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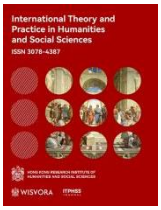

A Study on The Application of Generative Digital Art in Song and Jin Dynasty Opera Brick Carvings in Shanxi

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Abstract

This study aims to explore the digital dissemination pathways and cultural heritage approaches of Song and Jin Dynasty opera brick carvings in Shanxi. By leveraging theories related to generative digital art, a design model for applying digital generative art to the imagery of Shanxi's Song and Jin opera brick carvings is constructed. This model serves as a foundation for analysis through historical textual verification, image analysis, and symbolic interpretation methods, ensuring fidelity in restoration. During the composition phase, primary images are selected, thematic symbols are extracted, and visualization tools such as the visual programming software Touch Designer are employed. This approach integrates musical instruments, narration, and textual information to achieve an audiovisual synthesis, presenting the visual effects of generative digital art. The application of digital art expression enables the assimilation and effective utilization of the ideological concepts and artistic symbols embedded in Shanxi's Song and Jin opera brick carving culture. This approach bridges the gap between disseminators and audiences, alleviating ambiguity and resistance in understanding cultural content, fostering new conceptual thinking, and inspiring innovative digital design for Shanxi's Song and Jin opera brick carvings in the context of intelligent interaction.

1. Introduction

Shanxi Province is one of China's major regions for cultural heritage. Since the 20th century, numerous opera-themed brick carvings from the Song and Jin dynasties have been unearthed in southern Shanxi. While Shanxi's residential brick carvings are well-known and widely studied, another significant chapter in the history of Shanxi brick carving is found in opera-themed carvings from burial sites. These carvings vividly depict scenes featuring opera characters, indirectly reflecting the social status of the tomb owners during their lifetime and the lifestyle of

the aristocratic class of the era. These images not only showcase the historical development and regional characteristics of Shanxi's traditional brick carving schools but also embody a collective consciousness and cultural psychology gradually shaped by local people through daily practices. With significant historical, artistic, and scientific value, these carvings deserve broader recognition. However, the current dissemination methods for Shanxi Song and Jin opera brick carvings remain relatively singular, and their cultural transmission pathways are limited, making it necessary to propose targeted and feasible measures to address these challenges.

2. Explanation of Related Concepts

2.1 The Origins of Shanxi's Song and Jin Dynasty Opera-Themed Brick Carvings

During the Song and Jin dynasties, most regions of Shanxi experienced a period of peace and stability. To prevent military uprisings, the rulers of the time encouraged court officials and influential eunuchs to indulge in leisure and entertainment. This societal trend stimulated the flourishing of folk arts and propelled various performing arts, such as singing, dancing, storytelling, and dramatic performances, to new levels of sophistication. Consequently, Shanxi became the epicenter of the most vibrant development of zaju (variety drama) during this period (Niu Jia , 2015).Since the 1950s, numerous Jin dynasty tombs have been excavated across southern Shanxi, revealing a dense and widespread distribution. Among the discoveries, brick carvings primarily depicting Song and Jin zaju performances stand out. These carvings, as material artifacts from the Song and Jin periods, exhibit the unique characteristics of the theatrical culture of the time through detailed portrayals of characters, facial expressions, and movements. They are renowned for vividly capturing the dynamism of performances while also illustrating contemporary societal life, interpersonal relationships, and reflecting social structures and class distinctions (Jiao Chenglu,2013).The study of these works holds profound significance not only for the fields of art history and cultural heritage preservation but also for gaining insights into ancient society, aesthetic values, and modes of entertainment. They provide a unique and invaluable visual resource for understanding the ethical principles, evolving aesthetics, and lifestyles of ancient times (Ma Liang,2014).

2.2 The Origins and Creative Principles of Generative Art

The term "Generative "first appeared in the field of literature and can be traced back to the Dada movement. Herbert Franke, an Austrian scientist and pioneer of generative art, created a series of unique experiments titled "9 Analogue Graphics" (Figure 1.1). Vera Molnar, one of the first artists to apply computer technology to art, began exploring the theme of "disorder." She used early programming languages such as Fortran and BASIC to create generative artworks, often studying how lines and geometric shapes could change randomly (Figure 1.2). In the 1960s, with the widespread adoption of computer technology, more artists began exploring the intersection of computers and art. They conducted various innovative experiments and produced generative art featuring curved lines. Newly developed programming languages provided artists with tools to explore new possibilities in the digital domain, while also advancing the development of digital art through new technologies. German mathematician Frieder Nake focused on computer algorithms designed by humans (Figure 2.1).

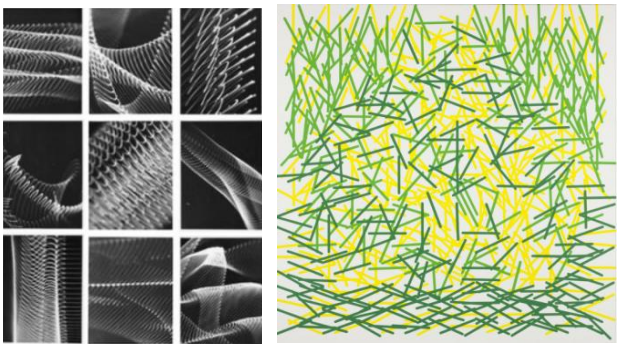

Fig1.1 Herbert Franke - 9 analogue graphics (1956/1957)

Source：http://www.culmart.com/play/creative_technology/Generative-Art.html

Fig1.2Vera Molnár, Meule en hommage à Claude Monet, 1977-2013

Source：https://artvue.net/portfolio/vera-molnar-the-alchemist-of-lines/

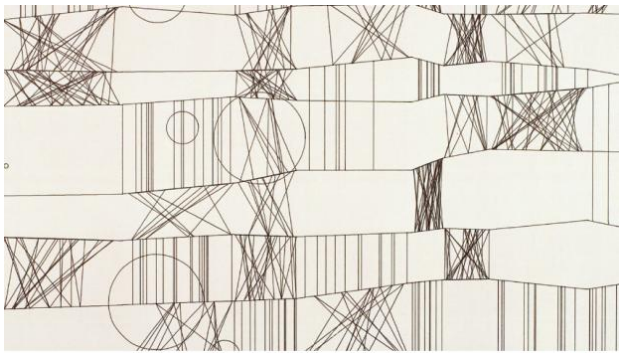

Fig2.1.Frieder Nake，Homage to Paul Klee1965

Source：https://www.rightclicksave.com/article/an-interview-with-frieder-nake

In the process of creating generative art, artists often utilize principles such as randomness, recursion, and feedback loops to design unique artworks. Randomness is widely used in the creation of art that produces unpredictable outcomes, such as music composition and procedural terrain generation. For example, in 2017, Refik Anadol created a digital generative artwork titled "Winds of Boston" (Figure 3.1), which was generated by analyzing data collected from Boston Logan Airport on wind speed, direction, gust patterns, as well as time and temperature throughout the year. Recursion generates intricate patterns and structures by repeating its process within the artwork. For instance, Australian digital artist Jonathan McCabe's "Flow Fields" series (Figure 4.1) uses recursive algorithms to simulate fluid motion found in nature, creating visual effects similar to rivers, smoke, and clouds. Feedback loops involve using the output of one process as the input for another, creating a continuous cycle of input and output. This method can generate ever-changing effects. For example, American artist Christopher Baker's "Hello World! or: How I Learned to Stop Listening and Love the Noise" (Figure 5.1) is a large video installation that showcases clips from thousands of video blogs, which are selected and organized using specific algorithms, forming a constantly evolving ocean of visuals and sounds.

Fig.3.1《The Wind of Boston》

Source：https://vimeo.com › Refik Anadol › Videos

Fig.4.1 《Flow Fields》

Source：https://www.flickr.com/photos/jonathanmccabe/albums/

Fig.5.1《Hello World! or: How I Learned to Stop Listening and Love the Noise》

Source：https://vimeo.com/1553583

3. Current State of Dissemination Forms for Song-Jin Opera Brick Carvings in Shanxi

Chinese traditional decorative artworks refer to various art pieces created during ancient Chinese historical periods, designed to adorn and beautify spaces. These artworks encompass a wide range of materials and forms, including ceramics, brick carvings, wood carvings, stone engravings, gold and silverware, textiles, embroidery, and murals.They reflect the values, religious beliefs, and folk traditions of ancient society, offering a window into historical lifestyles. The aesthetic value of these artworks is inseparable from their technical excellence and unique artistic styles, making them outstanding representatives of traditional Chinese art and exerting a profound influence on subsequent artistic creations (Bao Xiaoyue,2024). The Song-Jin opera brick carvings of Shanxi similarly embody rich cultural heritage and historical depth. However, over the long course of history and during the process of transmission, the original brilliance and vibrancy of these carvings have gradually faded due to the passage of time (Fu Liya,2023).

According to research, the primary mode of dissemination is through physical exhibitions.

These are mainly held in spaces such as museums, art galleries, and cultural heritage preservation institutions, where tangible displays allow visitors to experience the texture and intricate details of the artworks up close, enhancing their engagement with and understanding of traditional culture (Yan Ling,2024). In addition, virtual exhibitions are conducted through museum websites, mini-programs, and other online platforms (Gao Yuan,2024). However, this mode of dissemination remains relatively limited. Many individuals lack the time or opportunity to visit physical exhibitions, and inadequate promotion of certain artworks has led to their historical and cultural allure going unrecognized. This traditional approach also tends to lack engaging elements, making it less appealing to a broader audience.

4. Construction of a Design Model for Generative Art in Shanxi Song and Jin Dynasty Opera Brick Carvings

This design model begins with an analysis of the patterns, symbolic motifs, and cultural connotations of the design medium. Based on the principles of design, it selects sensory combinations to explore the possibilities of sensory engagement. Next, it outlines the methods of constructing the artwork, including the figurative processing of the design medium, the use of digital technology, and interactive techniques. These methods aim to achieve multimedia integration and cross-sensory experiences, eliciting emotional resonance, aesthetic anticipation, and bidirectional interaction from the audience (Figure 6.1).

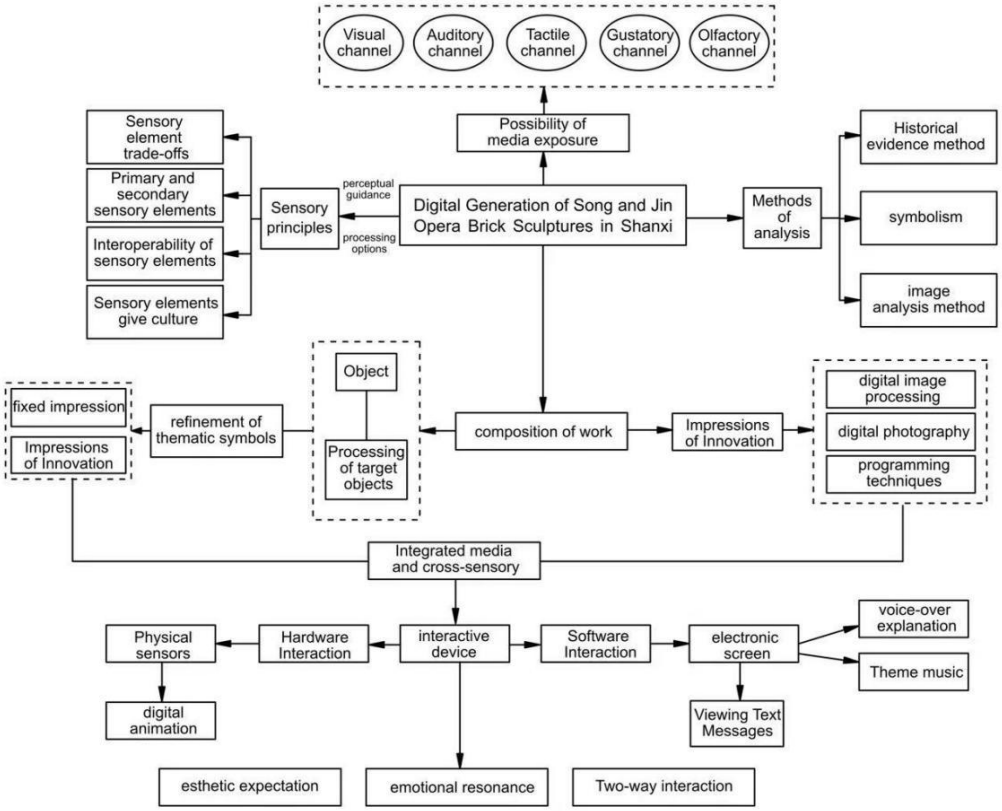

Fig6.1. Design model

4.1 Analytical Methods

4.1.1 Historical Textual Research Method

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This study examines historical documents, ancient texts, and archaeological findings related to Song-Jin opera-themed brick carvings in Shanxi, revealing their primary distribution in Yuncheng City and Linfen City. In Yuncheng City, the sites include the Xiaoluozhuang Jin Tomb, Sibai Jin Tomb, Yupu Jin Tomb, and Podijinqu Tomb in Wenxi; the Beisu Village Jin Tomb in Xinjiang; the opera and instrumental brick carvings in Dali Village and Nanfanzhuang, Xinjiang County; the opera character brick carvings in Beiwangma Village; and various carvings in Jishan, such as the opera orchestra brick carvings from Tomb No. 1, the opera performance brick carvings from Tomb No. 2, and opera character and orchestra carvings from Duan Family Tomb Nos. 3, 4, and 5. Other sites include the opera character brick carvings in Hualue, the opera character brick carvings from Miaopu Jin Tomb, and others.

In Linfen City, the primary site includes the opera-themed brick carvings from the Xiangfen Jin Tomb (Niu Jia,2015). Additionally, the literature categorizes the performance images on Song-Jin opera brick carvings into three main types: song, dance, and variety shows; opera with masked costumes; and comprehensive performances involving narrative and singing (Table 1.1).

Tab 1.1：Jin Dynasty opera relief bricks from Nan yuan zhuang /Bei su cun Tomb in Xinjiang, Shanxi

Song, dance, and variety show category				
				
Opera Mask Dressup Class				
narrative and singing				

4.1.2 Symbolic Analysis Method

During the Song, Liao, and Jin dynasties, wearing or pinning flowers was not merely an external decoration, but carried rich cultural meanings and profound symbolic significance. In the imperial court, wearing or pinning flowers was regarded as an important symbol of celebratory events, reflecting the ceremonial atmosphere of court festivities. Among the common people, wearing or pinning flowers similarly symbolized celebration and joy, becoming an indispensable part of feasts and festivals. In addition, wearing or pinning flowers also represented a proud and independent personality, reflecting the way the scholar-official class expressed their individuality, transcended worldly concepts, and critiqued traditional prejudices (Cheng Yajuan,2013)(Table 2.1). In the brick carvings of the bamboo-horse play, the children are dressed in cloud-shaped shoulder decorations, symbolizing blessings and auspiciousness(Table 3.1).

Such decorations and symbols not only enriched the spiritual and cultural life of people at that time but also provide an important perspective for understanding the social customs and cultural values of the Song, Liao, and Jin dynasties today. Through the study of these decorative arts, we can gain a deeper understanding of the people's pursuit of beauty, their attitudes toward life, and their desire for personal expression in that era.

Tab 2.1: Symbolic Meaning of Wearing Flowers

Customary	Title of the literature	Symbolism
flower hairpin	Dìng fēng bō · Shī shū mì xí shàng fù	Folk, Feasts, Celebratory
	Zhè gū tiān · Zuò zhōng yǒu Méi shān yǐn kè Shǐ Yìng zhī hé qián yùn, jí xí dá zhī	Independent Personality
	A Study of the Music, Dance, and Costume Art of the Song, Liao, and Jin Dynasties	National Celebration

Tab 3.1: Characteristics of Musician Costumes

cultural connotation	Title	Character	Features of attire

Secularization and popularization	mán pái Dance	Kids	Bare-chested with a collar around the neck, wearing pleated trousers below, with a belt tied into a knot at the waist, ribbons fluttering in the wind, and the pleated trousers secured at the bottom with 'diao dun' bindings.
	zhú mǎ Dance	Kids	The attire of paper-crafted zhuma.
	Lady Qiao	Kids	A veiled hat, wearing a long robe and a long skirt.
Blessing	zhú mǎ Dance	Kids	The collar area is adorned with cloud shoulder patterns in the shape of interconnected ruyi motifs

4.1.3 Image Analysis Method

Through the review of relevant literature, it can be found that the Shanxi Song and Jin Dynasty theatrical brick carvings are rich in variety. The costumes and colors worn by different performers, roles, and characters in various plays and storylines are carefully chosen. "The Song History – Records of Costume and Garments" in the Song History mentions that officials of the third rank and above wore purple robes, those of the fifth rank and above wore red robes, those of the seventh rank and above wore green robes, and those of the ninth rank and above wore blue robes (Zhang Beibei,2011). In the Dong family tomb in Houma, Shanxi, from the Jin Dynasty, the figurines of minor roles are dressed in yellow tiger-patterned clothes, black trousers, and red shoes. In the study "Research on Costume in Song and Jin Dynasty Dramas", in the "Shehuo" brick carvings from the Jin tomb in Nan Fanzhuang, Xinjian County, Shanxi, the figures wear a futou (official's cap), a belt at the waist, and black shoes .In the "Meng Liang Lu ", the kabuki part of the costume features mainly purple, scarlet and green wide shirts, gold belts, and yellow yiqi; the drummers have wide shirts, and there are also purple wide robes (Liu Yixin,2023).The "Wenxi Xiaoluozhuang Jin Mingchang Kabuki Brick Sculptures" show a different artistic style, as these kabuki figures were burned by molding technique, reflecting the fullness of the shape.These kabuki figures were fired by the molding technique, reflecting full shapes and vivid expressions. The three main colors used in the work are black, white, and vermilion.This simple

but bright color combination demonstrates its unique aesthetic characteristics, whether it is brilliant or simple, through the appropriate coordination and contrast of the three colors, a harmonious and unified visual effect is achieved.The visual effect of harmony and unity is achieved through the appropriate combination and contrast of the three colors.

4.2 Composition Methods of the Work

4.2.1 Figurative Approach

For the digital representation of Song and Jin Dynasty theatrical brick carvings, the primary step is to process the main subjects and extract symbols corresponding to cultural themes. For example, this can be applied to the images of performers in "Sanyue Baixi" (miscellaneous entertainments), "Shehuo" performances, bamboo horse performances in brick carvings, and the musical performance brick carvings from the Jin tomb at Xiaoluozhuang in Wenxi.

4.2.2 Digital Image Processing

Using the TouchDesigner visual programming software for visualization, the process starts with importing the base color-drawn brick carving images using the Movie File In node (TOP component). Next, a Grid node (SOP component) is created, with grid parameters adjusted to establish the Z-axis. Then, an Add node (SOP component) is inserted to create the X and Y axes. At this stage, the brick carving image appears with a relief effect. In geo1-Instance2-Color OP, RGB sampling is performed, and RGB is enabled, allowing the brick carving image to display its original colors. The brick carving image is then transformed into particle form. Adjusting the Z-axis coordinate values causes the particles to shift according to the numerical changes, resulting in a separation effect in the brick carving image. Finally, by tweaking the speed and noise parameters, the particle effects can be observed (Jin Yizhe,2022).

Through generative digital art, a visually dynamic and impactful effect is created. These particles can dynamically distribute according to the image's color, brightness, and shape, forming a work that retains the essence of the original brick carving art while offering a completely new visual experience. By adjusting the size, color, transparency, and motion trajectories of the particles, TouchDesigner brings these static brick carving images to life, as if ancient performance scenes are being reenacted before the audience's eyes (Feng Qiao,2023).

For the integration of auditory and tactile senses, generative digital art can further enrich the sensory experience through audio synthesis and haptic feedback technology. Audio input is used to import MP3 music files that match the instruments depicted in the musical performance brick carving images. All rhythm switches are enabled, and the music is trimmed. By adjusting relevant parameters and inputting expressions, the images automatically shift in response to the music's rhythm, while different images switch dynamically, creating a dynamic effect (Zeng Ziqing,Bi Wei,2024).

4.3 Application of Interactive Installations

Following the principles of sensory selection, sensory elements need to be prioritized, classified into primary and secondary, interconnected, and culturally enriched. In software interaction design, integrating touch-screen technology can provide users with an immersive and highly interactive experience. This allows them not only to listen to and read about the Shanxi Song and Jin theatrical brick carvings but also to enjoy the different instruments from the Song and Jin periods simultaneously. Such a design makes the learning and appreciation of traditional culture more vivid and intuitive.

First, after entering the application interface through the touch screen, users can view a series

of exquisite theatrical brick carving images. Alongside each image, detailed textual descriptions are provided, including the historical background, artistic features, the opera story depicted, as well as the characters and scenes featured in the carvings. Users can freely and interactively explore by simple touch gestures, such as swiping the screen to browse images or tapping specific areas to access more detailed information, making the learning process both flexible and engaging (Cao Chengxing,Duan Yong,2024).

Meanwhile, the application incorporates sound samples and introductions of different instruments from the Song and Jin periods. When users browse specific theatrical brick carving images, such as those depicting musical performance scenes, the application automatically plays the sounds of the instruments featured in the scene. Alternatively, users can actively choose to listen to the performance of a particular instrument, experiencing the charm of ancient music. This combination of sound and visuals not only enhances the user's sense of immersion but also helps them gain a more comprehensive understanding of the music culture and artistic styles of the Song and Jin periods (Luo Xueying,Shang Shuo,2024).

In summary, the application of digital image processing in multisensory experiences and generative digital art is not merely about the digitalization of brick carvings but also a recreation and reinterpretation of culture. It enables audiences to comprehensively and deeply perceive and understand the unique characteristics of ancient Chinese traditional art within the realm of digital art, offering new pathways for cultural inheritance and innovation. This process aims to spark audiences' interest in traditional art and imbue it with new vitality in the digital age.

In hardware interaction design, the integration of physical sensors to enable touchless gesture control provides users with a completely new interactive experience. By utilizing microcontrollers like Arduino and various sensors such as infrared detectors, an interactive system can be designed that allows users to manipulate digital art effects through gestures. Particularly in applications showcasing the particle effects of Shanxi Song and Jin theatrical brick carving images, this hardware interaction design not only enhances audience engagement but also enriches and adds dimensionality to the artistic experience.

Specifically, audiences can control the emergence and dissipation of particle effects in the brick carving images purely through air gestures, without the need to touch any screen or physical interface, as if they were manipulating smoke. This experience is undoubtedly both striking and magical. The touchless gesture control system uses infrared sensors to capture the audience's hand movements, while the Arduino microcontroller interprets these movements and translates them into corresponding commands to control the particle effects of the brick carving images. For example, a waving motion might cause the particle image to quickly disperse, while a pushing motion might make the particles slowly gather and eventually fade away.

In addition, tactile feedback devices such as vibration modules can provide haptic feedback when users perform specific gestures, enhancing the realism of the interaction. Visually, the particleized brick carving images dynamically change under user control, offering a sense of aesthetic beauty and artistic experience. Aurally, sensor-based controls can synchronize sound effects with gestures, such as matching specific gestures to the sounds of different instruments, ensuring that each user action is accompanied by corresponding auditory feedback, further enhancing the immersive experience (Chen Yujun,2023).

By integrating visual, auditory, and tactile multisensory interactions, this hardware interaction design not only provides users with a more intuitive and profound experience of traditional culture but also significantly increases the appeal and engagement of artistic works. Through this innovative interaction method, the ancient theatrical brick carving art is presented to the public in a modern technological form, not only paving new pathways for the inheritance of traditional

culture but also exploring new possibilities for the development of digital art.

5. Conclusion

In this context of an interconnected world, the forms of cultural dissemination have also undergone transformation. This presents both a challenge and an opportunity to foster innovation and rejuvenation. There is an urgent need to strive for the preservation and revitalization of these art forms, aiming to restore and showcase their inherent unique charm, thereby drawing more attention to them and helping people understand and appreciate them (Jia Li,2022). To achieve this, it is essential to deeply explore and inherit the deeper cultural essence while implementing profound reforms in institutional mechanisms to adapt to the renewal of traditional arts and cultural transmission under the impact of digital media. This involves leveraging the advantages of big data and employing technological means to more precisely protect and pass on traditional art. At the same time, great emphasis must be placed on the application of new media technologies to integrate traditional art into contemporary contexts, enabling it to better meet the aesthetic needs of modern audiences (Zhang Hanyue,Xu Ganli,2024).

Digital generative art, as a new art form emerging from the integration of contemporary digital technology and traditional art, possesses characteristics such as virtuality, interactivity, and digitality, and continues to refine its content and modes of expression through evolution (Jin Jiaqin,Xia Cuijuan,2021). Digitizing artistic and cultural expressions not only provides audiences with richer multisensory experiences but also enhances their ability to receive and comprehend information through interactivity, immersion, and innovative forms of presentation. This digital approach breaks the limitations of traditional dissemination methods, offering a comprehensive integration of visual, auditory, and even tactile elements to make art and culture more vivid and engaging, thereby attracting audiences from diverse backgrounds. Moreover, this experiential form of dissemination stimulates the audience's active participation, transforming them from mere recipients of information into contributors and creators of cultural communication. In this process, audiences gain a deeper understanding of the essence of art and culture, deriving a sense of fulfillment and belonging, and ultimately realizing their personal value. At the same time, digital expression provides broader channels for the dissemination of art and culture. Leveraging online platforms and new media technologies maximizes the social value of cultural transmission, allowing traditional art to be revitalized on a larger scale and fostering the inheritance and innovative development of culture.The digital expression of art requires drawing from and effectively utilizing the ideas and artistic symbols embedded in the culture of Shanxi Song and Jin theatrical brick carvings. This approach shortens the distance between communicators and audiences, reduces ambiguity and resistance in understanding cultural information, and encourages audiences to adopt new perspectives. By viewing Shanxi Song and Jin theatrical brick carving culture through a lens of discovery, audiences can develop an emotional resonance with the art form (Xu Guojun,2022).

In addition, digital generative art captures the interest of young people by emphasizing interactivity, innovation, and multisensory experiences, aiming to actively engage the younger generation in exploring this traditional art form (Huang Junhua,Zou Changyang,2024). The digital representation of traditional culture brings it new vitality, transforming it from static to dynamic and from one-way dissemination to interactive engagement. By presenting traditional culture in digital formats, it not only provides younger generations with more appealing ways to access these cultural treasures but also allows them to experience and interpret them from entirely new perspectives. Taking the Shanxi Song and Jin dynasty opera brick carvings as an example, digital tools can vividly showcase the historical narratives, artistic techniques, and cultural

significance of these carvings through virtual reality, animated videos, and other forms, offering audiences an immersive experience. Such efforts encourage young people to gain a deeper understanding and appreciation of the unique charm of brick carving art, sparking their interest in traditional culture while enhancing the influence of cultural heritage preservation. This initiative is not merely a means of safeguarding traditional art but also a fusion of cultural inheritance and innovation, aiming to inspire the younger generation's enthusiasm for traditional culture in the digital age, allowing it to flourish with renewed vitality in a modern context.

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