AI-Assisted Design for Intangible Cultural Heritage: A Study on the Tujia Hand-Waving Dance

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Abstract. Taking the Tujia hand-waving dance as an example, this study aims to apply AI technology to design to improve the design efficiency of intangible cultural heritage and promote the development and communication of related digital collections. Firstly, based on the video of inheritors’ performance, the study establishes a semantic dataset of the typical postures of Tujia hand-waving dance. Then, the study tries 3D reconstruction of the human body from the single-view images using AI algorithms. Later, the designer carves the details of the 3D models generated by AI. Finally, the human-AI co-created 3D models are transformed into NFT works. This study initially confirms that not only the AI-assisted workflow may obviously reduce the workload that designers need to invest in the early stage of modeling, but also can efficiently connect the links of data collection, 3D modeling, detail carving, and morphological transformation, thus improving the design efficiency of intangible cultural heritage.

Keywords. human-AI co-creation, intangible cultural heritage, 3D modeling, NFT

1. Introduction

The Tujia hand-waving dance is an ancient sacrificial dance included in the national intangible cultural heritage list. Inheriting the hand-waving dance in a contemporary cultural environment needs the support of innovative design and communication, which is also low-cost, flexible, and efficient at the same time. To explore the role AI-assisted design can play in this area, we carried out this experimental design. As shown in Figure 1, our research frame consists of the following parts.

- Design elements extraction. At this stage, we conducted fieldwork, filmed inheritors’ performance, built the image dataset, and selected the representative dance poses.
- AI-driven 3D modeling. At this stage, we constructed the computing framework, preprocessed images, and reconstruc ted the human body from single-view images.
- Manual refinement of the 3D model. At this stage, we drew the main view, sculpted the details of the 3D models, designed the style, and named the work series.
- NFT creation. At this stage, we casted the NFTs and authenticated them.

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2. Related Work

2.1. Single-view 3D dance posture reconstruction

The research reconstructs 3D model from frontal photos of the inheritors, involving algorithms such as gesture recognition, spatial prediction, and image translation. In terms of 2D posture reconstruction, previous research was based on OpenPose and image translation [1,2] to achieve the recognition and reconstruction of dance postures [3]. 3D reconstruction focuses on reconstructing pose using as little information as a single view [4,5,6,7,8,9]. Related work has initially achieved 3D reconstruction of the human body from single-view images or videos [10, 11, 12, 13, 14, 15, 16]. PIFuHD maps 2D images to 3D surfaces by predicting front and back normal maps in image space [17]. Its pre-training requires expensive computing resources and big data. But fine-tuning based on pre-trained models will be much more convenient. This research is based on PIFuHD to quickly generate 3D models, and then perform subsequent manual carving and scene rendering to realize the co-creation of humans and AI.

2.2. Blockchain-based NFTs

Previous studies have proposed that distributed protocols and cryptocurrencies can ensure the ownership of digital artworks, thereby promoting the development of the digital art market [18, 19]. Researchers believe that the art blockchain provides creators with opportunities to get closer to content consumers and buyers of cultural products [20], changing the ownership structure of digital artworks, forming two parts: collective ownership and private collections [21]. Blockchain-based NFTs present exciting opportunities for intangible cultural heritage. Traditionally, cultural products related to intangible cultural heritage are displayed and sold in tourist destinations, and most of them are physical products. For dance, this approach has many limitations. Our research attempts to digitize and transform cultural products into NFT collections and explore new ways in which intangible cultural heritage dance can be disseminated and sold in the contemporary cultural environment.
3. Design elements extraction

3.1. Inheritors interview and performance filming

We conducted a field survey in the birthplace of the Tujia hand-waving dance, Longshan County, Xiangxi Minority Autonomous Prefecture, Hunan Province, China. We interviewed the inheritors of the hand-waving dance, filmed the performance of the hand-waving dance in the hand-waving hall, and recorded the inheritor’s explanation of the main dance sequence. Figure 2 shows part scenes of the fieldwork: row (a) is about the survey on the big hand-waving dance, and row (b) is about the survey on the small hand-waving dance.

![Figure 2. Field survey in the birthplace of the Tujia hand-waving dance.](image)

3.2. Representative dance poses selection

The big hand-waving dance is a dance performed by the Tujia people to worship the ancestors of the Eight Great Kings. During the big hand-waving dance, the sound of drums is deafening, and the men hold sticks or short knives, like soldiers on the battlefield. The small hand-waving dance poses are based on women’s labor scenes and daily life, which are brisk and lively. We selected four representative poses from the big hand-waving dance and fourteen representative poses from the small hand-waving dance. As shown in Figure 3, these selected poses with rich narrative attributes and visual appeal are organized into four series of works.

4. AI-driven 3D modeling

The computational framework of AI-driven 3D modeling was referred to PIFuHD, which has a multi-level framework: a coarse level that integrates global geometric information by taking the down-sampled images as input and producing backbone images, and a fine level that adds more subtle details. A TelsaK80 GPU was used for computing. Figure 4 shows the process of modeling. Firstly, each single-view image was preprocessed, including cutting, binarization, denoising, and edge enhancement, to form a standard binary image of 512 * 512 pixels. After that, the frontside and backside normal maps of the single-view binary image were predicted based on the image translation algorithm pix2pixHD. Subsequently, the normal maps were converted into coordinates in 3D space, and the position of the Z-axis of each point in 3D space was calculated by the pixel-
aligned depth predictor. At the same time, the single-view binary image was synchronized to the lightweight human pose function for posture recognition and extraction. When the normal maps, spatial coordinates, and posture were determined, the value was recompiled from computer language to 10000 to 100000 3D surfaces of the 3D model with the pythoch3D function. Finally, the 3D human mesh diagram was rendered and saved in obj format for the subsequent carving.

![Figure 3. Representative poses of the hand-waving dance were organized into four series of works.](image)

It can be seen from Figure 5 that the AI-driven 3D modeling, which is based on a single-view image and without any additional information, basically completed the 3D modeling tasks. However, these AI-generated 3D models also have obvious flaws, such as missing parts, rough texture, etc., which means they need to be refined.

![Figure 4. The process of AI-driven 3D modeling.](image)
5. Manual refinement of the 3D model

When manually carving 3D models, the traditional approach is to conduct three-dimensional carving referring to the three views of the object, including the main view, side view, and top view. In the previous work step, AI-driven modeling completed the overall structure of the 3D model, which has greatly reduced the workload of human designers. At this stage, the designer only needs to perfect the frontside structure and texture of the model referring to the main view (see Figure 6).

In terms of art style, we designed an abstract and modern appearance for the work while retaining the characteristics of hand-waving dance (see Figure 7).

- Color design. The big hand-waving dance series is mainly black and dotted with gold, referring to the main colors of the big hand-waving dance hall. The small hand-waving dance is mainly white dotted with red, referring to the main colors of the small hand-waving dance hall.
- Facial features. The abstract facial features are covered with the texture of a golden mask, and the forehead of the female faces are dotted with red, which adds to the sense of mystery.
- Series naming. In the Tujia language family, ‘Wengke’ means gold, which is related to sacrifice. ‘Busuo’ and ‘Yongni’ refer to the first father and mother in Tujia mythology. ‘Modi’ means a hardworking person. ‘Yuezhi’ means an excellent farmer. Combining the above words, we named the four series of works respectively as ‘Wenke Busuo’, ‘Wenke Yongni’, ‘Modi Wenke Yongni’, and ‘Yuezhi Wenke Yongni’.

![Figure 5. Some results of AI-driven 3D modeling.](image1)

![Figure 6. The process of manual refinement of the 3D model.](image2)
6. NFT creation

To develop cultural and creative products of Tujia hand-waving dance that adapt to the new cultural and technological environment, we use NFT art as a way of innovative communication and sales. The above series of works were cast, certificated, and finally released on the NFT China platform on April 8, 2023 (see Figure 8).

7. Conclusion

How to introduce emerging technologies, such as artificial intelligence and blockchain, into the workflow to improve the design efficiency and promote communication and commercial transformation of intangible cultural heritage is the core issue of this
research. Taking the Tujia hand-waving dance as an example, comprehensive AI-driven 3D modeling and manual refinement, we created 3D models from single-view images of represented dance postures of Tujia hand-waving dance and transferred them to the NFT collections. The experimental creation process and results preliminarily confirm that the human-AI co-creation could significantly reduce the workload and cost that human designers need to invest in. In addition, the digital process significantly improves the overall efficiency of the design work.

With the widespread application of AI technology in the field of art and design, human designers need to master more IT skills. AI specialists are convinced that there’s some evidence that today’s larger models have some creative capability, but it is still rudimentary. When designers have more aesthetic ideas to express, the role of AI is still limited. The value of art and design lies in the expression of multiculturalism and the exploration of human creativity. Under the human-AI collaborative mode, this core value remains unchanged. Future research should pay more attention to fair access to AI technology, that is, to ensure that designers of different nationalities, languages, and technical resources can more easily use the latest AI technology for creation, thereby helping designers express their culture and ideas faster and better.

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