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AIGC empowers the interactive narrative logic and immersive aesthetic paradigms of chinese opera films and television

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Abstract: Opera film serves as both a significant medium for promoting Chinese opera culture and a vital pathway for realizing its contemporary expression. It carries the mission of preserving the theatrical heritage while driving the modern transformation of opera art. The empowerment of Generative Artificial Intelligence (AIGC) has fundamentally expanded the narrative grammar and expressive dimensions of opera. Through virtual production and interactive imaging technologies, it transforms the traditional one-way viewing of stage performances into an immersive aesthetic experience, endowing the ancient art form with new contemporary significance and aesthetic tension. While adhering to the aesthetic core of opera's *Four Skills and Five Methods*, this study selects the classic Sichuan Opera *The Story of the Colored Tower* from the *Eight Great Plays* as the core empirical object. It explores how to leverage digital media methods to overcome communication barriers while maintaining the aesthetic essence of opera, investigating an innovative breakthrough path for Chinese opera films to evolve from *stage documentation* towards *cinematic re-creation*.

Keywords: Generative Artificial Intelligence; Traditional Chinese Opera Film and Television; Sichuan Opera; Digital Technology

1. Introduction

The evolution of Chinese opera film and television is essentially a process of dynamic adaptation between technology and art. From *Dingjun Mountain* (1905) to digital virtual-real integration, media technological advances have continuously restructured opera's communication modes. For a long time, opera film has been constrained by the dual paradox of documentation and creation: realistic cinematic settings erode opera's stylized aesthetics, while simplistic stage recordings cannot satisfy modern audiovisual expectations^[1]. Unlike conventional CG mechanical modeling, AIGC based on large-model generative mechanisms can capture imagery and style, exhibiting topological resonance with traditional Chinese aesthetic concepts such as likeness in unlikeness and vital rhythm. AIGC has evolved from a production tool to a co-creative agent, reconstructing the improvisational logic of opera and innovating its narrative discourse^[2].

2. Bottlenecks and Challenges in Traditional Opera Film and Television Production

For a long time, Chinese opera film and television has faced persistent difficulties in the inter medial transformation from stage art to screen art. These challenges are not only manifested at the level of production technology but are also deeply rooted in the ontological differences between the two art forms^[3]. The following analysis examines four dimensions: scarcity of narrative language, conflict in spatial concepts, production cost constraints, and aesthetic experience fragmentation^[4].

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2.1. Scarcity of Narrative Language

Traditional opera film and television has long been constrained by mechanical stage documentation, relying mainly on fixed cameras and simple lens movements. Although this approach preserves performance integrity, it abandons cinematic montage and expressive visual language^[6]. The camera acts only as a passive spectator, leading to weak audiovisual expression and failed integration of cinematic logic and opera aesthetics^[7]. Such works are thus reduced to premium recordings rather than genuine opera films.

2.2. Conflict in Spatial Concepts

Opera and film differ fundamentally in spatial conception. The operatic stage is a stylized theatrical space, emphasizing scene follows performer, environment arises from mind, constructing psychological time-space through performance^[8]. By contrast, traditional cinema prioritizes material realism and concrete physical space^[9]. This ontological conflict causes excessive representation and aesthetic disintegration. Pursuing cinematic realism via location shooting often creates strong incongruity when stylized opera performers appear in realistic settings.

2.3. Production Cost Constraints

Although computer-generated imagery (CGI) technology can be employed to create virtual scenes, its practical application faces dual dilemmas^[10]. On one hand, there are constraints related to cost and efficiency: high-quality visual effects production requires lengthy production cycles and substantial financial investment, making it unaffordable for most regional opera genres^[11]. On the other hand, there is the problem of aesthetic incompatibility: traditional CGI, rendered based on physical lighting models, typically presents an industrialized hard realism and highly naturalistic quality, failing to capture the ink-wash-like vitality and spirit pursued in Chinese opera. This results in technological means that struggle to effectively serve operatic aesthetic expression^[12].

2.4. Aesthetic experience fragmentation

In the era of digital media, audience aesthetic habits have undergone transformation, with viewers increasingly preferring immersive, highly interactive audiovisual experiences. However, traditional opera films continue to adhere to the proscenium arch stage's performance-audience relationship, with the fourth wall firmly intact, positioning viewers as mere observers. This one-dimensional viewing mode struggles to evoke deep emotional resonance in audiences and fails to provide the sense of presence and immersive aesthetic experience that contemporary viewers desire, thereby creating barriers and discontinuities in the modern dissemination of opera art^[13].

3. The Current State of Opera Film and Television Creation from the Perspective of Media Convergence

In the context of media convergence, opera film and television is shifting rapidly from traditional linear production to digital and intelligent paradigms, with AIGC as the core driving force^[14]. AIGC models (Stable Diffusion, Midjourney, Sora) enable text-to-video generation, which is highly isomorphic with the freehand aesthetic logic of Chinese opera, and this theoretical compatibility has been increasingly validated in creative practice^[15]. The industry has explored AIGC applications across multiple opera genres^[16]. To clarify AIGC's empowerment mechanism, this study selects

representative cases and systematically analyzes them from four dimensions: genre, AIGC technology, innovative value, and presentation.

Table 1: Recent Innovative Works of Traditional Drama Empowered by AIGC

Work Title	Work Type	AIGC Technology Type	Innovative Value	Works Display
Dragon Gate	Digital Stage Production	Virtual Scene Generation, Digital Stage Modeling, Real-time Image Integration	Enhancing the digital expression of opera's freehand space	
Flame Mountain	AI Peking Opera Short Film	Style Generation, Ink Wash Visual Modeling	Resolving the conflict between opera aesthetics and CGI	
Love (AI) Huang mei Opera	AI Series Program	Virtual Scene Generation, Stylized Imagery	Reducing production costs, enhancing visual expression	
Wandering in the Garden, Waking from a Dream	XR Immersive Theater	3D Asset Generation, Digital Human, Natural Language Processing (NLP) Interaction	Immersive experience breaking the fourth wall	

As shown in Table 1, AIGC integration in opera film and television is not merely instrumental supplementation, but a multi-form, full-chain deep penetration^[17]. AIGC technologies including virtual scene generation, stylized rendering and digital stage modeling free opera from physical stage limitations and enable multidimensional immersive aesthetics. For example, Longmen expands expressive space via virtual scene fusion; Flame Mountain reconciles CGI and opera aesthetics through ink-wash stylization; The Peony Pavilion: Wandering in the Garden, Waking from a Dream enhances immersion with XR and interactive NLP^[18].

In summary, AIGC reconstructs the interactive narrative logic of opera film and television, extending user experience from psychological space to multidimensional digital realms. Its generative mechanism supports flexible narrative recombination and reduces fragmentation. AIGC also drives an aesthetic shift from realism to surrealism, achieving consistent stylization between scenes and performances like animated traditional paintings, thereby resolving the long-standing ontological contradiction between authentic performance and artificial setting, or vice versa^[19].

4. Reconstruction and Extension of Interactive Narrative Logic from the AIGC Perspective

AIGC integration has established a multidimensional narrative system for Chinese opera film and television. Structurally, it breaks the linear causality of traditional opera and forms a decentralized, rhizomatic narrative network. Secondly, at the dynamic level, it achieves adaptive iteration and value orientation of the narrative generation impetus. Finally, at the spatiotemporal level, it materializes the abstract freehand brushwork spirit of Chinese opera into perceptible and tangible dynamic scenes. The three-dimensional reconstruction of narrative structure, dynamic mechanism and spatial

context jointly alleviates the ontological gap between the traditional stage and modern images, providing solid logical support for the modern expression of ancient opera in the digital era, as illustrated in Figure 1.

AIGC-Enabled Reconstruction of Interactive Narrative Logic in Chinese Opera Film and Television

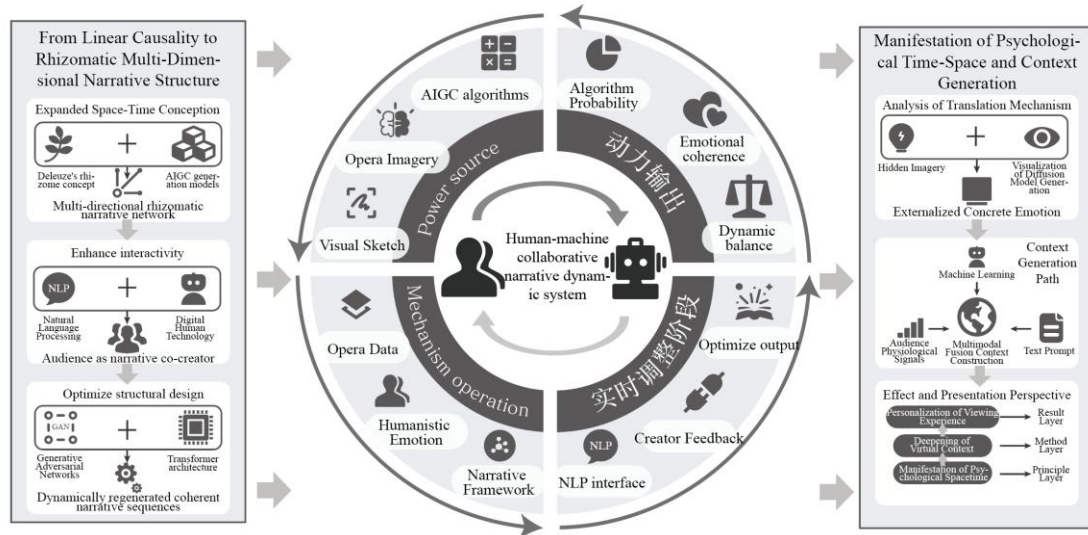


Figure 1 Schematic diagram of the reconstruction model of interactive narrative logic for Chinese opera film and television empowered by AIGC

4.1. From Linear Causality to a Multi-dimensional Rhizomatic Narrative Structure

AIGC reshapes the narrative logic of opera film and television through three progressive stages: spatiotemporal expansion, interactivity enhancement, and structural optimization^[20].

First, spatiotemporal expansion. Traditional opera narratives are linear and constrained by stage boundaries. Drawing on Deleuze's rhizome theory, AIGC breaks the tree-like single-line structure via generative models, constructing multi-dimensional digital spaces and forming a decentralized, multi-directional rhizomatic narrative network.

Second, interactivity enhancement. AIGC introduces human-computer interaction via NLP and digital human technologies, transforming opera from passive viewing to active participation. This branching narrative mode enables real-time audience intervention in plot development, generating multiple parallel storylines and positioning audiences as co-creators.

Third, structural optimization. Within the decentralized narrative framework, AIGC employs a probability-driven controlled generation mechanism to unify narrative randomness and logical coherence. Based on GAN and Transformer architectures, the algorithm internalizes opera's stylized conventions as computational constraints. When audiences trigger plot divergence, AIGC dynamically regenerates coherent narrative sequences in accordance with character logic and operatic performance norms.

4.2. Human-computer Collaborative Narrative Dynamic System

From the AIGC perspective, human-computer collaboration constitutes the core narrative dynamic system of opera film and television, emphasizing technology-humanities complementarity rather than substitution. Derived from the collaborative creation between AIGC generative algorithms and opera artists, this forms a symbiotic dynamic mechanism.

First, in terms of dynamic sources: unlike traditional opera narrative dynamics, AIGC introduces algorithms as collaborative subjects that simulate creative processes through deep learning. For instance, Midjourney generates visual sketches from artists' opera imagery input, while actors adjust digital human movements in real time to form a human-computer feedback loop, shifting dynamics from a human-centered to a human-computer co-creation model.

Second, at the level of mechanism operation, human-computer collaboration is reflected in multi-layer interactions:

(1) the pre-generation stage, where AIGC automatically produces narrative frameworks based on large models trained on opera datasets;

(2) the real-time adjustment stage, where creators input feedback via NLP interfaces to optimize outputs and avoid algorithmic bias;

(3) the post-evaluation stage, where audience data are used to iterate the model and ensure the adaptability of the dynamic mechanism.

Finally, in dynamic output, human-computer collaboration enhances narrative tension—algorithms inject probabilistic unexpected twists, while humanistic intervention ensures emotional coherence. Attention is needed to avoid dynamic imbalance. This mechanism reconstructs narrative dynamics and provides a sustainable engine for opera film and television development.

4.3. Visualization of Psychological Spacetime and Context Generation

AIGC digitizes and visualizes the psychological spacetime of opera, enabling dynamic and immersive context construction that aligns with the freehand narrative logic of traditional Chinese opera.

First, in visualization mechanisms, AIGC leverages diffusion models to transform implicit mental images into explicit visual representations. The algorithm extracts semantic features from latent space and maps abstract emotions of characters into concrete visual forms such as particle effects, light changes and dynamic textures.

Second, in context generation, AIGC adopts a multi-modal fusion framework, including text-prompt-based generation, interactive generation driven by audience physiological signals and virtual reality interaction, as well as iterative optimization via machine learning feedback loops.

Finally, the visualization of psychological spacetime significantly enhances immersive experience. It materializes abstract emotions and inner states through dynamic visual elements, creating layered virtual contexts. Combined with real-time interaction and audience physiological feedback, this approach delivers a personalized and in-depth aesthetic experience.

5. Construction and Innovation of the Immersive Aesthetic Paradigm Empowered by AIGC

AIGC intervention not only updates production tools but also profoundly restructures the traditional aesthetic mechanism of Chinese opera. This new paradigm includes three progressive dimensions: dematerialized visual texture that reconciles realism and freehand brushwork, reshaped performance-audience relationship that shifts from spectatorial gazing to embodied presence, and multi-modal collaboration that achieves sound-image isomorphic synesthetic aesthetics. Together they elevate Chinese opera film and television from visual representation to multi-dimensional perceptual immersion as shown in Figure 2.

Construction of Immersive Aesthetic Paradigm Empowered by AIGC

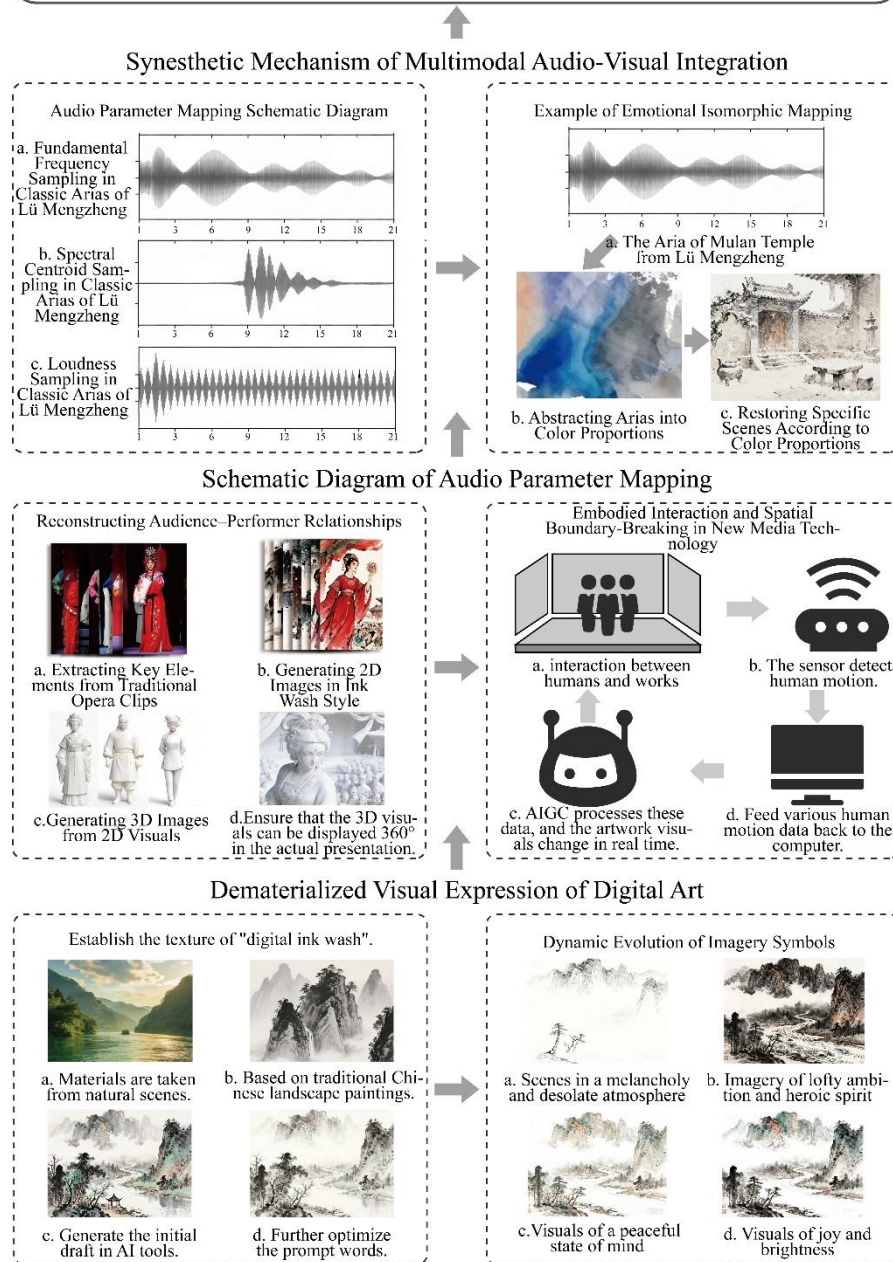


Figure 2 Construction of the Immersive Aesthetic Paradigm Empowered by AIGC

5.1. Dematerialized Visual Expression in Digital Art

On the one hand, AIGC overcomes the physical rigidity of traditional CGI and creates a digital ink-wash style. AIGC diffusion models with LoRA integrate ink-wash effects and delicate lines, generating semi-abstract particle images. This visual style conforms to Chinese opera's resemblance beyond likeness and preserves aesthetic space for performance.

On the other hand, AIGC realizes dynamic symbolic evolution and fluid stage aesthetics. Supported by ControlNet, backgrounds change with the plot: sharp textures for grief, soft textures for calmness. This emotional visualization breaks the limits of objective filming, turning the environment into expressive narrative language.

5.2. Embodied Interaction and Spatial Breakthrough via New Media Technologies

The core of immersive aesthetics is to break the stage-audience boundary and shift perception from gazing to presence. AIGC digitally reconstructs opera space and bridges opera and audiences.

On the one hand, NeRF-supported volumetric video reshapes audience-performer relations. AIGC-assisted NeRF reconstructs high-fidelity 3D scenes and character motions, enabling six—degree—of—freedom navigation. Audiences become immersive participants rather than passive spectators, turning opera viewing into an embodied cultural ritual.

On the other hand, real-time rendering virtual production forms a virtual-real symbiotic field. With LED screens and real-time AIGC generation, actors perform in responsive digital environments. This space acts as both visual enclosure and perceptual extension, evolving opera space into an open interactive entity.

5.3. *Synesthetic Mechanism of Multi-Modal Sound and Image*

Chinese opera is a comprehensive sight-and-sound art that stresses the counterpoint between sound and image. AIGC's multimodal capabilities, especially audio-driven video, link auditory and visual senses to create a new synesthetic aesthetics.

On the one hand, AIGC visually translates opera music: it analyzes pitch, dynamics, and timbre, then maps them to color, brightness, and motion in visuals. On the other hand, it builds an emotionally isomorphic audio-visual model. Unlike traditional film, sound becomes the source of image generation. AI matches arias' emotions to suitable visuals, achieving deep emotional synchronization and strengthening opera's artistic appeal.

6. **Sichuan Opera Colorful Tower as a Case Study**

As one of the classic Eighteen Jianghu Plays and Eight Great Stories of Sichuan Opera, Colorful Tower is derived from the Southern Opera Broken Kiln. It tells the love story between Liu Cuiping, daughter of Prime Minister Liu Mao, and the poor scholar Lü Mengzheng of the Song Dynasty. As a representative classic of Sichuan Opera, it features stylized performance and freehand narrative, focusing on emotional and moral conflicts, and has been adapted by many operas. Taking *Entering a Dream · Colorful Tower* as an empirical case, this study uses AIGC to explore its innovative transformation from traditional stage to digital imagery based on interactive narrative and immersive aesthetics^[21].

6.1. *Reconstruction of Content Narrative in Sichuan Opera Colorful Tower*

At the level of content narrative, a hybrid narrative strategy combining a classic mainline with probabilistic branches is implemented, aiming to achieve a dynamic balance between operatic stylistic norms and interactive freedom. Specifically, at the macro-structural level, the strategy strictly adheres to the narrative framework of Sichuan Opera Colorful Tower, fully preserving the classic plot chain to ensure the complete inheritance of the opera's cultural ontology^[22]. At the micro-interactive level, AIGC is employed to introduce a probabilistic generation mechanism, allowing the coexistence of multi-dimensional parallel storylines and empowering the audience to intervene in the plot development according to their subjective will, as illustrated in Table 2.

Table2 Plot Node Parameter Configuration Table for *Entering a Dream · Colorful Tower*

Node Name	Interaction Type	Number of Branches	Key Parameters	Scope of Influence
Choosing a Son-in-law at the Colorful Tower	Physical Manipulation	3 main lines+1 sub-line	Trajectory of the embroidered ball	Locks main and branch lines
Prime Minister Rejecting the Son-in-law	Dialogue Options	3	Father-daughter relationship value (0-100)	Subsequent subsidy amount
Sacrificing the Stove in the Cold Kiln	Item Selection	3	Emotional fit value (0-100)	Depth of husband-wife interaction
Rushing to Mulan Temple for the Fair	Strategy Selection	3	Mentality value (0-100)	Psychological preparation for the imperial examination
Evaluating Comments and Tracing Clues	Evidence Collection	3	Trust value (0-100)	Direction of husband-wife relationship
Going to the Capital for the Examination	Route Selection	3	Exam preparation concentration (0-100)	Result of the imperial examination
Reunion at the Temple	Attitude Selection	3	Reconciliation posture	Final outcome

When the audience triggers key interactive nodes, the system intelligently invokes AIGC-generated opera movements, professional vocal recordings, or stylized dynamic images as aesthetic punctuation. This human-machine co-performance model enhances narrative playability and engagement, transforming traditional one-way viewing into deep immersive performance^[23].

Entering a Dream · Colorful Tower extracts key scenes with intense dramatic conflicts as core interactive nodes, converting implicit character emotional fluctuations into visualizable relationship values and psychological thresholds. Through AIGC's real-time parameter calculation and branch deduction, the script becomes a data-driven dynamic topological structure rather than fixed text. The following section will deeply analyze the narrative reconstruction mechanism and multi-dimensional path evolution from fixed script to generative script based on the designed key interactive node system^[24].

6.1.1 Multi-stable Construction of the Narrative Starting Point

The first act Choosing a Son-in-law at the Colorful Tower uses a structure of three main lines and one discrete sub-line, with plot direction determined by the user's interactive precision. The orthodox chain follows the classic plot: the user throws the embroidered ball to Lü Mengzheng, activating Striving in the Cold Kiln. The heterogeneous chain leads to Feuds Among the Powerful if the ball goes to a noble. The absurdist chain triggers a comic or tragic turn when the ball falls to a beggar. The subject-awakening sub-line activates Ending 2: Independence in the Mortal World if the heroine flees, deconstructing feudal marriage and embodying modern female consciousness^[25].

6.1.2 Gradient Threshold Mechanism of Relationship Values and Its Operational Logic

At the second interactive node Prime Minister Rejecting the Son-in-law, the system takes father-daughter relationship value as the core narrative variable, quantified into three critical levels—30, 60, and 90—each corresponding to distinct survival logics and endings. A value below 30 triggers ethical breakdown and Ending 3 Skeleton in the Cold Kiln, symbolizing the tragedy of unsupported idealism. A value above 90 leads to the protagonist's loss of autonomy and Ending 4 Canary in a Cage, a puppet of feudal ethics. Only a balanced value around 60 enables the protagonist to retain marital autonomy and minimal kinship support for the Cold Kiln narrative^[26].

6.1.3 Game Model of Emotion and Mentality and Its Deduction Mechanism

Currently, the narrative focuses on micro-emotional maintenance and individual psychological construction. In Sacrificing the Stove in the Cold Kiln, item selection involves trade-offs between survival and emotional capital: clear water and reed firewood enhance emotional fit, while exchanging gold hairpins for rice sustains survival but reduces it; inaction leads to shortages in both.

Insufficient emotional fit causes trust crisis and collapse in later Evaluating Snow and Tracing Clues, triggering Ending 6 Separation of the Swallow and the Oriole. In Rushing to Mulan Temple for Alms, users must maintain Lü Mengzheng's mentality value through rational choices; values below the threshold eliminate imperial examination motivation and lock Ending 5 Mediocre Life.

6.1.4 The Ultimate Divide of Value Rationality

In the final chapter Reunion at the Temple, an algorithmic narrative mechanism based on ability accumulation and strategic choice is adopted, with the system adjusting concentration, academic talent and moral values to form path-dependent probabilistic logic. Secular socializing impairs concentration and integrity, leading to Ending 8 Shade of the Skirt; power-seeking misconduct results in Ending 9 Black Python Swallowing the Elephant, where AIGC visuals reflect power-induced human alienation. Strong concentration and moral integrity bring top academic achievement and multiple endings, allowing users to fulfill Confucian ideals or choose seclusion, reflecting literati's transcendence.

6.2 Rendering of the Ink-wash Opera Style Model

For the work *Entering Dreams · Colorful Tower*, the traditional physical lighting rendering paradigm is abandoned in visual presentation. A digital ink wash rendering pipeline centered on latent space feature extraction is constructed. According to the appearance frequency of characters, three-view 3D modeling and systematic scene construction are completed for core roles. The character images and scene effects are shown in Figures 3–5.

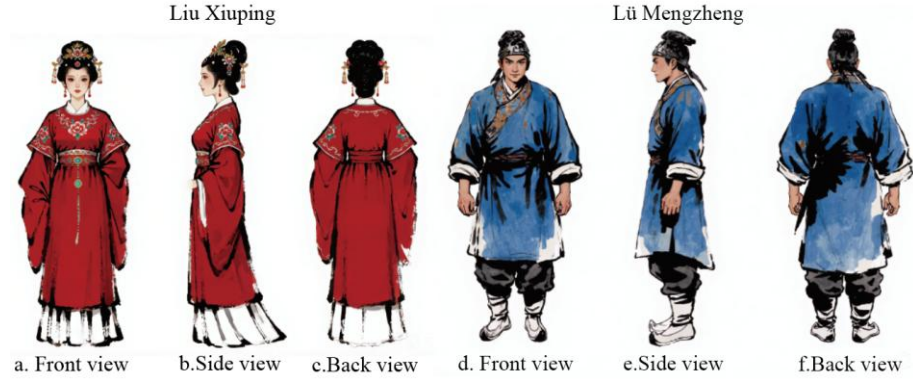


Figure 3 Three Views of the Male and Female Protagonists in *Dreaming · Colorful Tower*



Figure 4 Three Views of Minor Characters in Entering the *Dream: The Colorful Tower*

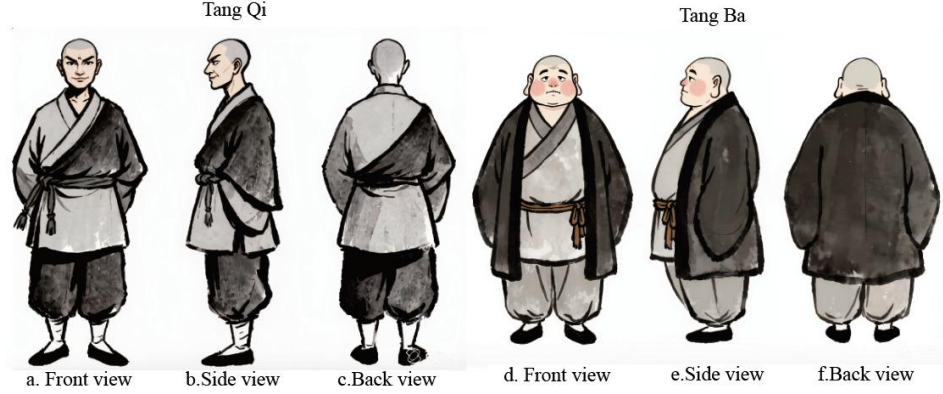


Figure 5 Three-View Drawings of Main Characters in Key Scenes of *Entering Dreams · Colorful Tower*

The design discards the traditional paradigm of physically realistic lighting and shadow, integrating the distinctive sartorial features of Sichuan opera costumes with the freehand aesthetic texture of digital ink wash, thereby constructing visually expressive representations with profound aesthetic connotations for the narrative system of the Sichuan opera ink wash style^[27].

6.2.1 Vertical Domain Aesthetic Construction via LoRA Model Fine-tuning

General-purpose AIGC models struggle to accurately grasp the complex costume regulations of Chinese opera and the brushstroke logic of ink wash painting. To address this, we constructed a high-quality vertical dataset incorporating resources such as the Sichuan Opera Costume Atlas and Master Splashed-ink Landscape Paintings. We then fine-tuned the Stable Diffusion large model using Low-Rank Adaptation (LoRA) to generate an aesthetic weight file exclusive to Colorful Tower.



Figure 6 Presentations of key scenes: Choosing a Son-in-Law at the Colorful Tower, Kitchen God Worship in the Cold Kiln, and Weaving for Rice.

As evident from the character designs in Figure 6, whether in the scene of Liu Cuiping selecting a husband at the colorful tower, or in the episodes of offering sacrifices to the Kitchen God at the cold kiln and weaving cloth to exchange for rice, the costume details and facial features retain the distinct characteristics of Chinese opera while being imbued with the diffused texture of ink wash painting. The LoRA model effectively integrates the meticulousness of meticulous heavy-color painting with the boldness of freehand ink wash, establishing the overall tone of the play as externally ethereal yet internally substantial, embodying both form and spirit.

6.2.2 High-Precision Controllable Generation Paradigm under ControlNet Collaborative Mechanism

To ensure narrative coherence and the stylized standards of movements, and to avoid the common flickering and deformation issues in AI-generated videos, a technical approach integrating rough model-driven animation and AI re-rendering was adopted. First, simple scene geometry and character skeletal animations were constructed in a 3D engine to output basic depth maps and skeletal maps. Subsequently, ControlNet technology was utilized to take this spatial geometric information as strong constraints, guiding the AIGC in image generation.



Figure 7 Presentations of key scenes: Dismissing the Son-in-Law from the Prime Minister's Mansion, Begging for Food at Mulan Temple, and Judging the Truth by Snow.

As shown in the three key scenes in Figure 7—Expelling the Son-in-law from the Prime Minister's Mansion, Begging for Meals at Mulan Temple, and Judging the Trace in the Snow—ControlNet precisely locked the perspective structure of the temple and the body momentum of the characters, ensuring the rigor of the composition. Meanwhile, prompts guided the AI to replace building materials with flowing ink traces and treat the sky as blank space or rendered cloud aura. This method not only retains the efficiency and accuracy of industrialized production but also endows the images with the artistic charm of traditional ink wash.

6.2.3 Emotion–Tone Adaptive Rendering Driven by Multi-modality

Based on the sensory translation mechanism elaborated above, *Entering Dreams·Colorful Tower* adopts a multimodal collaborative driving strategy integrating text, image and audio, as shown in Figure 8.



Figure 8 Key scenes: Going to the Capital for the Imperial Examination, Reunion at the Temple, and the Start Page of *Entering the Dream·Colorful Tower*.

The visual style evolves dynamically with the plot's emotional parameters. In key festive scenes, the AI adopts high-saturation warm tones to create a lively atmosphere. In tragic scenes, it switches to low-saturation cool tones to convey harsh environments and inner desolation. Driven by script semantics and musical emotion, this dynamic color rendering realizes visual narration where scenery expresses emotion, turning each frame into the digital externalization of the characters' inner state.

6.3 Validation of the Multi-modal Embodied Interactive Experience Mechanism

This study adopts an empirical method combining subjective and objective approaches to validate the experience of the multi-modal interactive system in *Entering a Dream·Colorful Tower* from two dimensions: subjective sensory evaluation and objective physiological indicators, so as to quantitatively assess the effectiveness of the immersive opera aesthetic paradigm.

6.3.1 Subjective Validation: Scale Assessment of Flow State and Cultural Identity

To verify the empirical validity of immersive interactive aesthetics, this study used a rigorous randomized controlled trial (RCT) with 100 participants equally divided into two groups. The control group watched a high-definition recording of the traditional Sichuan opera *Colorful Tower*, while the experimental group experienced the AIGC-

based interactive VR work *Entering a Dream · Colorful Tower*.

After the experiment, a 5-point Likert scale was used to quantitatively assess participants' sensory and psychological responses. Statistical analyses were then conducted on both groups, with detailed comparisons and significant differences presented in Table 3.

Table 3 Differential Assessment of Subjective Experience in *Entering a Dream · Colorful Tower*

Dimension	Item Content	Traditional Group (n = 50) M ± SD	Interactive Group (n = 50) M ± SD	t-value
Audiovisual Perception & Aesthetic Experience	Q1. Realism of 3D Scenes and Characters	2.04 ± 1.14	3.74 ± 1.26	-7.073
	Q4. Visual Appeal of Digital Ink Wash Aesthetics	2.24 ± 1.20	3.54 ± 1.40	-4.971
	Q7. Immersion Brought by Color, Brightness and Visual Effects	1.98 ± 0.98	3.58 ± 1.28	-7.023
Spatial Immersion & Flow State	Q10. Perception of Eliminating the Barrier Between Audience and Stage	2.32 ± 1.15	3.52 ± 1.36	-4.765
	Q11. Sense of Presence in the 3D Panoramic Space	2.02 ± 1.08	3.56 ± 1.31	-6.413
	Q20. Level of Focus During Interactive Sessions	2.40 ± 1.26	3.56 ± 1.18	-4.747
Sense of Control & Desire for Exploratory Interaction	Q13. Degree of Autonomy of Choice Throughout the Experience	2.36 ± 1.22	3.46 ± 1.22	-4.507
	Q15. Perceptible Impacts of Divergent Choices on Story Endings	2.12 ± 1.21	3.72 ± 1.14	-6.807
	Q17. Awareness of Hidden Metrics (e.g., Character Relationship Values)	2.54 ± 1.33	3.72 ± 1.29	-4.500
Emotional Resonance & Cultural Identity	Q21. Emotional Fluctuations Triggered by Interactive Plot Development	2.14 ± 1.05	3.72 ± 1.09	-7.386
	Q23. Emotional and Aesthetic Catharsis at Climactic Endings	2.16 ± 1.13	3.60 ± 1.09	-6.487
	Q25. In-depth Comprehension of Core Essence of Traditional Chinese Opera and Culture	1.84 ± 0.71	4.10 ± 0.81	-14.788

Notes: M denotes the mean value, and SD stands for standard deviation. The degrees of freedom (DF) for independent-samples t-test is 98.

Empirical research demonstrates that the deep integration of AIGC technology and interactive narratives into digital traditional opera goes beyond a mere superficial extension of the medium. Rather, it catalyzes a fundamental paradigm shift in the logic of audience experience, transitioning from "passive observation" to "embodied participation." Data robustly confirms ($p < 0.001$) that interactive mechanisms, functioning as effective "attention anchors," not only drive a leap in the audience experience—from unidirectional audiovisual reception to a state of deep flow—but also facilitate profound emotional empowerment. By granting audiences subjective agency and a sense of control over narrative outcomes, this approach sublimates rational, symbolic cognition into intense empathy and aesthetic catharsis. Of greatest strategic significance is that this paradigm achieves a substantial leap in traditional cultural identification across core metrics. This proves that embodied interaction can serve as a crucial medium for bridging the chasm between modern contexts and traditional art

forms. Ultimately, it enables the cultural essence of traditional opera to transcend rigid symbolic representations, becoming deeply internalized within the psychological structures and value systems of modern audiences^[28].

6.3.2 Objective Validation: Emotional Isomorphism Monitoring Based on Physiological Feedback

To investigate the physiological arousal and emotional responses of audiences experiencing AIGC interactive traditional opera, this experiment conducted full-process physiological signal monitoring on 100 participants from both the AIGC interactive group and the traditional viewing group. The study utilized the ErgoLAB human-machine-environment synchronization cloud platform, combined with a multi-channel wireless physiological recorder, to collect real-time data on the participants' instantaneous heart rate (HR), heart rate variability (HRV), and electrodermal activity (EDA) across 7 key interactive nodes, as detailed in Table 4.

Table 4 Descriptive Statistics of Physiological Indicators (HR, HRV, EDA) at Key Interactive Nodes

Physiological Indicators	Measurement Dimensions	Traditional Group (n=50) M $\pm$ SD	Interactive Group (n=50) M $\pm$ SD	t-value
Baseline Heart Rate (BPM)	Control Variable	72.44 $\pm$ 2.99	72.11 $\pm$ 2.80	0.576
Heart Rate Increment Δ HR (BPM)	Overall Emotional Arousal	2.09 $\pm$ 0.45	12.55 $\pm$ 0.50	-109.711
Peak Task Heart Rate (BPM)	Transient Intense Stimulus Response	80.80 $\pm$ 3.70	101.71 $\pm$ 4.68	-24.773
RMSSD (ms)	Cognitive Load and Flow-State Stress	42.34 $\pm$ 2.94	27.53 $\pm$ 2.86	25.524
Number of Peak Skin Conductance Responses (times)	Sympathetic Nervous System Emotional Catharsis	4.52 $\pm$ 1.23	16.52 $\pm$ 2.68	-28.746

In conclusion, the empirical comparison of multimodal physiological data provides robust objective evidence for the embodied participation effect in AIGC interactive opera. With baseline consistency rigorously controlled, the highly significant between-group differences across physiological metrics ($p < 0.001$) indicate that interactive mechanisms successfully trigger deeper dimensions of emotional arousal and cognitive engagement. On one hand, the surge in Δ HR and peak HR, coupled with highly active EDA in the interactive group, accurately maps the intense emotional fluctuations and ultimate aesthetic catharsis experienced by audiences at critical narrative nodes. On the other hand, the significant decrease in RMSSD objectively reveals the high cognitive load mobilized during interactive decision-making, signifying a sharp convergence of attention and the attainment of a deep flow state. Ultimately, these objective physiological profiles compellingly confirm that interactive narratives effectively shatter the physiological inertia inherent in traditional audiovisual reception. By deeply involving modern audiences at the level of the autonomic nervous system, this paradigm drives a definitive transformation from detached observation to immersive empathy.

7. Conclusion

With deep AIGC integration, opera film and television creation has gone beyond simple technological empowerment. By reconstructing narrative logic and innovating aesthetic paradigms, it demonstrates how AIGC resolves structural contradictions between opera and film. In the future, AIGC will further advance cross-border

integration, helping more local operas adapt to the digital ecosystem and supporting cultural diversity. Yet we must guard against cultural alienation caused by technological dominance, balancing humanistic ethics and artistic subjectivity. Ultimately, AIGC is not just a tool but a catalyst for the contemporary revitalization of ancient opera, supporting the construction and dialogue of the global digital humanities landscape.

8. Competing interests

The authors declare no competing interests.

9. Data availability

The datasets generated and/or analyzed during the current study—including the questionnaire and corresponding analysis data, heart rate monitoring data, AIGC-generated prompts, the interactive demonstration video of the artwork, and video clips of each interactive node—are available in the Baidu Netdisk repository at <https://pan.baidu.com/s/1SG6KD8diB4UnfRLJsyQTCg?pwd=drtt> (Access code: drtt).

10. Ethics declarations

This study involves human participants (including questionnaire surveys and the collection of physiological data, such as heart rate monitoring). All research procedures strictly adhere to the ethical guidelines and principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the Academic Affairs Office of Northeast Electric Power University.

Prior to the interactive experiment and data collection, all participants were fully informed regarding the purpose, procedures, and potential risks of the study, as well as the scope of data usage. Informed consent was obtained from all individual participants included in the study. All questionnaire responses and physiological monitoring data have been strictly anonymized and are utilized exclusively for academic research purposes, ensuring the complete protection of participants' privacy and confidentiality.

11. Author contributions

Lu Peng: Conceptualization, research framework design, overall paper writing, case study design of Sichuan Opera *The Story of the Colored Tower*, data analysis, revision of the full manuscript, corresponding author.

Zhang Jinxuan: Literature collection and sorting, collation of AIGC opera film and television cases, table and figure production, experimental data statistics, draft polishing, proofreading of references.

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