Moving Interactive Posters: A Study on Particle-Based Mimetic Imagery with the Case of Digital Nuo Ritual

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Abstract: - The evolution of particle-based mimetic imagery stems from simulating particle systems in computational physics, utilizing algorithms to model behavior and generate dynamic visualizations. Advances in interactive technology, particularly tools like TouchDesigner, now enable researchers and designers to manipulate particle trajectories, forms, and interaction logic in real-time. Integrating sensors, audio, or custom data transforms static posters into dynamic media. This study, using the *Digital Nuo Ritual* poster as a case, examines the methodology of employing TouchDesigner's particle systems for mimetic imagery and dynamic expression. It showcases the Nuo mask—a hand-carved wooden artifact central to ancient Chinese religious and witchcraft traditions dating to 1600 BC—exploring its digital transformation from national intangible cultural heritage. The research aims to preserve and disseminate this ancient ritual through innovative digital means.

Key-Words: - Moving interactive posters, TouchDesigner, Particle-based mimetic imagery, Nuo masks, Computing technology, Nuo culture, Traditional culture.

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1 Introduction

With the advancement of digital technologies, interactive media has emerged as an indispensable component of contemporary visual communication design. Within the domain of traditional graphic design (e.g., books and posters), designers are actively exploring novel interaction paradigms to adapt to the evolving demands of digital platforms, graphic designers are exploring new interaction models. Moving posters are an example of this. This type of poster combines the specific features of motion and print worlds to produce attractive forms of communication that explore and exploit the potential of digital screens, [1]. Within this domain, moving interactive posters, as a design medium that employs innovative approaches to extend the functional essence of traditional posters, have significantly enriched the dimensionality and depth of poster design. A moving interactive poster represents a digital media format that integrating moving visual elements with user interaction functionalities. Typically deployed through computer software, mobile applications, or web platforms, it generates real-time visual feedback in response to user behaviors such as clicks, swipes, and hovers. This form of poster not only conveys information but also enhances user experience through dynamic effects and interactivity, incorporating principles from ergonomics/human factors, human-computer interaction (HCI), and interaction design (IxD), [2]. TouchDesigner, a node-based visual programming tool with a distributed architecture, provides an enhanced and user-friendly interface to develop interactive design, [3].

The morphological design of Nuo masks aligns with the iconography of deities worshipped in contemporaneous ritual practices. Originating in primitive societies, the Nuo exorcism ceremony emerged under the combined influences of hunting

activities, totemic worship, and shamanistic practices, with the donning of Nuo masks constituting a central ritual act. The mask, when worn, transcends its material form to embody divine agency; its removal reverts the wearer to human status. Thus, the Nuo mask is a liminal medium bridging the human and heavenly realms, materializing intangible spiritual forces into perceptible forms. Through this mechanism, the Nuo ritual establishes a symbolic nexus between empirical reality and metaphysical constructs, [4], [5].

The differences between the article and the existing literature are: (1) This article investigates transforming images into particles in TouchDesigner from the perspective of Nuo culture digitalization. (2) This article employs the particle system in TouchDesigner to design and analyze the creation of a moving poster for Nuo masks, an intangible cultural heritage. It further explores integrating particle systems with digitally preserving intangible cultural heritage. This interdisciplinary design theme remains underexplored in current literature.

2 Review of Research

2.1 Constructing Digital Art with TouchDesigner as the Foundation

The title 'Audiocloudscape'. Within Touchdesigner, I play with the point cloud by transforming the point particle cloud to respond to the live audio feed I perform in real-time. The combination of two data inputs, being high and low frequencies, creates a visual that glitches at the interference of two sources, [6]. Another project by Vincent Houzé's 2018 "Fluid Structure 360", In this immersive digital artwork that engulfs the audience by stretching all around the room, projectors shine on the walls of the darkroom and together with motion sensors and computer-generated visuals creates a spectacle where the visitor is constantly influencing and changing the look and state of the artwork by TouchDesigner, [7]. An exploration of TouchDesigner's applications in the digital innovation of ink art, this artwork presents a novel approach for the preservation and reinterpretation of Chinese traditional culture and art, [8]. A project at the University of Greenwich, making use of procedural interaction design using the TouchDesigner software, will map noise parameters onto a 3D particle system to be displayed on an AR environment, [9].

2.2 The Artistic Representation and Preservation Practices of Nuo Masks

2.2.1 The Artistic Features and Symbolism of Nuo Masks

Nuo masks are sacred objects, theatrical props, and artistic creations. Existing Nuo masks can be categorized into four primary types: deity-beast type, anthropo-zoomorphic type, deity-general type, and folk deity type. Masks of the deity-beast type predominantly exhibit animalistic features, including purely animal forms. The anthropo-zoomorphic type integrates human and animal characteristics, often displaying a fierce demeanor. Masks of the deity-general type represent divine generals derived from historical narratives or legends. Lastly, the folk deity type encompasses minor deities and secular figures.

Regarding carving and modeling, Nuo masks preserve the rough textures and coarse lines characteristic of hand-carved woodwork, emphasizing decorative elements, intricate textures, and dynamic lines. Facial expressions vary widely across different masks. The chromatic schema employs high-saturation contrastive color pairings—notably red-black and white-green—to demarcate facial zones and amplify symbolic resonance. Decorative motifs integrate traditional patterns such as cloud scrolls and flame volutes, which serve dual functions as aesthetic embellishments and cosmological signifiers. This synthesis of vernacular craftsmanship and symbolic codification constitutes a unique visual grammar within East Asian ritual art traditions, bridging material practice with spiritual semiotics, [10].

2.2.2 Digital Construction of Nuomian Masks

With the rapid advancement of the internet, multimedia, and communication technologies, the intersection between technology and culture has become increasingly intertwined, creating new design opportunities for the inheritance and innovation of intangible cultural heritage (ICH). Digitization facilitates the migration of cultural assets into online platforms, significantly broadening the dissemination of ICH.

Current digital initiatives for Nuo masks primarily focus on three directions: 3D Digitization and Archival Preservation: This approach employs 3D scanning and modeling techniques to construct a comprehensive database of Nuo masks, ensuring the long-term preservation of their digital morphological data.

Big Data Integration and Shared Platform Development: Centered on holistic data processing of Nuo culture, this strategy integrates multidimensional resources—including 3D mask models, Nuo opera repertoires, and panoramic maps of ritual sites—to establish a networked resource-sharing platform with standardized management through two-dimensional data aggregation, [11].

Visual Programming and Generative Redesign: Leveraging computational design technologies, this direction extracts formal elements such as sculptural features and decorative patterns for digital reconstruction and innovative design. Dynamic graphics generated via TouchDesigner enhance multidimensional artistic expression in virtual environments, as demonstrated in recent research, [12].

As static material artifacts, Nuo masks are inherently constrained by their fixed forms and ritual contexts, limiting their modes of dissemination. The dynamic reconfiguration of Nuo masks using TouchDesigner preserves their artistic essence while harnessing the "fluidity" of digital mediums. This synthesis bridges traditional and modern aesthetics, offering a novel paradigm for disseminating and presenting ICH.

2.2.3 Inheritance and Protection of Nuo Masks

The protection of Nuo culture is currently conducted through two primary approaches. First, the inheritance of traditional handicrafts associated with Nuo culture has been prioritized. For instance, Jiangxi Province has established a team comprising 18 skilled artisans and three provincial-level inheritors to ensure the continuity of these crafts. Second, efforts are being made in digital dissemination. Although the 3D modeling and data archiving of Nuo masks have only been implemented on a small scale within regions where Nuo culture thrives and in museums, Guangxi Province is actively promoting the development of the Nuo cultural industry in relevant universities and fostering university-enterprise collaborations. The protection of Nuo masks integrates both material carriers and intangible cultural connotations. Digital technology, as a current research hotspot, plays a crucial role in this process. By leveraging digital platforms such as international intangible cultural heritage exhibitions and virtual museums, combined with dynamic design forms, it becomes possible to balance the preservation of traditional elements with innovative expressions of Nuo culture.

3 Particle-Based Mimetic Imagery

3.1 Basic Concepts and Key Characteristics of Particle-Based Mimetic Imagery

The principle of particle-mimetic imagery constitutes a visual technology that simulates behavioral patterns of natural particles, such as the diffusion of smoke, the undulation of flames, and the fluid dynamics of water, to generate image effects characterized by hyper-realistic fidelity and kinetic aesthetics. When applied to dynamic interactive posters, this methodology significantly enhances visual impact while enabling the conveyance of layered information and affective states through particle-based parametric transformations. By leveraging the inherent dynamism of particle systems, the technology facilitates nuanced communication of semantic content and elevates user sensory engagement, thereby optimizing information transmission efficacy within interactive media environments, [13].

In the context of interaction design and music visualization, the particle system serves as a computational model and a powerful tool for artistic expression. The construction of a particle system relies on the precise control of individual particle attributes, such as position, velocity, color, size, and life cycle on the screen. Since the concept of dynamic particle systems was first introduced in 1983, [14], research in this area has continuously advanced, enabling the simulation of increasingly complex and realistic natural phenomena while creating visually dynamic elements. In 2015, particle swarm technology was optimized to automatically generate complex graphic characters, representing a significant milestone in applying particle systems in graphic design and artistic creation, [15]. In moving interactive posters, particle systems' dynamic effects, interactivity, and technical implementation collectively drive the image transformation process. This particle-based mimetic image transformation enhances visual impact and enriches the posters' expressive dimensions and emotional depth, [16], [17].

To further enhance interactivity and user experience, designers can leverage tools such as TouchDesigner to integrate particle systems with audio signals, user interactions, and other dynamic elements. Through audio analysis, music's rhythm, frequency, and intensity can be mapped onto the movement and transformations of particles, enabling a synchronized and immersive presentation of music and visuals. Simultaneously, by incorporating sensors or other input devices, users can directly

engage with the poster, dynamically influencing particles' behavior and visual effects, thereby creating a distinctive and personalized experience. Moreover, the principle of particle mimetic imagery can be synergized with data visualization techniques, translating abstract data into intuitive and visually engaging particle representations. This data-driven approach delivers rich and moving visualizations and empowers users to explore and interpret the underlying stories and meanings within the data.

3.2 Implementation of Particle Mimicry Image Technology in TouchDesigner

TouchDesigner (TD), developed by the Canadian company Derivative, is a node-based visual programming software. It can handle data processing for both local and network scenarios, sensor signal transmission and reception, 2D/3D graphics generation engines, virtual reality simulation, and other full-media functionalities. Hence, TouchDesigner is one of the most prevalent design tools for generating interactive moving posters.

TouchDesigner produces content through a node connection programming approach. Its nodes are categorized into distinct module sets based on diverse content production logics: TOP (Texture Operators for image processing node sets), CHOP (Channel Operators for data processing node sets), SOP (Surface Operators for 3D modeling node sets), MAT (Material Operators for material rendering node sets), DAT (Data Operators for dataset processing node sets), COMP (Components for interface node sets), and Custom (Custom node sets).

In TD, custom node linkages can accomplish the dynamic effect of converting an image into particle mimicry. Typically, five steps are necessary to realize the dynamic transformation from an image to particles: Input-control chain, mapping chain, instance chain, render & post chain, and movie file out. The Input-control chain is to establish a flexible image material transformation system, within which users can switch image materials at will. Different image materials reach the mapping chain, the core step for achieving "image particleization". Its objective is to "translate" the image output from the previous step into a language that the particle system can comprehend and utilize. The instance chain is based on the particles generated in the last stage mapping, which contain attributes such as position and color, to form a dynamic particle cloud effect. Through the render & post chain, the constructed 3D particle scene is captured and rendered into a video by a virtual camera, ultimately facilitating video export.

4 Application Examples and Case Studies

4.1 The Design Framework of "Digital Nuo Ritual"

In visual design, the integration of interactive design with particle-mimetic imagery has unlocked multifaceted innovative possibilities across diverse design domains, particularly demonstrating unique expressive potential in visual communication design and new media art. Translating intangible cultural heritage or traditional cultural elements into moving visual representations has become a prominent research focus within contemporary design practice. Regions worldwide are actively advancing the development of digital exhibitions and platform optimization.

Digital Nuo Ritual exemplifies a moving poster design project synthesizing China’s national-level intangible cultural heritage—Nuo masks—with particle-mimetic imagery. The conceptual impetus originated from the author’s field research at the Guizhou Nuo Mask Museum, where insights into the challenges facing the modern preservation and transmission of this ancient ritual prompted collaborative initiatives with local academic institutions. This interdisciplinary endeavor aims to innovate developmental strategies, creative reinterpretation, and conservation methodologies for Nuo culture.

To achieve the digital image transformation of Nuo masks, it is essential first to categorize their typological characteristics. Among the over 700 preserved masks, they are broadly classified into four types: deity-beast type, anthropo-zoomorphic type, deity-general type, and folk deity type.

The anthropo-zoomorphic type synthesizes human facial structures with zoomorphic traits, resulting in masks that ambiguously straddle human and beast-like appearances. Masks of the deity-general type emphasize authoritative expressions, typically featuring wide-open eyes to accentuate solemnity and power. The folk deity type predominantly embodies agrarian deities from folk beliefs, such as the Earth God and Kitchen God, reflecting farming communities' aspirations for prosperity. After photographing these four categories of masks, four representative specimens with distinctive morphological configurations, chromatic compositions, and expressive characteristics were selected for digital reinterpretation. The framework comprises three processes in Figure 1: visual prototyping based on

cultural taxonomy, technical transformation protocols, and digital adaptation workflows.

This case study demonstrates a comprehensive design workflow and critical technical implementation for transforming Nuo mask materials into dynamic particle-based videos through particle-mimetic imagery, ultimately generating dynamic posters. The analysis focuses on the nodal architecture within the core project components, elaborating on three primary stages—material input and control, feature extraction and data mapping, and particle system construction and dynamization—to detail the functional roles, parameter configurations, and data logic conversions of pivotal nodes. This systematic exposition provides technical references for research and creative practices in computational design and cultural digitization.

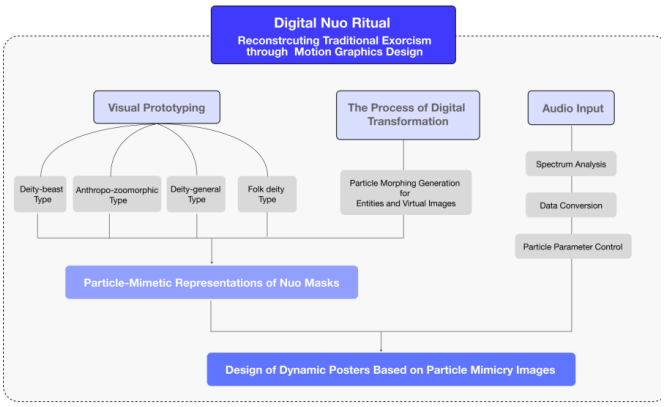

Fig. 1: The Design Framework of "Digital Nuo Ritual"

4.2 Material Input and Control System

This section focuses on establishing a flexible material management system in TouchDesigner (TD) capable of dynamically loading and switching source images as shown in Figure 2. The selected materials undergo basic size normalization and preliminary color adjustments to ensure stability and consistency in subsequent processing. Each node's corresponding material file can be precisely identified by programmatically reading file parameters. For material switching, the author implemented a keyboard-driven control chain. Script analysis reveals the inter-node connections and parameter modes, elucidating the mechanism: the Keyboard Input node captures key signals, driving the Counter node to generate an incrementing index *i*. The Counter's loop upper limit N_{max} is not fixed but dynamically linked via an expression to the value of a Constant CHOP node storing the total material count, i.e., N_{max} = *op('constant3')[0]*. This design eliminates manual counter parameter adjustments when modifying material counts, enhancing scalability. The dynamically generated index i is passed to the Switcher node's Index parameter via Export or Bind modes, enabling cyclic Nuo mask switching through keyboard input. Batch-extracted annotation component text confirms this interaction design: pressing "1" cycles through images. After selection, materials pass through Size Adaptation and Color Adjustment nodes. Node parameter values reveal specific settings: all materials are resized to a uniform resolution 1280x1280 with preliminary brightness and contrast adjustments, ensuring consistent dimensions and visual characteristics for downstream processing.

Fig. 2: TouchDesigner Node Connection Diagram

4.3 Feature Extraction and Data Mapping

To extract the image features of Nuo masks for particle mimicry analysis, TouchDesigner (TD) divides the preprocessed image into two streams, each entering a separate threshold processing node. The parameters of these nodes are programmatically read via a script. Specifically, the location-based threshold node (thresh2) performs screening based on brightness *L*, with its logic formalized as Eq. (1):

$$Pixel_{pos} = \begin{cases} 1 & if \quad L(I(u,v)) \geq T_{pos} \\ 0 & otherwise \end{cases} \quad (1)$$

Here, *I(u,v)* denotes the pixel value of the image at the *(u,v)* coordinate. The color threshold node (thresh1) employs the softness parameter Scol to produce a result with gradient Alpha for subsequent transparency control. The two threshold-processed images are routed to two critical image-to-channel nodes (TOP to CHOP). By analyzing their key parameters, the system accurately reconstructs the core mapping rules:

(1) Color Mapping (TOP to 1): The color information of the pixels filtered through thresh1 is extracted. This process can be shown as Eq. (2):

$$(C_r, C_g, C_b, C_a) = (R, G, B, A)_{I(u,v)} \quad (2)$$

Write these values into the r, g, b, and a channel of the output channel operator (CHOP).

(2) Position Mapping (TOP to 2): For the pixels filtered through thresh2, extract their normalized coordinates *(u, v)* on the image plane. These coordinates are subsequently processed and mapped to three-dimensional coordinates *(Px, Py, Pz)*, written into the CHOP's tx, ty, and tz channels. The linear mapping is expressed as Eq. (3):

$$\begin{aligned} P_x &= scale_x \times (u - 0.5) \\ P_y &= scale_y \times (v - 0.5) \\ P_z &= f(I(u,v),t) \quad or \quad constant \end{aligned} \tag{3}$$

Among them, $scale_x$ and $scale_y$ are scaling factors; -0.5 is used to shift the coordinate center to the origin, while P_z can either be a fixed value or determined by pixel brightness or an external dynamic signal (e.g., a low-frequency oscillator, LFO) as implemented in this project file.

The Image-to-Channel node (TOP to CHOP) is the core executor of "mapping analysis." Its internal algorithm performs pixel sampling on the TOP element according to user-defined parameters. By reading these parameters, computer analysis enables us to infer and describe the algorithm's behavior precisely: extracting pixel position information based on output coordinates, extracting color components based on RGBA values, and writing these values into the corresponding channels of the CHOP element. Each row represents a potential particle, and each channel corresponds to an attribute of that particle. This process establishes the critical "mapping" from visual images to abstract numerical data, while script-based analysis provides an objective foundation for understanding, validating, and reproducing this core transformation step.

4.4 Particle System Construction and Dynamicization

The core functionality in this case, transitioning from image to dynamic particle realization, lies in the construction and dynamicization of the particle system. TD analysis confirmed the chain of nodes−gridSOP, convertSOP, and null1−that provides the instantiated geometry template. By reading the parameters of the Instance node in geo1 through a script, the instantiation mechanism can be precisely validated: the Instance OP points to null4, which contains the particle attribute data. This indicates that geo1 creates a geometric instance for each row of data in null4. The parameters of Translate OP and Color OP also reference null4, with the corresponding X/Y/Z and color R/G/B/A parameters set to use the tx, ty, tz, and r, g, b, a channel names generated during the mapping process in null4. This clearly demonstrates how the spatial position and initial color of each particle are precisely driven by the channel data generated in the previous mapping step, achieving the effect of illuminating particle graphics based on image data.

Next, to animate the particles, the parameter mode analyzes the remaining instantiation parameters of geo1. The driving source, as confirmed by the script, points to the dynamic signal generation network composed of lfo3, delay1, and math7. For example, lfo3 generates a smooth periodic signal, and its output $V_{LFO}(t)$ can be expressed as Eq. (4):

$$V_{LFO}(t) = A \times wave(2\pi ft + \phi) + offset \tag{4}$$

Among them, A represents the amplitude, f denotes the frequency, ϕ signifies the phase, and wave refers to the waveform function. This signal is generated by passing through the delay node, see Eq. (5):

$$V_{delayed}(t) = V_{LFO}(t - \Delta t) \tag{5}$$

Then, the mathematical operation node processes these signals to generate the channel $S(t)$, which controls the scaling, see Eq. (6):

$$S(t) = S_{base} + k \times V_{processed}(t) \tag{6}$$

Here, S_{base} represents the base scaling value, k denotes the influencing factor, and $V_{processed}(t)$ refers to the processed LFO or delay signal. The $S(t)$ channel is ultimately bound to or mapped onto the scale parameter of geo1. This realizes the dynamic behavior of the particles, endowing the particle system with an organic and continuously evolving sense of vitality. Lastly, line1 is applied to geo1, determining the final rendered appearance of these extensively instantiated points or lines.

4.5 Moving Interactive Poster of "Digital Nuo Ritual"

This study systematically deconstructed the comprehensive design and technical workflow for creating a moving poster of particleized Nuomu mask images using TouchDesigner through computer analysis methods and visual network observation. By integrating the aforementioned content analysis with refined design elements, the study successfully transformed static cultural symbols into engaging digital moving visual artworks in Figure 3.

Fig. 3: Screenshot of the Moving Interactive Poster"Digital Nuo Ritual"

5 Conclusion

The evolution of the internet has enabled the widespread application of programming software across diverse fields. TouchDesigner, with its node-based visual programming environment, grants creators' exceptional flexibility by allowing the construction of complex real-time interactive systems through the interconnection of modular nodes. While this graphical development approach enhances operational intuitiveness, it may concurrently lead to increasingly intricate and expansive project architecture. Practical case studies combined with systematic engineering analysis can elucidate inherent mechanistic variations while streamlining subsequent creative processes.

This research centers on the principle of particle-mimetic imagery within moving interactive posters, integrated with the digital representation of China's national intangible cultural heritage—Nuo masks—to explore TouchDesigner's technical pathways and practical value in cultural preservation and innovative design. The "Digital Nuo Ritual" case study validates particle systems' feasibility and real-time interactivity in moving visual transformation. Leveraging TouchDesigner's node-based programming, a comprehensive technical framework was established, encompassing the extraction of Nuo mask image features, data mapping, and dynamic particle system generation. This framework facilitates the transformation of static cultural symbols into dynamic interactive media, preserving the original artistic essence of Nuo masks while harnessing the fluidity of dynamic particles to expand their communicative potential through flexible, reusable technical solutions.

As an iterative study, current research acknowledges limitations, such as the potential integration of traditional Nuo opera and dance with music visualization and 3D modeling programming to reconstruct Nuo cultural contexts more comprehensively—a direction prioritized for future investigation.

The fusion of particle-mimetic imagery principles with Nuo culture embodies a dialogue between technology and art and a symbiosis of tradition and modernity. This work advocates for heightened scholarly, designer, and artist engagement in the digital representation of traditional culture, anticipating future interdisciplinary case studies that harness technological innovation to revitalize cultural heritage with contemporary vitality.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the first author used Deepseek AI tool, in order to paraphrase few paragraphs. After using this tool, the first author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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