

Digital Transformation of Intangible Cultural Heritage: Application Research of Southern Opera Elements in Fashion Digital Design

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Abstract: With the rise of concepts such as the metaverse, NFT, and digital twins, digital fashion has become a new frontier in the fashion industry. At the same time, how to utilize digital technology to revitalize intangible cultural heritage has become an important contemporary issue. This paper takes the ancient Chinese opera art - Southern Opera as the research object, exploring the application paths, methods, and value of its aesthetic elements in fashion digital design. The article first analyzes the core characteristics of Southern Opera in terms of clothing, makeup, performance movements, and cultural core, and then from the perspective of the combination of design science and digital technology, proposes a four-layer application model of "form extraction - image translation - narrative reconstruction - technology empowerment". Through theoretical analysis and practical case demonstration, this paper elaborates on how the elements of Southern Opera are transformed into new fashion assets such as 3D modeling, dynamic capture, AI generation, blockchain certification, etc., through digital technologies. The research aims to provide a new "digital activation" paradigm for the contemporary inheritance of intangible cultural heritage and inject profound cultural into the digital fashion industry.

Keywords: Southern Opera, Digital Fashion, Intangible Cultural Heritage, Metaverse, NFT, 3D Design.

1. Introduction

1.1. Research Background and Significance

In the context of globalization and digitalization, the innovative expression of Chinese local culture is confronted with both opportunities and challenges. The rapid development of digital technology has provided new dissemination carriers and expression forms for traditional culture. The rise of the concept of the metaverse has promoted the development of the virtual fashion industry. According to industry reports, the global digital fashion market size has exceeded 50 billion US dollars in 2023, and is expected to maintain an average annual growth rate of 30% until 2025.

Nanxi, as the earliest mature form of Chinese opera, urgently needs innovative inheritance of its artistic value and cultural connotations. Traditional intangible cultural heritage protection mostly focuses on physical preservation and stage inheritance. In the digital era, it faces challenges such as an aging audience and a single dissemination channel. Integrating Nanxi elements into digital fashion design not only expands the inheritance path of intangible cultural heritage but also injects unique cultural identity into digital fashion, achieving a dual enhancement of cultural value and commercial value.

This research has significant theoretical and practical significance. At the theoretical level, it has constructed a cross-disciplinary research framework for traditional opera aesthetics and digital fashion design; at the practical level, it has provided an operational methodology for the modern transformation of intangible cultural heritage, and promoted the upgrade of "national trend" from symbolic expression to in-depth cultural experience.

1.2. Literature Review

Current academic research in this field mainly focuses on three areas:

In the study of southern opera, Yu Minwei (2009)'s "History of Southern Opera" [1] systematically reviewed the historical evolution and artistic characteristics of southern opera, but focused on literature and performance systems, and lacked exploration of the modern transformation of visual elements. Sun Chongtao [2] (2015)'s research on the costume system of southern opera provided an important historical basis, but lacked connection with modern design language.

In the field of digitalization of intangible cultural heritage, Wu Guangrong [3] (2020) proposed the technical path for the digital protection of intangible cultural heritage, but mostly concentrated on archival-style records, with less research on creative transformation. Li Dan (2021) explored the integration of intangible culture and digital media, but did not delve into the specific application in the fashion industry.

In the field of digital fashion research, Dong [4] (2022) systematically discussed the technical system and development trends of digital fashion, but mainly took Western practices as the main cases, lacking a local cultural perspective. Domestic research mostly follows technological trends and does not deeply explore the cultural foundation.

This paper aims to fill the gaps in existing research, construct a systematic framework connecting the aesthetics of southern opera and digital fashion design, and promote the dynamic inheritance and innovative development of intangible cultural heritage.

1.3. Research Ideas and Methods

This research adopts a multidisciplinary approach, integrating perspectives from art studies, design studies, and computer science. Through literature research, the aesthetic characteristics of Nanyue opera are explored. Using case analysis, the technical path of digital fashion is analyzed. And through practical verification, the "four-layer application model" is constructed. The research emphasizes the combination of theory and practice, emphasizing both the in-

depth exploration of cultural connotations and the feasibility of technical implementation. Digital art provides a new medium and narrative possibility for the contemporary transformation of traditional culture [5]. Digitalization has become an irreversible trend in the protection, inheritance, and development of intangible cultural heritage, with its goal shifting from static preservation to dynamic activation and innovative transformation [6].

2. Deconstruction of the Aesthetic Elements of Nanxi Opera

2.1. The Rhythm of Costumes:stylization, Symbolism and Color System

The costumes of Nanxi Opera possess distinctstylization characteristics, presenting the identities and social status of the characters through specific costume regulations. The cheongsam worn by male roles adopts the form of a double-breasted robe with wide sleeves and a belt, embodying the refined demeanor of scholars; the pleats and veils worn by female roles are delineated by smooth lines, showcasing the gracefulness of women. These costume shape features provide a unique form basis for 3D modeling.

In terms of the color symbolism system, Nanxi Opera follows the traditional Chinese "five-color view": blue symbolizes loyalty and integrity, red symbolizes loyalty and bravery, yellow symbolizes majesty, white symbolizes treachery, and black symbolizes uprightness. This color symbol system can be digitally calibrated using the Pantone color library to establish a unique color system for Nanxi Opera. In terms of material expression, the soft luster of silk and the rough texture of linen can be highly simulated through the PBR material system of Substance Painter.

2.2. Unusual Makeup: Plain Face, Flower Face and Unique Facial Symbolism

The makeup of southern opera presents a binary structure of "plain face" and "flower face". The roles of male and female are mostly depicted with "plain face", emphasizing the elegance and beauty of the face; while the roles of clown and villain are represented with "flower face", using exaggerated patterns to express personality traits. Especially the "doughnut-shaped" facial mask of the clown, with a white powder block centered on the nose, is simple in form but highly expressive.

This highly symbolic facial art has a natural affinity with the emoji culture and virtual character design in the digital age. Through facial tracking technologies such as FaceApp and ARKit, the southern opera facial masks can be transformed into dynamic digital makeup, forming new cultural dissemination symbols on social media platforms.

2.3. Rhythm of Movements:stylized Performance and the Use of Water Sashes, Fans and Other Props

Thestylized movements of southern opera form a complete system of body language. The "hook, lift, stretch, and rush" movements of water sashes create beautiful trajectories, and the "swing, turn, combine, and open" movements of fans create rich spatial rhythms. These movements can be digitally recorded using Vicon optical motion capture systems or Xsens inertial motion capture systems to establish a database of southern opera movements.

The application value of movement data lies in multiple aspects: Firstly, it can serve as a mechanical reference for the dynamic simulation of digital clothing, enabling virtual clothing to present realistic movement effects; Secondly, it can drive the performance of virtual idols, achieving modern expressions of traditional culture; Finally, through algorithm analysis, action feature parameters can be extracted to generate new performance sequences.

2.4. Core of Culture: The Graceful and Gentle "South Tune" and Popular Narratives

The cultural core of southern opera is reflected in its musical system and narrative themes. The "South Tune" vocal style is gentle and lingering, based on the pentatonic scale. This musical feature can be sampled and reconstructed using digital audio workstations such as Ableton Live as background music for digital fashion shows. In terms of narrative, southern opera focuses on secular emotions and the lives of the common people, such as the exploration of the concept of loyalty and filial piety in "The Pipa Record", and the praise of the steadfastness of love in "The Jingtai Record". These themes have cross-era resonance value, providing rich materials for the narrative design of digital fashion.

3. Design Language and Technical Framework of Digital Fashion

3.1. Scope and Characteristics of Digital Fashion

Digital fashion is a new form of fashion design that uses digital technology as its core medium. Its scope encompasses virtual clothing, digital accessories, smart wearable devices, and other fields. Compared to traditional fashion, digital fashion has the following characteristics:

Firstly, it is virtual in existence, with clothing existing in digital files and presented through screens and AR/VR devices; secondly, it is dynamic and interactive, with digital clothing responding to external inputs such as environmental data and user actions; finally, it is infinitely creative, breaking through the material limitations of the physical world and achieving surreal design expressions.

3.2. Core Technical Tool Chain

The creation of digital fashion relies on a complete technical tool chain: in the modeling stage, CLO3D and Marvelous Designer focus on the digital calculation of clothing, while Blender and Maya provide a comprehensive three-dimensional creation environment; in the rendering stage, Unreal Engine 5's Nanite virtualized geometry and Lumen dynamic global illumination technology can achieve photo-realistic visual representation; at the blockchain application level, Ethereum, Flow, and other public chains provide the basis for the ownership and transaction of digital fashion assets.

3.3. Transformation of Design Paradigm from Physical to Digital

Digital fashion has brought about a fundamental transformation in the design paradigm. Designers are no longer constrained by the physical properties of fabrics and production processes, but instead focus on algorithmic generation, parametric design, and interaction logic. This transformation enables traditional cultural elements such as

opera to be interpreted and expressed in a more free and diverse manner.

4. Application Models and Paths of Southern Opera Elements in Digital Fashion Design

4.1. First Layer: Morphological Extraction and Direct Translation

This layer focuses on the digital reproduction of visual elements of Southern Opera. Taking the water sleeves as an example, through the sheet design function of CLO3D, the plane structure of the water sleeves can be accurately restored. Then, by adjusting the parameters of gravity, elasticity, and damping, the dynamic effects of different materials can be simulated. Designers can break through physical limitations and enlarge the size of the water sleeves to several meters, or give them semi-transparent and luminous materials to create visual expressions beyond tradition.

The digital translation of the ZhuangYuan hat demonstrates the advantages of parametric design. Through the Grasshopper visual programming platform, the morphological features of the ZhuangYuan hat are transformed into algorithmic parameters to achieve infinite variations in the shape. Each variation retains the core identifying features while presenting a unique digital aesthetic.

4.2. Second Layer: Imagery Extraction and Abstract Reconstruction

This layer goes beyond form imitation and enters the deep transformation of cultural imagery. Taking the narrative of "Zhang Xie ZhuangYuan" as an example, through AI painting tools such as Stable Diffusion, inputting keywords like "unfaithful man taking the examination · poor woman's deep love · broken mirror reunion", abstract texture patterns can be generated. These patterns not only carry the emotional core of the original story but also possess modern aesthetic characteristics, and can be applied to the UV mapping design of digital clothing.

The deconstruction and reconstruction of Southern Opera masks demonstrate the modern transformation path of traditional cultural symbols. Extracting the "dough block" facial mask elements of the clown, through algorithmic reorganization, they are transformed into the makeup system of a metaverse Avatar. Users can freely combine these cultural symbols in the virtual world to create personalized digital identities.

4.3. Third Layer: Narrative Integration and Scene Reconstruction

This layer integrates the narrative and performance space of Southern Opera into the digital fashion experience. Taking the virtual fashion show of "Pu Pa Ji" themed on "The Pipa Record" as an example, a Song Dynasty street market scene is constructed in Decentraland. Audiences participate as Avatars. The walking path of the models conforms to the plot development, and the lighting, sound effects in the scene change along with the narrative progression, creating an immersive cultural experience.

The development of AR filters based on Southern Opera's ritualistic movements demonstrates the empowerment of technology in cultural dissemination. Through the facial

capture and world tracking functions of ARKit, users can summon virtual water sleeves in the real environment and control their dancing trajectories through gestures, experiencing the charm of traditional performing art in interaction.

4.4. Fourth Layer: Technology Empowerment and Value Anchoring

Blockchain technology provides a solution for the value confirmation of Southern Opera digital fashion. The "Southern Opera Four Records" NFT series not only issues limited-edition digital clothing but also embeds complete cultural metadata in the smart contract, including the background of the opera, the source of design inspiration, and the cultural symbolic meaning of each piece, making each work a collectible cultural asset.

The combination of dynamic capture technology and real-time rendering has created a new form of digital clothing performance. By recording the water sleeve movements of the Southern Opera performers, the dynamic simulation of the virtual clothing is driven, and special effects are added through the Niagara particle system of UE5, creating a "digital water sleeve" interactive art installation that interacts with the audience in real time at the exhibition site.

5. Challenges and Reflections

5.1. Balance between Cultural Core and Form Innovation

There is a risk that the cultural connotations may be diluted during the digital translation process. When the symbols of Nanyue opera are removed from their original context (the stage of traditional opera) and enter the field of fashion consumption, will their meanings be "whitened" or "misinterpreted"? Will the new digital symbol system establish a healthy community for meaning interpretation? [7]

Excessive pursuit of visual impact may lead to the symbolization and superficial application of Nanyue opera elements. Designers need to deeply understand the cultural context and aesthetic system of Nanyue opera to ensure that innovative expressions do not deviate from the cultural essence. Establishing a cross-disciplinary cooperation mechanism and inviting scholars in opera studies to participate in the design process is an effective way to ensure cultural accuracy.

5.2. Conflict between Technical Threshold and Art Expression

Digital fashion creation requires mastering both professional design software and programming knowledge. This technical threshold may limit the freedom of artistic expression. Developing more user-friendly creation tools and establishing standardized work processes can reduce technical barriers. At the same time, art colleges should update their curriculum systems to cultivate new talents with both traditional cultural literacy and digital technology capabilities.

5.3. Long-term Value and Sustainability of Digital Assets

The intense fluctuations in the NFT market pose challenges to the long-term value of digital fashion assets. It is necessary to establish a value assessment system beyond financial

attributes, emphasizing the cultural connotation and artistic value of the works. In terms of sustainability, the popularization of low-energy blockchain technologies such as proof of stake will alleviate the conflict between digital creation and environmental protection concepts.

6. Conclusion and Outlook

6.1. Research Summary

This study has established a systematic framework for the application of Nanxi elements in digital fashion design, demonstrating the feasibility and value of the integration of traditional culture and cutting-edge technology. Through the four-layer model of "form extraction - imagery translation - narrative reconstruction - technological empowerment", the aesthetic elements of Nanxi have been transformed into digital fashion assets with contemporary vitality. Digital technology not only expands the inheritance path of intangible cultural heritage but also enriches its expression dimension, enabling traditional culture to regain new vitality in the digital civilization.

6.2. Future Outlook

The core of future development is to build a "culture-technology-business" virtuous ecosystem. At the cultural level, a digital resource library for Nanxi needs to be established to provide academic support for creation; at the technological level, a toolchain specifically for the digital transformation of traditional culture should be developed to lower the threshold of innovation; at the commercial level, a model combining virtual and real elements should be explored, such as the linkage of digital collectibles and

physical rights, and the complementarity of online display and offline experience.

The practice of digital fashion in traditional Chinese opera provides a reference model for the modern transformation of more types of intangible cultural heritages. This is also the fundamental purpose of the digitalization work of intangible cultural heritage - to achieve sharing and sustainable development.

Through digital translation, traditional culture will transform from "protected heritage" to "utilized resources", presenting a unique Chinese temperament in the global digital cultural landscape.

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