Exploring the Path of Cultural Sustainability for Traditional Costume Embroidery Patterns Based on Digital Generative Art

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Abstract: Utilizing the modern application of traditional Chinese costume embroidery patterns as a starting point, and addressing its challenges, this research explores culturally sustainable methods within a modern context. It employs line elements to generate and design contemporary embroidery patterns, incorporating glitch art for the visual effects of these images, and integrates random elements into the design approach in generative and glitch art. Focusing on the creative process, it utilizes Touch Designer as the primary digital tool and employs case study methods to investigate modern approaches for transforming traditional patterns using digital media technology. This research is pioneering in integrating pattern generative art with new media and fashion, infusing traditional patterns with contemporary artistic traits, reimagining visual forms, enriching cultural contexts, and fostering dynamic

innovation. It offers insights for the sustainable preservation and dissemination of Chinese traditional intangible cultural heritage in the modern era.
Keywords: Traditional Chinese costume embroidery patterns; Cultural sustainability; Digital generative art; Touch Designer; Pattern innovation

1. INTRODUCTION

China, a unified multi-ethnic nation, has jointly created a long history and splendid traditional Chinese culture among its ethnic groups, forming a diverse yet unified pattern. Traditional costume embroidery patterns, as an integral part of Chinese national costume culture, are rich and varied in themes, colors, styles, and craftsmanship, uniquely stylizing the artistic expression of Chinese natural and human culture. These patterns, like the text in history books, record process of communication and integration among Chinese ethnic groups, serving as valuable channels for historical research. Thus, costume patterns possess not only aesthetic value but also profound cultural and spiritual significance, featuring appreciative, practical, and symbolic functions (Xiong, 2016). According to Xu , cultural inheritance is the grand design of Chinese culture and the fundamental basis for the creative transformation of digital technology; cultural dissemination is the grand narrative of Chinese culture and the natural extension of innovative development in digital technology (Xu & Tu, 2023). Therefore, under the goal of sustainable development, the efficient inheritance of traditional Chinese culture cannot be separated from the boost of digital technology. This study analyzes the current application and challenges of traditional Chinese costume embroidery patterns from a cultural sustainability perspective. It organizes new demands for the modern transformation of traditional costume patterns from both design and consumer perspectives. Starting from the pattern generation process, the study introduces Touch Designer, a node-based visual programming language, incorporating the pattern generation process as part of artistic creation. Using glitch art style visual effects as a reference, it specifically explores digital pattern generation paths of traditional costume embroidery patterns.

2. MODERN APPLICATION STATUS OF TRADITIONAL CHINESE COSTUME EMBROIDERY PATTERNS

Traditional ethnic costumes are increasingly rare in daily wear, even in minority communities where modern attire often outnumbers traditional

garments. Today's challenge is to effectively revitalize traditional embroidered patterns, a crucial aspect of garment culture. As an everyday consumer good and necessity, clothing serves as the ideal medium for these patterns. Therefore, utilizing clothing as a medium is essential to infuse new life into traditional embroidered patterns, encouraging modern individuals to embrace these designs in daily life, thereby ensuring effective and sustainable dissemination of this artistic and cultural heritage. Qiang embroidery, an integral component of China's intangible cultural heritage, has a rich history. Characterized by bright colors, diversse shapes, and fine textures, its patterns draw inspiration from flora, fauna, and natural phenomena, mirroring the aspiration for a beautiful life. To grasp current aesthetic preferences and acceptance of modernized traditional ethnic embroidery patterns, a survey targeting 16-35-year-olds was conducted among Han and Qiang residents in Beichuan and Pingwu, resulting in 52 valid responses. The primarily pictorial questionnaire covered traditional Qiang costumes, embroidery elements, their use in tourism and cultural creative clothing, and popular national fashion brands, focusing on garments respondents would wear in daily life. Survey results show that both Han and Qiang youth prefer simple, casual styles for daily wear, favoring modern patterns redesigned to suit contemporary aesthetics over traditional patterns replicated onto cultural shirts; notably, most young people within these ethnic groups accept the visual effects of "redesigned" traditional patterns. This indicates that the "redesign process" of traditional ethnic costume patterns is vital in their modernization. A large number of designers and scholars have been studying the topic on "research and application of traditional ethnic costume elements." Compared with the researches by foreign scholars such as Finnane (Garrett, 2009), Garrett, V (Finnane, 2008) which mostly relied on the traditional dresses to conduct theoretical study from the angle of art anthropology, domestic scholars have carried out lots of practical research on top of theoretical research (Shen & Xu, 2011; Xu & Zhang, 2012). For example, on Qiang embroidery, a significant intangible cultural heritage, Xu Jing, Shen Lei, et al looked into the origin of and analyzed the Qiang embroidery from its composition, hues, process, theme, etc. Additionally, in the aspect of the fashionable and innovative research of traditional Qiang embroidery, Song Dandan sought the feasibility and combination of Qiang embroidery in modern women's dresses through the cases of ready-to-wear design and manufacture (Song, 2018). Lu Na brought up new ideas in the modern application of Qiang embroidery from the aesthetic perspective of Qiang embroidery and mentioned the decomposition and application methods of Qiang

embroidery patterns based on cultural understanding (Lu, 2013). Zhong Wei proposed the thinking modes to convert and apply the handicraft resources of the Qiang ethnic minority in cultural innovative designs (Zhong, 2010). In terms of application aided by computer digitization, Zhang Haopeng systematically sorted the types, materials (Zhang, 2013), crafting processes, and clothes textures, etc. of traditional Qiang clothes, discovered a modern digital technology to rescue and preserve traditional Qiang clothes, and established a relatively complete digital resource bank. Yang Yonghua achieved the 3D demonstration of traditional Qiang dresses for women based on the technologies such as virtual simulation and CAD (Yang, 2020). The virtual presentation of the traditional clothes with complex patterns offered new approaches and ideas. However, most studies employ very basic clothing CAD to digitally restore the ethnic costumes or the clothes elements, and very few of them studied creative application programming and interactive digital tools, etc. in the artistic, innovative design of traditional clothes. Furthermore, most of the existing design practice research decomposes, restructures, and reforms the 2D visual effects of the patterns from the perspective of design aesthetics. Despite their varied design styles, the creation processes of most patterns are based on the linear thinking mode. The entire creation process is relatively closed from top to bottom, inevitably resulting in a lack of freshness when the consumers passively receive the 2D visual output. Thus, on the designing side, new tools, approaches, and mindsets are required in creation, and on the consuming side, new visual experiences and consuming processes need to stimulate consumption. Therefore, seeking a brand-new design possibility and exploring the boundaries of different art fields are the shared demands of modern consumers and the fashion industry. The integration of modern digital media has significantly expanded the possibilities for creating and displaying garment patterns. This research extends beyond the conventional roles of pattern embroiderers and innovators, incorporating diverse entities such as machines, software, visitors, and consumers in the contemporary reinterpretation of traditional patterns. Consequently, it explores a more complex pattern generation process, aiming to bolster the cultural sustainability of traditional costume embroidery elements.

3. GENERATIVE ART AND TOUCH DESIGNER

3.1 Pattern Generative Art

Traditional ethnic costume embroidery, a key component of national

intangible cultural heritage, embodies unique cultural characteristics. Interviews with traditional costume pattern embroiderers revealed that they often design patterns in their minds based on accumulated experience, life perceptions, and daily observations, before directly embroidering them onto fabric. As handcrafted artifacts, traditional ethnic costume embroidery patterns are the result of the creators' subjective decisions, making the embroidery process highly subjective. The creation process of traditional costume patterns lacks a digital history for reference or traceability; the patterns on the garments themselves are the sole record of the pattern's creation and completion. As modern technology develops, generative art is born naturally. Philip Galanter defines it as a process in which the artists adopt a system such as natural language rule (Galanter, 2016), computer programming, robot, or other inventions to complete the artistic creation with a certain level of autonomy. From the perspective of generative art, digital technology enables the pattern creation process to be recorded. Moreover, like the handcrafted patterns, digitally manufactured artworks, particularly the patterns created through generative art, hinge on the creator's subjectivity and reflect his techniques, perspectives, and values. Meanwhile, the emergence of digitally generated art led to a brand-new cooperative creation form. Such a non-linear thinking mode can enable the creators to jump out of their aesthetics and prejudices, reducing their subjectivity, giving the robots and experiencers the role as art creators, and broadening the dimensions of art creation. This broadening of dimensions is exactly what is needed for the current cultural sustainability of traditional costume patterns. The digital patterns thus generated carry the critical traits of generative art and create the new meaning of the aesthetic, demonstrative, and cultural aspects. Touch Designer, the major digital tool employed in this research, can provide technical support to closely connect generative art with graphic art, sound art, mixed media art, bio-art, etc., greatly enriching the methods and connotations of art creation and offering more possibilities to the creation of pattern generative art.

3.2 Overview of Touch Designer

Touch Designer (hereinafter referred to as TD) is developed by Derivative, a Canadian software company. It is a platform for visual nodal programming and real time interactive multimedia content, optimised for giving a versatile support to live performances. Unlike the traditional complex programming tools, TD offers a brand-new creation mode using visual nodes as creation methods. Without having to worry about the low-level programming development, the creator and designer can concentrate

their energy on integrating different media installations and creating a more imaginative cross-domain new media work. It has the features such as highly integrated node components, extensive connection areas, and an extremely flexible process to generate raw materials. There are six types of basic TD components, and they are COMP (component operator,) TOP (Texture Operator,) CHOP (Channel Operator,) SOP (Surface Operator,) MAT (Material Operator,) and DAT (Data Operator.) By superimposing various components, using and converting channels, and controlling codes, designers can create 2D, 3D, and special-effect animations to realize real-time 3D rendering, control mechanic installations, and generate the output of special effects like real-time lighting and sounds, etc. Meanwhile, due to the powerful systematic integration and numerous API interfaces of TD, it can easily utilize external devices such as Kinect, OSC signal, Arduino, VR headsets. Therefore, TD can make a contribution in various aspects including stage visual and audio performance, mechanic control, lighting design, architecture projection, and the creation of interactive media installation system. Thanks to its above characteristics, TD is one of the ideal digital tools to complete the generative art creation of patterns. The TD-based pattern generation process uses nodes and joining lines to form a "generation process web" that can save mass work history, edit historic data, and present a real-time preview of the effect through each node. Therefore, adopting TD software to complete the artistic conversion of patterns is creation and recording and allows more possibilities in the subsequent pattern display. The case in the following text uses TD as the major digital tool in the process of generation and creation to explore the path of integrating Qiang embroidery patterns with modern digital pattern generative art.

4. TD-BASED PATHS TO GENERATE INNOVATIVE ETHNIC EMBROIDERY PATTERNS IN GLITCH ART STYLE

Glitch theorist Rosa Menkman defines 'glitch' as follows: a glitch is an '(actual and/or simulated) break from an expected or conventional flow of information or meaning within (digital) communication systems that results in a perceived accident or error' (Menkman, 2011). As Kemper stated, a glitch is thus a seemingly faulty deviation from routine functionality, and this deviation can be communicated both visually and aurally (Kemper, 2023). Born in the process of generation, glitch art is one of the outcomes of generative art. Initially, glitch art originated from the

image errors in electronic imaging technology. Later, as glitch graphics gradually evolved into a unique aesthetic preference, glitch art came into existence. According to Den Heijer, Glitch art and evolutionary art share a number of similarities. Both employ a sort of 'generate and test' paradigm, whereby a software program generates a number of possibilities, and a selection is performed by an artist or by a software component (den Heijer, 2013). Created in the erroneous or unstable running of software, games, images, videos, audios, and other digital devices, glitch art is something aesthetically recreated from a transitory state produced by artists by capturing errors that broke out occasionally on digital devices or deliberately inducing errors in the device. Rather than merely a presentation of electronic errors, glitch art has already evolved into an art creation formed by beautifying the glitch (Du et al., 2020). Glitch artworks often demonstrate the visual characteristics of broken images and distorted colors, etc., with the beauty of randomness and uncertainty and using abstract geometric elements like lines as their basic visual elements. As China's typical traditional ethnic costume embroidery patterns are embroidered with yarns and different techniques, they can be perceived as patterns composed of lines which are its fundamental components. As one of the three major basic elements, the line element is rhythmic and super expressive and one of the basic elements for artists in different domains to convey information most succinctly and powerfully. As glitch art is one of the outcomes of generative art and its visual effects have the characteristics perfectly matching the research object of this research, the paper will attempt to employ TD as the research tool to introduce the random elements in the design mentality of generative art and glitch art through discussing the functions of and empirically studying its TOP components in different categories. Then, by directly using the promptly-generated adjusting TOP and indirectly using GLSL TOP, it establishes the creative visual generation paths for the line-based traditional patterns from the two perspectives of curves and straight lines.

4.1 Paths to Generate Glitch Art Style Images Using Straight Lines as Principal Design Elements

One of the most fundamental elements in the line structure, straight lines can make the image terse, clear, with patterns, and in order. Plus, it can divide the layout and the space. There are many ways to add straight lines to the pattern. This section will start from the perspective of glitch art and use straight lines as the main visual elements to be added to explore the modern paths to generate traditional costume embroidery patterns. The

original images selected in the case are the typical cross-stitch patterns on Chinese traditional costume embroidery. Due to its unique embroidering process, cross-stitch embroidery is general, abstract, and geometric, which makes it fit modern aesthetics. After drawing it digitally with vectors, the visual effect and pixel art have achieved the same satisfactory results. For this reason, the typical Qiang cross-stitch embroidery pattern is chosen as the original input image (Figure1. (a)) in this paper for the output images to be closer to the glitch art style and visually demonstrate the characteristics of different generation paths. As the most common component cluster in TD visual projects, TOP (Texture Operator) is one type of component in TD for inputting and outputting 2D pictures and images. As TOP components are based on pixel, TD has impressive efficiency and flexibility in processing pictures and analyzing videos. Since the traditional carrier of the patterns is in a 2D space, this paper takes TOP as the main research object to offer practical paths and methods for the 3D pattern design in the future. This paper brings up two methods that directly use the promptly-generated adjusting TOP in TD to generate creative Qiang embroidery patterns in glitch art style. The first method is used on the condition that the original picture is in JPEG format and is a a full design pattern covering the entire canvas. Then, directly use Movie File In TOP to connect with Transform TOP and select Hold mode under Extend of Transform. Adjust the index values of Translate to generate effects like dragged straight lines. As Qiang patterns are mostly separate designs, it's not easy to comply with the restraints of the original pictures, and the generated pictures can only have a dragging visual effect on the edges. Thus, it is not the best path.

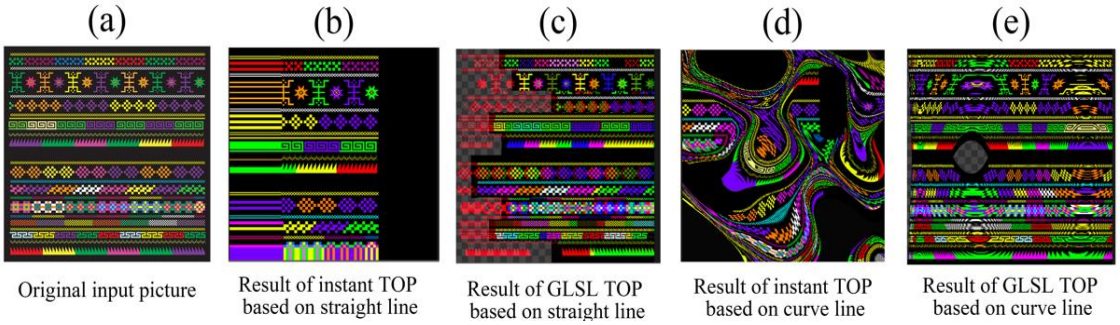

Figure 1: Visual effects of different paths

The second method first forms a connection path of "Movie File In TOP—Transform TOP—Crop TOP—Over TOP." At the same time, it connects a Constant TOP to the input end of Over TOP. Select the "Native Resolution" mode for the Pre-Fit Overlay in Over TOP to retain the original resolution ratio of the picture. Select the "Hold" mode in

Extend Overlay to use the hold function on the overlaid picture layers. In the end, remember to adjust the resolution ratio of the background picture in Constant TOP for it to match that of the input picture. Like this, the visual effects similar to glitch art will be generated by adjusting the Crop Left/Right/Bottom/Top in the Crop TOP index window (Figure1. (b)). This approach has minimal restraints on the formats and patterns of the original picture, and it also allows adjustment from multiple angles by combining the index windows of Transform TOP and Crop TOP. However, its operability and changeability still need to be enhanced. It's certainly very convenient to directly use the promptly-generated adjusting TOP of TD. But the changeability is lower. Therefore, the paper puts forward a method that uses straight lines as the primary elements to create patterns with glitch art effects through GLSL TOP in TD and OpenGL Shading Language. Firstly, form a connection path of "Movie File In TOP—GLSL TOP—Out TOP" in the work area of TD. Input as shown in Figure 2 in the code window of GLSL pixel. Start from the Floor function and use the rand function to generate a random dynamic effect with the segmented picture blocks. Enter "blocks" in the column "Uniform Name 0" of the "Vector" property window of GLSL TOP to enter the number of picture blocks segmented in the "Value" column. Enter "iTime" in the "Uniform Name 1" column and type in "absTime.seconds" in the "Value" column for the segmented picture blocks to generate a dynamic effect along the x-axis. Enter "adjust" in the "Uniform Name 2" column to adjust the color special effect of the output pictures by changing the values in the "Value" column to make it closer to the glitch art style (Figure1. (c)).

```
01. uniform float blocks;
02. uniform float iTime;
03.
04. uniform vec4 adjust;
05.
06. out vec4 fragColor;
07. void main()
08. {
09.  vec2 uv = vUV.st;
10.  float segmentation = floor(uv.y * blocks);
11.  float rand = fract(sin(dot(iTime, segmentation))) ;
12.  vec4 color = texture(sTD2DInputs[0],uv);
13.
14.  color.r = texture(sTD2DInputs[0],uv + vec2(rand*adjust.x,0)).r;
15.  color.g = texture(sTD2DInputs[0],uv + vec2(rand*adjust.y,0)).g;
16.  color.b = texture(sTD2DInputs[0],uv + vec2(rand*adjust.z,0)).b;
17.  color.a = texture(sTD2DInputs[0],uv + vec2(rand*adjust.w,0)).a;
18.
19.  fragColor = TDOutputSwizzle(color);
20. }
```

Figure 2: Code Window of GLSL Pixel

The advantage of this path is that it can define multiple Uniform variables based on the design needs. For example, we can change the codes on line 11 to "float rand = fract(sin(dot(iTime, segmentation)) * moveAmp) * amp - ph;" and define the Uniform variable of "moveAmp,"

"amp," and "ph" to flexibly adjust the output picture effects by working on the "Vector" property window. This allows consumers to participate in the design later on and generates patterns closer to the consumers' imagery through interactive operations (See Above Figure 2).

4.2 Paths to Generate Glitch Art Style Images Using Curves as Principal Design Elements

Soft, dynamic, random, and free, curves are very fluid and decorative. Distorted electronic images will create a curve-based glitch art effect. Distortions in different forms, at different places, and with different magnitudes will lead to different work styles. This section will still use the typical Qiang cross-stitch embroidery pattern chosen in the previous experiment as the source picture and explore the creative path to generate Qiang embroidery patterns in glitch style art by adding the visual elements of curves. Turn the vector-graph of Qiang embroidery into a glitch-style pattern based on the warped curves through the functions of main components. Likewise, the paper will also experiment with two different methods. The first method will directly use the promptly-generated adjusting TOP of TD. The components deployed include Noise TOP and Display TOP. The operation is as follows: Use Noise TOP to generate dynamic Noise images: Create a Noise TOP that generates a variety of noise patterns including Perlin, Simplex, Sparse, Alligator, and Random. Select "Simplex 3D (GPU)" as the "Noise Type" in the index window of Noise TOP operator. Spared from the struggle with the principles of the algorithms of generating natural noises, you can just repeatedly and coordinately adjust the major indexes like Period, Exponent, and Amplitude to generate the target noise images. In the "Transform—Translate" column of the index window of Noise, enter the codes "absTime.seconds / 5" in the data input column "tz," which means "retrieving the absolute time with a second as the unit," to generate dynamic effects instantly. Establish the basic connection path of Noise TOP, Movie File In TOP, and Displace TOP. (See Figure 3): The Displace TOP will cause one image to be warped by another image. A pixel of the output image at (Uo,Vo) gets its RGBA value from a different pixel (Ui, Vi) of the Source Image by using the second input image (the Displace Image.) And its function in the path in this case is to "change the texture coordinates of the first image (the source image imported through Movie File In TOP) based on the pixel distribution of the second image (the dynamic image generated by Noise TOP)". Add the components like TOP and CHOP in the basic path based on the design need: It's required to

design the added components in the initial path based on the customized images imported by Movie File In TOP and the visual requirements on the generated images. If we want the Noise image generated in the previous step to have a more vivid texture of water waves, we can reconnect a Displace TOP between Noise TOP and Displace TOP to achieve the target visual effect by adjusting the Displace/UV/Offset Weight. For example, we can also connect the outlet of Movie File In TOP with the TOP components like Transform, Level, Blue, and Render to generate output images matching the visual demands (Figure1. (d)). Or we can also control the image generation process by adding the controlling components like Mouse CHOP and Audio CHOP for the images to be utilized in the subsequent interactive programs or installations in the background. Regarding the future interaction section, this paper will elaborate on it in the next chapter.

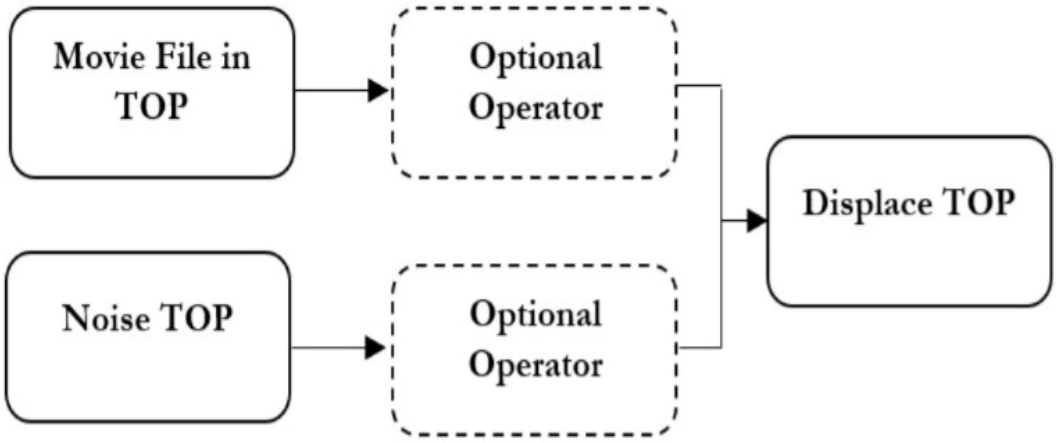

Figure 3: Basic path of instant TOP

Apart from directly using the promptly-generated adjusting TOP of TD to create the path to generate innovative curve-based glitch art style patterns, it is also possible to create a more complex warped Slit-Scan effect through GLSL code (Figure 4).

```
01. out vec4 fragColor;
02. void main()
03. {
04.  vec4 color1 = texture(sTD2DInputs[1], vUV.st);
05.  float x = color1.x;
06.  vec4 color = texture(sTD2DInputs[0], vUV.st+vec2(x,0));
07.  fragColor = TDOutputSwizzle(color);
08. }
09.
```

Figure 4: GLSL code

In this method, the main work areas are divided into three sections. 1. the adjustment of the original input image (the first image;) 2. the adjustment of the reference image of warped pixel texture (the second image;) 3. GLSL code processing and output. The reference image of the warped pixel texture is generated by connecting the two components Pattern CHOP—Chop to TOP. The advantage of adopting this method to generate the reference image is that Pattern CHOP has more controllable indexes and allows convenient adjustments on the final output image effect following the design intention. Of course, TD has several components to generate the reference image with warped pixel texture. After adjusting the initial image and the reference image, insert GLSL TOP and enter the codes with the functions similar to Displace TOP in the GLSL Pixel code input box to change the texture coordinates of the first image based on the pixel distribution of the second imaged. The detailed codes are in picture 2. More diverse components can also be added to the basic path to create the desired design. For example, copying the last group of the reference image of warped pixel and creating Fit TOP after Chop to TOP can activate the Rotate function of Fit TOP to make the warped effects richer and more interesting (Figure1. (e)).

5. TD-BASED PATTERN DISPLAY AND INTERACTION MODES

After pattern generation, the pattern presentation is a vital section of pattern generative art based on TD. It employs different display modes to complete the pattern generative art process and enables the original pattern creator, pattern enhancer and creator, consumer, robot, software, visitor, and many different roles to participate in the pattern generative art. The patterns generated through TD are no longer limited to the static state. Its process of generating patterns through different components is part of the art creation process and enables the generated patterns to have dynamic features like changeable, varied, and interactive. Plus, the subsequent display process based on TD can break through the 2D dimensions and upgrade to the 3D dimensions and even mixed fields. Like the case in the above chapter three, most TOP components can adjust and control data, and every channel can connect with the subsequent interactions and displays. Modern technology offers more carriers and formats to display the patterns. A large number of components and highly flexible interfaces of TD make various display formats possible. This section focuses on traditional Chinese costume embroidery patterns, exploring potential

interactive display and development methods in the field of garment pattern design.

5.1 Display Mode Integrating Multiple Carriers

With the Projection Mapping Calibration function, TD can efficiently complete the 3D projection mapping display for the project achievements. Its projection mapping carrier is not limited to a single screen. It has the image display function of large split screens, can project the animations precisely on irregular objects, and play different virtual contents on the same physical object. For example, with clothes as the carrier, PROFORMA studio projected the dynamic images generated by TD on the clothes in its DROMe project in 2015. The dynamic images largely rely on the parallel and radiating movements of geometric lines to create changeable visual effects. The traditional Chinese costume embroidery patterns processed by TD digital technologies can be displayed immediately on the clothes as static and dynamic images through projection mapping. On this basis, more diverse carriers can be combined as well to form a brand-new multiple-carrier combination on carriers with different materials and surfaces and even different dimensions, generating a new visual effect from the integration. New exhibition themes can be created with traditional Chinese costume and cultural art. The projection integration of multiple-carrier interfaces will bring a more immersing experience to the audience.

5.2 Interactive Display Using Hand Gestures and Somatosensory Recognition

Both hand gestures and somatosensory recognition interactions are mainstream live presentation modes. The commonly used controller in hand gesture recognition interaction is Leap Motion that can identify various hand gestures and obtain the 3D coordinate information of the finger joints. The controller frequently used in somatosensory recognition is Kinect, an external hardware device for somatosensory launched by Microsoft in 2010. TD has component interfaces for both Leap Motion and Kinect, can read the skeleton data captured by all the deep cameras through Kinect CHOP and Leap Motion CHOP, and can be used efficiently to develop interactive presentation projects using hand gestures and somatosensory recognition. For example, by collecting the users' hand gestures and skeleton movements, the real-time transformations of the patterns can be achieved using different program algorithms. Different

from the simple controlling interactions that only control the size and location of the images, it can use algorithms to enable the backtracking operation of all the TD components. One example is using the location tracker and movement capturing devices to control the index influencing factors of all the particular effects in the patterns on site. The unpredictable transformations of the images through simple hand gestures or body movements, coupled with the modern visual effects like the special effects of particles and lights and shadows, generate visual images that are digitally glamorous based on the traditional Chinese costume embroidery patterns. It enhances the interactivity, immersion, and participation of the visitors. Additionally, in combination with multiple external controllers, it is also possible to connect with various output devices like generators and steering engines and many sensors like vibration sensors, sound sensors, infrared sensors, collision sensors, touch sensors, thermal sensors, photosensitive sensors through the open-source electronic prototype platform Arduino to achieve different types of interactive sensor perception presentation.

5.3 Interactive Display Based on Digital Reality Technology

A collective reference to the forms like AR (Augmented Reality) VR (Virtual Reality,) and MR (Mixed Reality,) XR (Extended Reality) is an environment that combines reality with the virtual world and allows human-machine interactions through computer technologies and wearable devices. XR technology enables the clothes patterns to change freely in different dimensions, perfectly meeting the new needs in the designing end and consuming end, as mentioned earlier. Therefore, it has enormous potential and extensive development directions in the future. AR (Augmented Reality) is a technology integrating real scenes and virtual scenes. In AR applications, along with the cross functions of the technologies like computer image recognition and artificial intelligence technology, software tools like Unity and Vuforia can be combined to effortlessly convert the patterns generated by TD into formats identifiable in the AR application program development. They offer the users an augmented reality sensory experience. For example, recognize images based on AR technology, use hand-held AR devices to scan the modern-style patterns on the clothes digitally converted by TD, search with the data interface, generate the original or similar embroidery patterns (and comments on the patterns) on the screen in AR form. Thus, it has practical values in cultural innovative product development, digital museum construction, and education and teaching, etc. Meanwhile, TD also offers component interfaces for Open VR (unified VR data interface,) Oculus

(Oculus VR headset screen,) Vive (VR headset screen developed by HTC&Valve.) Simply connect with the corresponding hardware to develop a virtual reality interactive experience project. Besides, it is very convenient to link with the subsequent immersive interactive experiences.

6. CONCLUSION

This study, through practical research on different pattern generation paths using the same traditional ethnic costume embroidery material and visual analysis and comparison of images produced via these paths, confirms the feasibility of using the digital tool Touch Designer for innovative pattern creation. It also analyzes the advantages of these paths in terms of convenience, variability, and interactivity. Focusing on the TOP components of Touch Designer (TD), this study thoroughly explores paths influenced by glitch art in the "pattern designing and generating phase." These findings can lay the groundwork for similar research endeavors. In the "pattern presentation and display phase," the study summarizes pattern presentation and interaction methods, including multi-carrier integration, hand gesture and somatosensory recognition-based interactive displays, and digital reality technology applications. Future research can delve deeper into two key areas: First, it can explore a wider range of TD components to create more varied static and dynamic patterns through the coordinated use of TOP, CHOP (Channel Operator), and SOP (Surface Operator). Second, it can conduct in-depth research on specific interactive modes in the "pattern presentation and display phase," integrating hardware such as sensors to explore the fusion of clothing art and digital media, and investigate sustainable development of traditional ethnic art and culture in the digital realm.

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