultural heritage throughout its evolution. This requires us to uphold the principle that "technology serves content" while leveraging technological means to expand its reach, thereby preventing a decline in artistic quality due to excessive adaptation to environmental pressures.

Specifically, a tiered protection strategy should be implemented. At the mass communication level, moderate formal innovation and cross-sector integration may be permitted to sustain public interest, but a "cultural baseline" must be established. For instance, technologies such as VR/AR can be employed to recreate historical settings of pipa art, guiding audiences to grasp its underlying aesthetic essence through immersive experiences rather than merely providing superficial sensory stimulation.

At the core of heritage preservation, it is essential to establish a high-fidelity digital repository. Digital technologies should be employed to comprehensively and accurately document the traditional techniques and repertoire of various schools, preserving their original characteristics without embellishment. Additionally, an academic review and evaluation mechanism for digital content must be established, involving intangible cultural heritage experts to vet disseminated materials and eliminate "substandard content" that severely distorts historical facts or exhibits vulgar content. By combining this strategy of "differentiated development" with "core protection," the vitality of the art form can be sustained in the digital environment while safeguarding the essence of pipa artistry. This ensures its unique artistic charm and cultural significance are not eroded by the flood of online traffic, achieving a balance between "living inheritance" and "authentic preservation."

4.3 Mechanism for Optimizing the Energy Cycle in Industrial Ecosystems

To address the "clogging" issues in industrial development, it is essential to promote institutional innovation and talent cultivation to unblock all links in the value chain, thereby establishing a virtuous cycle system of collaboration among industry, academia, research, and application. This aims to enhance the competitiveness and operational efficiency of pipa art in the digital market economy environment, achieving sustainable development.

First, it is essential to enhance the legal and technological frameworks for digital copyright protection. By leveraging blockchain technology to establish an immutable rights confirmation

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and transaction system, we can rigorously combat infringement and ensure that economic benefits are accurately returned to rights holders and creators, thereby fostering sustained production of high-quality content.

Secondly, it is essential to actively explore diversified business models, foster the growth of innovative formats such as "cloud performance + e-commerce" and "IP licensing + brand collaborations," develop digital cultural and creative products as well as online education services tailored to modern consumption habits, and broaden revenue streams.

In talent cultivation, it is essential to reform the existing model and focus on nurturing "interdisciplinary" talents proficient in both art and technology. Through collaborative training programs between universities and digital enterprises, inheritors can acquire digital media literacy, while technical professionals gain an understanding of the essence of pipa art, thereby bridging the "digital divide" and "cultural gap." Such comprehensive adjustments establish a closed-loop pathway—from cultural resources to industrial capital and back to cultural preservation—fostering a virtuous cycle where "culture drives industry and industry enriches culture." This enables pipa art to truly develop the self-sustaining capacity to thrive independently in the modern digital society.

5. Conclusion

Drawing on the theoretical framework of cultural ecology, this study systematically examines the survival dynamics and evolutionary logic of pipa art in the digital age. Research reveals that digitization serves not only as a technical tool for preserving pipa art but also as a transformative environmental force that fundamentally reshapes its survival mechanisms. Through digital archiving of core resources, symbiotic expansion of dissemination networks, and cross-sector industrial integration, pipa art has actively constructed a new digital ecosystem, demonstrating remarkable adaptability and enduring vitality.

However, this ecological transformation is far from smooth. The fragmentation of digital ecosystems, cultural alienation driven by traffic-driven logic, and energy stagnation within industrial cycles constitute the primary characteristics of current ecosystem imbalance, posing threats to the sustainable development of pipa art. To address these challenges, we must transcend mere technical applications and focus on building a holistically coordinated digital ecosystem. By standardizing infrastructure to integrate ecosystem components, upholding authenticity principles to preserve cultural genes, and optimizing energy flows across industrial value chains, we can achieve dynamic equilibrium between technological environments and cultural heritage. Only by establishing a positive ecological interaction mechanism between "protection" and "innovation," as well as "inheritance" and "dissemination," can the millennia-

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old pipa's legacy undergo dynamic evolution in the new era of digital civilization, realizing a fundamental transition from "static heritage" to "living culture."

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