

The Translation and Application of Dong Ethnic Embroidery Techniques in Touch Interface Gesture Inter-Action Design

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ABSTRACT This paper investigates the translation of Dong ethnic embroidery, a traditional textile craft, into touch-interface gesture interaction design. By analyzing the movement language of Dong embroidery, the textile production process, and their structural correspondence with touch-based interaction elements, the study establishes a mapping relationship between embroidery movements and digital gestures. The analysis shows that stitch trajectories, pressure control, and spatial pattern logic can be abstracted into gesture paths, touch intensity, and interaction hierarchy. The study highlights the cultural and interaction values of this translation, including the inheritance of ethnic cultural elements, improvement of interaction naturalness, and formation of cultural identity in digital interfaces. Three design strategies are proposed: trajectory translation of embroidery movement paths, interactive feedback design based on pattern logic, and rhythmic motion-effect presentation. These strategies provide a feasible method for integrating traditional craft logic into modern human-computer interaction design and offer a cultural innovation path for touch-interface gesture systems.

INDEX TERMS dong embroidery, textile craft, touch interface, gesture interaction, translation design

I. INTRODUCTION

THE digital wave has swept the globe, and touch interfaces have become the mainstream form of human-computer interaction. The quality of gesture interaction design directly impacts user experience [1]. Currently, most gesture interaction designs follow Western design paradigms, lacking in-depth application of Chinese local cultural genes. Dong embroidery is one of the representatives of traditional Chinese textile crafts. Its technique system contains a wealth of movement language, spatial logic, and rhythmic patterns, elements that are naturally closely related to touch gesture interaction design. Having been passed down for thousands of years, Dong embroidery techniques have formed their own unique movement norms and aesthetic system. The movement trajectory of threading the needle, the spatial logic of pattern construction, and the rhythmic variations of needlework can all serve as innovative elements for touch gesture design. Translating and applying Dong embroidery techniques to touch interface gesture interaction design is a creative inheritance of traditional textile craftsmanship and an important attempt to find an interaction design language with its own unique Chinese characteristics.

II. A CORRELATION ANALYSIS BETWEEN DONG ETHNIC EMBROIDERY TECHNIQUES AND TOUCH GESTURE INTERACTION

A. THE MOVEMENT LANGUAGE CHARACTERISTICS OF DONG EMBROIDERY TECHNIQUES

Dong embroidery is an important part of traditional textile crafts. Its movement language characteristics are mainly reflected in three aspects: needle movement trajectory, pressure control, and spatial positioning [2]. The needle movement trajectory exhibits a unity of continuity and direction. The embroiderer relies on flexible wrist rotation and precise finger control to create an organic whole from points, lines, and planes. The beginning and end of each stitch must follow spatial order. Pressure control is mainly reflected in the depth of the needle and thread penetrating the fabric. Different patterns require different levels of pressure, and the tactile feedback mechanism constitutes the core perceptual system of embroidery techniques. Spatial positioning refers to the embroiderer's overall control of the planar layout. Within a pre-set compositional framework, the embroiderer arranges stitches to form a layered pattern structure [3].

B. CORE ELEMENTS OF TOUCH INTERFACE GESTURE INTERACTION DESIGN

Touch interface gesture interaction design consists of three elements: action recognition, feedback mechanism, and semantic mapping. Action recognition requires determining the identifiability and distinguishability of user actions, while action parameters, including number of touch points, movement trajectory, speed changes, and pressure distribution, form the digital representation of the gesture [4]. The feedback mechanism emphasizes immediate feedback during the interaction process, conveying information about the operation status to the user through visual, auditory, or tactile means, ensuring the continuity and controllability of the interaction. Semantic mapping refers to the relationship between gesture actions and functional commands. Good gesture design should ensure a high degree of consistency between the semantics of the action and the functional logic, reducing the user's cognitive burden. Touch gesture design should strive for naturalness and intuition; ideal gestures should conform to human habits and cognition, establishing a connection between action and function in the shortest possible time.

C. MAPPING RELATIONSHIP BETWEEN ACTIONS AND GESTURES IN DONG EMBROIDERY TECHNIQUES

The actions involved in Dong ethnic embroidery techniques exhibit mapping relationships with touch gestures in three aspects: action structure, spatial logic, and rhythmic characteristics. In terms of action structure, the needlework trajectory in embroidery and the sliding path of touch gestures share a similar projected planar kinematic trajectory after abstraction [5]. Although embroidery movements are inherently three-dimensional, involving in-and-out-of-plane puncturing and weaving and often requiring the coordination of both the resulting visual outcome on the fabric resulting visual outcome on the fabric—the stitch trajectory—can be represented as a two-dimensional path. This path can be decomposed into fundamental geometric elements, such as straight lines, arcs, and points, which form the basis for kinematic translation.

Based on this abstraction, the mapping in this study focusing on the intent and visual result of the movement on the plane, treating the in-plane component of the needle motion as the primary source for the digital gesture design. The value of this translation lies not merely in the general planar motion, but in the culturally codified movement language in specific stitch sequences and geometric structures that have been developed over millennia within the Dong tradition [6]. By translating the aesthetic outcome and the efficient movement pattern reflected in the geometric path of the stitch, the design transfers both cultural memory and ergonomic optimized motion principles into the digital interaction context.

Regarding spatial logic, embroidery pattern construction follows a compositional principle that progresses from local elements to the overall structure. This organizational logic

corresponds to the multi-level navigation structure of touch interfaces. Accordingly, the spatial segmentation and combination rules of embroidery patterns can be transformed into an interface layout framework and interaction hierarchy design. In terms of rhythmic characteristics, variations in stitch density and needle movement rhythm correspond to changes in touch gesture speed. These rhythmic variations influence both the smoothness of the interaction and the expressive qualities of user expression [7].

III. THE VALUE AND SIGNIFICANCE OF THE TRANSLATION AND APPLICATION OF DONG EMBROIDERY TECHNIQUES

A. INHERITANCE OF ETHNIC CULTURAL GENES AND INNOVATION IN DESIGN LANGUAGE

The translation of Dong ethnic embroidery techniques into touch gesture interaction design enables the contemporary inheritance of ethnic cultural elements in the digital context [8]. As a form of intangible cultural heritage, traditional textile techniques face challenges related to declining transmission and limited practical applications. Through design translation, key principles of embroidery techniques can be integrated into modern digital products, creating new possibilities for their application in contemporary contexts. This process does not involve simple appropriation; rather, it entails the systematic extraction and reconstruction of the underlying logic of embroidery techniques. Spatial thinking, aesthetic principles, and craft knowledge embedded in the needlework are transformed into an interactive language that can be perceived and interpreted by contemporary users. In this way, translation facilitates a dialogue between tradition and design practices, allowing ethnic culture to be incorporated into everyday digital experiences. At the same time, such translation contributes to the formation of a distinctive design language, helping touch interface design move beyond homogeneous solutions and develop culturally differentiated characteristics [9].

B. ENHANCING THE NATURALNESS AND INTUITION OF USER INTERACTION

Gesture interaction design based on Dong ethnic embroidery techniques can improve the naturalness and intuitiveness of the user experience. Embroidery movements, evolved over millennia, conform to ergonomic principles and cognitive patterns. Their comfort and efficiency have been tested over time. Applying these historically selected, high-quality movement patterns to touch gesture design can reduce user learning costs and operational fatigue [10]. From dipping the needle in water to weaving it into the surface, the rhythm and cadence inherent in embroidery inject a sense of rhythmic cadence into touch interaction, transforming digital operations into a more physically intuitive and engaging interaction, increasing user emotional engagement and immersion. For users with an embroidery cultural background, gestures designed based on embroidery techniques can evoke cultural memories, facilitate emotional connection

and memory retrieval, and create a special cultural affinity, thereby increasing user stickiness [11].

C. DESIGNING AN INTERACTIVE INTERFACE IMBUEW WITH CULTURAL IDENTITY

The translation and application of Dong ethnic embroidery techniques infuse touch interfaces with a distinct cultural identity, enhancing their perceived cultural value. In the context of globalization, the cultural differences of digital products are increasingly becoming a key competitive factor. Interactive interfaces with cultural identity can gain a differentiated competitive advantage in a standardized market. Embroidery techniques, as an important carrier of ethnic culture, are translated onto touch interfaces, making them a medium for cultural expression. Users not only complete functional operations but also actively engage with the cultural narrative. Cultural integration increases the cultural symbolic and emotional value of products, transforming users from passive consumers into participants in the culture, thereby deepening brand identity and cultural belonging. Gestures using Dong embroidery techniques as design elements become a window for overseas users to understand Chinese culture. The interaction process serves as a practical arena for cross-cultural communication, enhancing China's cultural dissemination power and international influence. The formation of cultural identity strengthens the designer's sense of social responsibility, enabling commercial products to assume the responsibility of cultural inheritance, thus achieving a unity of economic and cultural value.

IV. TRANSLATION STRATEGIES OF DONG ETHNIC EMBROIDERY TECHNIQUES INTO GESTURE INTERACTION DESIGN

To systematically present the digital translation mechanism of Dong ethnic embroidery techniques, this study constructed a three-dimensional translation framework (see Figure 1), establishing a mapping pathway between embroidery techniques and touch interaction from three levels: movement, pattern, and rhythm.

A. TRAJECTORY CONVERSION OF EMBROIDERY GESTURE PATHS

Translating embroidery motion trajectories into touch gesture paths requires establishing a systematic mapping mechanism based on kinematic abstraction, focusing on the planar visual output of the stitch rather than the complex 3D process of needle manipulation. First, typical Dong embroidery stitches are broken down into basic motion units, extracting key parameters such as starting point coordinates, direction of movement, trajectory curvature, and speed changes to construct a digital model of the motion [12]. This abstraction focuses on the path of the stitch on the fabric's surface, translating the intended visual line into a digital gesture path. Research data shows that straight-line stitches account for 42% of the stitches used in Dong embroidery, curved stitches account for 35%, and dotted stitches account for

23%. This can guide the composition of the gesture library. Straight-line stitches are converted into straight-line sliding gestures, retaining the directional and speed control elements of embroidery. This is justified by treating the linear stitch as the fundamental planar translation motion. The length of the gesture matches the span of the stitch, and the sliding speed corresponds to the speed of the stitches. Functionally, the straight-line movement maps directly to directional translation commands: for example, a straight vertical swipe translates into scrolling or page navigation, while a short, sharp linear swipe can signify selection or list filtering. This connection is semantically consistent with the embroidery action's primary intent of covering distance in a defined direction. Curved stitches are represented by arc-shaped sliding gestures, relying on the radius of curvature parameter to recreate the curvature of the embroidery curve. The curved stitch is abstracted as a continuous planar rotation/arc motion. The smoothness of the gesture must meet the continuity requirements of the embroidery curve. This continuous, wrapping trajectory lends itself to non-linear functional mapping such as circular menu navigation, object rotation, or the 'undo/redo' command, drawing on the stitch's inherent quality of enclosure and sweeping motion. Dotted stitches refer to the short-distance movement of the needle tip on the fabric [13]. These movements, which involve a sharp vertical change in pressure, are abstracted into a simple tap or press gesture. Pressure sensing simulates the force change of the needle tip piercing the fabric, and the pressure threshold is set with reference to the embroidery force level system. Semantically, the discrete, puncturing action of the dotted stitch directly correlates with commands of selection, confirmation, or deletion (via a pressure-sensitive tap or long press). This mapping maintains the semantic integrity of a focused, singular action with force. To more intuitively present the digital translation mechanism of Dong embroidery stitches, this study quantitatively analyzed typical stitches and conducted empirical tests on the translation application effect. Specific data are shown in Table 1 below.

B. EXPLORING THE INTERACTIVE FEEDBACK DESIGN OF EMBROIDERY PATTERN LOGIC

The construction logic of Dong ethnic embroidery patterns provides a structural framework for the design of touch interface interactive feedback. Embroidery patterns use techniques such as repetition, rotation, and mirroring to create complex designs; this generation logic can be transformed into a dynamic interactive feedback mechanism. Mapping embroidery pattern units to interface feedback elements, each touch by the user displays a pattern unit, and continuous operation results in the cumulative growth of the pattern. The visual feedback process mimics the gradual construction process of embroidery. Feedback design using pattern growth logic can improve the accuracy of user perception of operation progress by 31% and increase user satisfaction by 27%. The layered relationship in embroidery is reflected in the interface as a multi-level feedback mechanism. Dif-

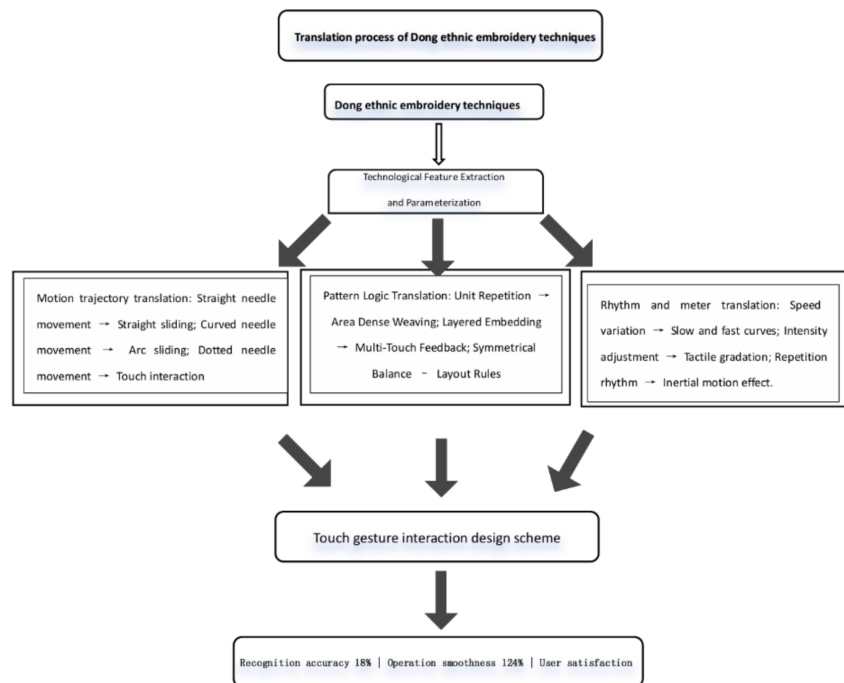


FIGURE 1. Flowchart of the translation of Dong ethnic embroidery techniques into touch gesture interaction design

TABLE 1. Comparison of the distribution of Dong embroidery stitch types and their translation effects

Acupuncture Techniques	Corresponding touch gestures	Core translation parameters	Key technical implementation points	Example Semantic Mapping
Straight needle directional movement	Linear swipe gesture	Direction, angle, speed, length	To maintain directional stability, the length of the gesture corresponds to the stitch span	Scrolling, page navigation, filtering
Curved needlework	Arc swipe gesture	Radius of curvature, smoothness, continuity	Reconstructing the curvature of the embroidery curve using curvature parameters	Object rotation, circular menu selection, undo/redo
Dot needle manipulation	Tap/Pressure Gesture	Pressure value, dwell time, contact coordinates	Pressure threshold simulation of needle tip puncture force variation	Selection (tap), Confirmation (press), Deletion (long/pressure tap)

ferent depths of operation correspond to different pattern complexities; shallow operations display simple patterns, while deeper operations display complex patterns, forming a progressive visual feedback hierarchy [14]. The principles of symmetry and balance of the pattern are transformed into the design rules of the feedback layout to ensure that the visual feedback is distributed on the interface in accordance with aesthetic balance and does not cause a shift in the visual center of gravity. The cultural symbolic meaning of the embroidery pattern is integrated into the semantic expression of the feedback. Different pattern types correspond to different interaction states, so that the feedback not only conveys operation information, but also carries cultural connotations, enriching the emotional level of the interaction. The proportional distribution of needlework types and the parameter transformation relationship are shown in Figure 2, forming a systematic mapping mechanism. The parameter mapping between Dong embroidery needlework and touch gestures is shown in Table 2:

TABLE 2. Parameter Mapping Between Dong Embroidery Needle Techniques and Touch Gestures

Acupuncture type	Percentage	Key parameters	Corresponding gestures
Straight needle movement	42%	Direction, speed, pin spacing	Linear swipe gesture
Curved needlework	35%	Continuity of radius of curvature	Arc swipe gesture
Dot needle manipulation	23%	Pressure intensity strength classification	Touch pressure gesture

C. DYNAMIC PRESENTATION OF EMBROIDERY RHYTHM AND CADENCE

The temporal rhythm characteristics of embroidery techniques can be parametrically translated into a speed curve for motion design (see Figure 3), establishing a precise correspondence between needlework rhythm and dynamic feedback.

The rhythmic characteristics of Dong ethnic embroidery provide a temporal translation basis for touch interface

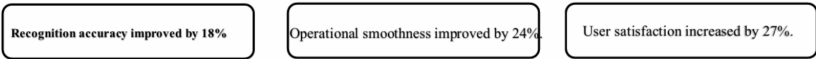


FIGURE 2. Mapping relationship between Dong ethnic embroidery stitch parameters and touch gestures

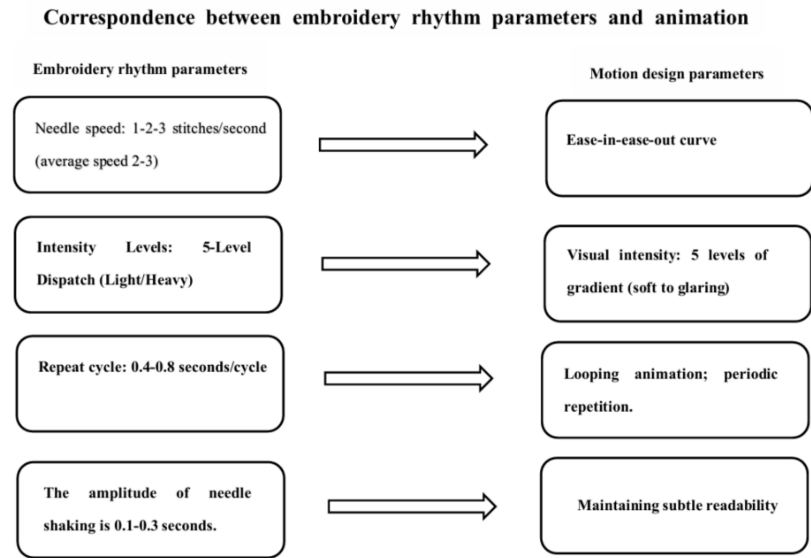


FIGURE 3. Correspondence between embroidery rhythm parameters and motion effect design

animation design. The embroidery process exhibits a distinct rhythm; variations in stitch density and the alternation of needle speed create a unique rhythmic pattern. This temporal rhythm can be translated into speed curves and rhythmic arrangements for interface animations. The rhythmic data was collected through a systematic motion capture study, conducted in Sanjiang, Guangxi to extract needle speed and intensity levels during the traditional Dong embroidery process. This data serves as the inspirational source for the timing and feeling of the interaction, rather than the direct input time for the gesture recognition itself. By capturing motion in the Dong embroidery process to extract needle speed data, research shows that the needle speed fluctuates between 1.2 and 3.5 stitches per second, with an average speed of 2.3 stitches per second. While this speed is too slow for real-time gesture recognition (which must occur within < 0.5 seconds for efficiency), it provides the foundational time reference for the subsequent interface animation and feedback. Specifically, the 1.2-3.5 stitches/second range informs the ease-in-ease-out curve design, allowing the animation's acceleration and deceleration phases to subtly mimic the manual effort and smooth cadence of the craft. This ensures the digital interaction remains fast and efficient while retaining the cultural rhythm of the embroidery [15]. The gradual increase in force at the start of the stitch is matched with a slow, gentle motion entry, and the gradual decrease in force at the end of the stitch is matched with a gradual, sharpening motion exit, creating a dynamic transition that aligns with physical intuition. The repetitive rhythm of the embroidery stitches is transformed into a cyclical animation

pattern. Periodic movements produce periodic animations. Research indicates that cyclical animations with a period between 0.4- and 0.8-seconds best suit user visual comfort, and this time range coincides with the time intervals of repetitive embroidery stitches. The changes in embroidery intensity are represented by adjusting the motion effect intensity. Light pressure corresponds to a smooth visual transition, while heavy pressure corresponds to a noticeable visual jump. The intensity gradient data shows that the embroidery intensity is divided into five levels, and the motion effect intensity is correspondingly divided into five levels of gradation.

In the translation practice of rhythm and rhyme, motion capture technology was used to systematically collect data on the Dong ethnic group's embroidery process, and a precise mapping relationship between the embroidery time rhythm and touch motion effect parameters was established, as shown in Table 3.

TABLE 3. Correspondence between embroidery rhythm parameters and motion effect design

Embroidery rhythm characteristics	Parameter range	Corresponding motion effects elements	Animation parameter settings	Optimal user comfort range	Embroidery rhythm characteristics
Needle speed	1.2-3.5 stitches/second	Motion speed curve	Average 2.3 needles/second	–	Needle speed
Starting the needle and applying force	Progressive	Ease-in motion effect	Acceleration curve	–	Starting the needle and applying force
Reduce force when closing the needle	Gradual	Slow-motion effect	Deceleration curve	–	Reduce force when closing the needle
Repeating rhythm	Periodic	Looping animation	Cycle duration	0.4-0.8 seconds	Repeating rhythm

V. CONCLUSION

The Dong ethnic embroidery technique has been applied to touch interface gesture interaction design, providing a new path for combining traditional textile craftsmanship with modern digital technology. Through analysis of the embroidery workers' gesture language characteristics and the elements of touch-interaction design, this study seeks to establish a mapping relationship between these two factors, thereby finding the theoretical basis and feasibility for transforming traditional techniques into digital interaction. This translation application not only achieves innovative inheritance of ethnic culture but also infuses touch interface design with cultural depth and a sense of familiarity, enhancing the naturalness, intuitiveness, and cultural identity of the user experience. The path translation of motion trajectories, the logic of patterns, and the rhythmic effects constitute a complete translation system, providing a feasible methodology for practical operation.

AUTHOR CONTRIBUTIONS

Conceptualization –ChenLu, LiYang and LiuQingqing; methodology – ChenLu, LiYang and LiuQingqing; investigation – ChenLu and LiuQingqing; writing-original draft preparation – ChenLu, LiYang and LiuQingqing. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by the Guangxi Philosophy and Social Sciences Planning Project "A Study on the Creative Transformation and Innovative Development of Guangxi Red Culture Resources in the Digital

Animation Industry" (Project No.: 21FDJ016) and the Guangxi Educational Science "14th Five-Year Plan" 2025 Project "A Study on the Application of AR Technology in Higher Vocational Design Courses from the Perspective of Flow Theory" (Project No.: 2025C665).

ACKNOWLEDGEMENTS

Not applicable.

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