
International Journal of Creative Multimedia

AI-Assisted Design for Bian Embroidery Cultural and Creative Products: A Framework for Intangible Cultural Heritage Innovation

Yibo Li

P20241000498@siswa.edu.upsi.my
Universiti Pendidikan Sultan Idris, Malaysia
ORCID: 0009-0004-3453-4016
(Corresponding Author)

Catherina Anak Ugap

catherina@fskik.upsi.edu.my
Universiti Pendidikan Sultan Idris, Malaysia
ORCID: 0009-0000-7131-9500

Abstract

This study explores the integration of generative artificial intelligence (AI) into the design of Bian embroidery cultural and creative products and proposes a conceptual framework for the contemporary transformation of intangible cultural heritage (ICH). Existing Bian embroidery products often rely on the direct transplantation of traditional motifs and surface decoration, while systematic approaches integrating cultural element extraction, AI-assisted generation, product adaptation, and evaluation remain limited. To address this gap, the study analyses the visual and cultural characteristics of Bian embroidery in terms of subject matter, colour, stitch techniques, motifs, and cultural meanings and organises these characteristics within an AI-assisted design process. A four-stage framework is proposed, comprising Cultural Element Extraction, Cultural Element Translation and AI-Assisted Generation, Product Application and Design Refinement, and a Proposed Evaluation and Feedback Mechanism. The framework is further illustrated through a design demonstration showing how selected Bian embroidery characteristics can be translated into AI-readable design information, developed through generative visual exploration, and subsequently adapted to contemporary cultural and creative products. Rather than treating AI as a substitute for traditional craftsmanship, the framework positions generative AI as an exploratory and supportive design tool. The proposed evaluation mechanism combines expert assessment with supplementary image-based similarity measures and is intended for future empirical validation. Overall, the framework provides a structured methodological approach to the AI-assisted transformation and contemporary design application of Bian embroidery and related intangible cultural heritage resources.

Keywords Artificial Intelligence; Bian Embroidery; Cultural and Creative Products; Intangible Cultural Heritage; Design Framework

Received: 22 May 2026, **Accepted:** 17 August 2026, **Published:** 30 September 2026.

Introduction

Rapid advances in AI have created new opportunities for visual design, product development, cultural communication, and the contemporary transformation of ICH resources (Li et al., 2025). Bian embroidery, inscribed on China's national list of intangible cultural heritage in 2008, is a traditional embroidery practice closely associated with Kaifeng, Henan Province. Its visual language reflects the artistic traditions of the Song Dynasty, regional cultural characteristics, and distinctive approaches to subject matter, colour, stitch techniques, and pictorial representation (Zhang & Yang, 2023). These cultural and visual characteristics provide an important basis for exploring how generative AI may support the contemporary design transformation of Bian embroidery.

Research on ICH-based cultural and creative product design has gradually expanded beyond the direct application of traditional motifs and symbolic elements to encompass cultural element identification, digital preservation, user experience, and AI-assisted generation. Studies addressing the integration of embroidery and digital technologies have explored areas such as image generation, pattern recognition, digital preservation, and individual design applications. However, comparatively limited attention has been given to how the cultural and visual characteristics of a specific embroidery tradition can be systematically identified, translated into AI-readable design information, and incorporated into a coherent cultural and creative product development process. In the context of Bian embroidery, a structured approach linking cultural element extraction, AI-oriented translation and generation, product application and design refinement, and subsequent evaluation remains insufficiently developed (Yu et al., 2025).

In recent years, Bian embroidery has been incorporated into a growing range of cultural and creative products, including sachets, round fans, tea coasters, and handbags. Nevertheless, many existing applications continue to rely primarily on the direct transplantation of traditional motifs or their use as surface decoration, with relatively limited attention to systematic digital translation and AI-assisted design processes. This limitation suggests a need to move beyond the reproduction of visual symbols towards a more structured process in which the cultural, visual, and craft-related characteristics of Bian embroidery can inform contemporary design development.

To address this gap, the present study proposes a conceptual framework for the AI-assisted design of Bian embroidery cultural and creative products. Rather than attempting to empirically verify the performance of a particular generative AI model, the study focuses on establishing a structured process comprising cultural element extraction, cultural element translation and AI-assisted generation, product application and design refinement, and a proposed evaluation and feedback stage. The framework is further illustrated through a design application to demonstrate how selected Bian

embroidery characteristics can be translated into AI-readable design inputs and subsequently developed into contemporary product concepts. In this way, the study seeks to establish a methodological link between traditional Bian embroidery resources and AI-assisted design processes, while positioning generative AI as a supportive tool for visual exploration rather than as a substitute for designers or traditional craft practitioners.

Research Objective

1. To identify and organise the principal cultural and visual characteristics of Bian embroidery that can inform AI-assisted cultural and creative product design.
2. To develop a conceptual framework integrating cultural element extraction, cultural element translation and AI-assisted generation, product application and design refinement, and evaluation and feedback.
3. To illustrate the operational process of the proposed framework through an AI-assisted design demonstration and to outline directions for its future empirical evaluation.

Literature Review

A Review of Research on Cultural and Creative Products

Cultural and creative products are generally developed through the contemporary transformation of cultural resources, historical symbols, regional characteristics, traditional crafts, and artistic elements. Their design involves translating cultural content into perceptible product attributes, including form, colour, material, pattern, usage behaviour, and cultural themes (Xiang et al., 2025). Accordingly, cultural and creative product design involves not only the visual application of cultural symbols but also the transformation of cultural meanings into forms that can be understood and experienced by contemporary consumers.

Previous studies have examined cultural and creative product design from the perspectives of symbolic expression, consumer perception, cultural identity, perceived value, and purchase intention. Liu and Zhao (2024) investigated the influence of metaphorical design based on traditional cultural symbols on consumer experience, cultural identity, perceived value, and purchase intention. Li and Li (2022), using cultural and creative products from the Palace Museum in China as their research context, examined the relationship between design aesthetics and consumers' purchase intentions. Their findings indicated that design aesthetics positively influences purchase intention through perceived value, while Chinese traditionality moderates this indirect relationship. These findings suggest that the effectiveness of cultural and creative product design depends not only on visual attractiveness but also on the meaningful integration of cultural characteristics.

ICH-based cultural and creative products also extend beyond their functions as commodities or cultural souvenirs. They can serve as carriers of cultural communication and contribute to local economic development, tourism, and rural revitalisation. Zhang and Wan (2024), for example, highlighted the potential contribution of ICH-based cultural and creative products to local economic development and rural revitalisation. From this perspective, the development of Bian embroidery cultural and creative products should not be limited to the decorative application of traditional motifs or conventional souvenir design. Instead, such products may function as contemporary media through which Bian embroidery is interpreted, communicated, and incorporated into present-day cultural consumption.

A Review of Bian Embroidery Research

Existing research on Bian embroidery has primarily addressed its historical development, artistic characteristics, cultural value, heritage conservation, and contemporary design applications. Ji and Ghazali (2023) examined the traditional visual characteristics of Bian embroidery, including its motifs, colours, and stitch techniques, and further discussed their transformation and application in contemporary fashion design. Drawing on historical document analysis, case studies, and related analytical approaches, their study provided insights into possible directions for the sustainable continuation and contemporary development of Bian embroidery.

From the perspective of heritage value, Wang and Yao (2016) examined the cultural value of Bian embroidery and explored approaches to evaluating its heritage significance through questionnaire-based research. Their study extended the discussion of Bian embroidery beyond its visual and technical characteristics by considering its broader cultural and heritage values.

Overall, existing Bian embroidery research has established an important foundation for understanding its historical development, artistic features, cultural value, and contemporary applications. However, limited attention has been given to the systematic translation of its cultural and visual characteristics into AI-readable design information and to the integration of such information into a coherent AI-assisted cultural and creative product design process. This gap provides the basis for the development of the conceptual framework proposed in the present study.

A Review of AI Cultural and Creative Products

With the continued development of artificial intelligence, generative AI has increasingly been explored in cultural and creative product design, particularly in relation to visual generation, cultural element transformation, user perception, and the contemporary communication of intangible cultural heritage.

Existing studies have examined both the potential of AI-generated cultural content and the ways in which consumers perceive and respond to AI-assisted design outcomes.

Zhang et al. (2023) investigated AI-generated Yangliuqing New Year prints and examined their potential contribution to the sustainable dissemination of intangible cultural heritage. Their study integrated the AISAS model with perceived value and cultural identity and employed questionnaire data from 291 participants. The findings suggested that the attractiveness, interest, and level of engagement associated with AI-generated cultural products can influence perceived value, while purchasing and sharing behaviours may contribute to cultural identity, which in turn is associated with the sustainable dissemination of intangible cultural heritage. This study demonstrates the potential relationship between AI-generated cultural content, user engagement, and cultural communication.

Li et al. (2024) investigated consumer satisfaction with AI-generated museum cultural and creative product designs. Their study noted the increasing application of generative AI within museum product development while highlighting the need for greater attention to consumer evaluation and the factors influencing satisfaction with AI-generated design outcomes. Such research indicates that the application of AI in cultural and creative product design should not be considered solely from the perspective of technological generation; cultural appropriateness, user perception, and product evaluation are also important components of the design process.

Taken together, existing studies demonstrate growing interest in cultural and creative product design, Bian embroidery, and AI-assisted cultural generation. Research on cultural and creative products has emphasised cultural transformation, consumer perception, and cultural value, while studies of Bian embroidery have established a foundation for understanding its artistic, technical, and heritage characteristics. Meanwhile, research on AI-assisted cultural design has demonstrated the potential of generative technologies for visual exploration and cultural communication. Nevertheless, relatively little research has integrated these three areas into a systematic design process specifically for Bian embroidery. There remains a need for a framework that connects cultural element extraction, AI-oriented translation and generation, product application and design refinement, and subsequent evaluation and feedback. The present study addresses this gap by proposing an AI-assisted conceptual framework for Bian embroidery cultural and creative product design.

Proposed AI-Assisted Design Framework for Bian Embroidery Cultural and Creative Products

Cultural Element Extraction

Bian embroidery is characterised by a rich visual and cultural system comprising subject matter, colour, stitch techniques, and motifs. Identifying and organising these cultural characteristics constitutes an essential preliminary stage in their subsequent translation into AI-readable design information. In terms of subject matter, Bian embroidery encompasses a wide range of themes, including flowers, birds, insects, fish, animals, landscapes, natural scenery, historical figures, and genre scenes. Since the establishment of the People's Republic of China, Bian embroidery has continued to preserve elements of traditional Chinese embroidery while also incorporating certain conventions of Western painting and realistic portraiture. Since the late twentieth century, it has also been applied to realistic portrait embroidery, including representations of international figures such as Mahathir Mohamad and his wife (Liu & Cai, 2026). This diversity of subject matter demonstrates the strong pictorial capacity of Bian embroidery and provides a broad visual resource for contemporary design transformation.

Colour is another important component of the visual identity of Bian embroidery. Its palette frequently incorporates gold and silver threads alongside red, yellow, green, blue, and other highly expressive colours. These colour choices are associated with both courtly aesthetics and regional cultural traditions. As Bian embroidery developed within the cultural context of the Yellow River Basin, its use of vivid colours also reflects regional folk beliefs concerning auspiciousness, protection from misfortune, and the pursuit of good fortune. More importantly, Bian embroidery is distinguished by its sophisticated treatment of colour gradation. Rather than relying on flat areas of a single hue, embroiderers employ subtle variations in thread colour, density, and intensity to create volume, light and shade, material texture, and spatial depth. Such tonal layering contributes significantly to the refined and realistic visual quality of Bian embroidery and constitutes one of its distinctive aesthetic characteristics.

The stitch system of Bian embroidery is similarly characterised by considerable diversity and technical refinement. According to previous studies, its repertoire has developed from approximately 12 traditional stitch techniques to 36 techniques, including 14 inherited traditional stitches, five adapted or modified techniques, and 17 newly developed techniques. Bian embroidery also encompasses various forms of practice, including single-sided embroidery, double-sided embroidery, and double-sided embroidery with different colours. Rather than relying on a single stitch technique, embroiderers typically combine multiple stitches according to the characteristics of the subject matter and the intended visual effect. Different combinations are therefore employed to represent landscapes, figures, flowers and birds, animals, architecture, and other themes. Based on a synthesis of previous studies concerning the techniques and artistic expression of Bian embroidery (Ji & Ghazali, 2023; Liu & Cai, 2026), the authors summarised the relationships between representative subject matter, commonly associated stitch techniques, and their principal expressive functions, as presented in Table 1.

Table 1. Relationship between bian embroidery stitch techniques and subject matter

Subject Matter	Common Stitch Techniques	Main Expressive Functions
Landscape	Random long-and-short stitch, overlay stitch, rolling stitch, flat stitch	To express spatial depth, misty atmosphere, flowing water, clouds, and tonal transitions
Flowers and Birds	Random long-and-short stitch, flat stitch, seed stitch	To depict petal gradation, leaf texture, flower stamens, and delicate natural details
Figures	Flat stitch, random long-and-short stitch, irregular stitch	To represent facial expression, clothing texture, body structure, and subtle shading
Animals	Irregular stitch, random long-and-short stitch, flexible stitch	To portray feathers, fur, movement, vitality, and realistic texture
Architecture	Flat stitch, couching stitch, gold-thread couching stitch	To emphasize structural lines, outlines, decorative details, and a sense of solemnity

Patterns constitute a key visual component of Bian embroidery, serving not only a decorative function but also as an important expression of its aesthetic values and cultural meanings. The subject matter of Bian embroidery is highly diverse, encompassing flowers, birds, insects, fish, animals, landscapes, pavilions, narrative figures, historical scenes, and embroidered reproductions of classical Chinese paintings. This thematic diversity reflects both the strong pictorial capacity of Bian embroidery and its potential for cultural narration. In contrast to the relatively planar and decorative treatment commonly found in folk embroidery, Bian embroidery places greater emphasis on painterly representation. Variations in stitch density, tonal gradation of coloured threads, and compositional hierarchy are employed to convey form, material texture, light and shade, spatial depth, and the relationship between solid and void. Overall, Bian embroidery patterns are characterised by an elegant and classical aesthetic, refined craftsmanship, realistic representation, and rich visual layering. These characteristics reflect the influence of Song Dynasty painting traditions while also embodying Central Plains cultural traditions, auspicious symbolism, and the distinctive craftsmanship of local intangible cultural heritage.

Cultural Element Translation and AI-Assisted Generation

The translation of cultural elements into AI-readable design information constitutes a central stage of the proposed AI-assisted design framework. The cultural characteristics of Bian embroidery extend beyond the surface appearance of individual motifs and encompass subject matter, colour, stitch techniques, compositional forms, and associated cultural meanings. Accordingly, AI-assisted design first requires the identification and classification of these visual and cultural characteristics, followed by their translation into textual descriptors, image references, and other design information that can be interpreted within the generative process.

The translation process can be organised into three interrelated levels:

- Representative subjects and motifs, including peonies, lotuses, plum blossoms, landscapes, pavilions, figures, birds, and animals, are converted into visual descriptors, prompt keywords, or image references that provide the basic content for AI-assisted generation.
- The technical and material characteristics of Bian embroidery are translated into descriptors relating to stitch direction, stitch density, silk-thread lustre, tonal gradation, layered texture, and other embroidery-related visual qualities. These descriptors enable the generative process to incorporate characteristics associated with the material appearance of traditional embroidery.
- Cultural meanings associated with Bian embroidery, such as prosperity, auspiciousness, elegance, resilience, and harmony, are incorporated into the semantic structure of the prompts. This level of translation aims to ensure that generated outcomes respond not only to the formal characteristics of Bian embroidery but also to the cultural meanings associated with its visual elements.

During the generation stage, these translated elements are integrated into text prompts, image references, and other controllable design inputs to support visual exploration. AI-generated outputs should not be regarded as direct reproductions of traditional Bian embroidery; rather, they function as exploratory interpretations in which traditional cultural characteristics are reorganised within contemporary design contexts. For example, floral and bird motifs, landscape compositions, tonal colour relationships, and silk-thread textures may be reinterpreted for subsequent application to scarves, packaging, stationery, accessories, digital illustrations, and other cultural and creative products. Such generative exploration can provide designers with alternative visual concepts that can be further selected, refined, and adapted according to specific product requirements.

The purpose of cultural element translation is therefore not to replace traditional craftsmanship with AI, but to establish a structured pathway linking traditional cultural elements, AI-readable design information, generative visual exploration, and contemporary product development (Figure 1). Within this process, AI functions primarily as a supportive tool for visual ideation and design exploration, while the interpretation, selection, and refinement of generated outcomes remain dependent on the cultural knowledge and professional judgement of designers and craft practitioners.

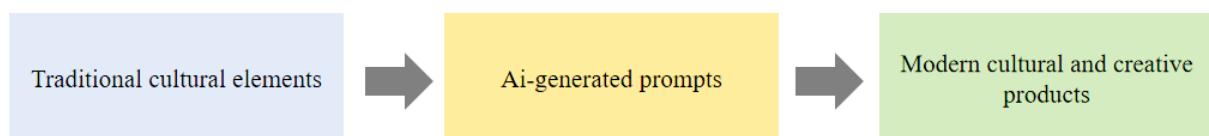


Figure 1. AI-Assisted Design Process for Cultural and Creative Products of Bian Embroidery

Product Application and Design Refinement

After the translation and generation of cultural elements are completed, the visual output generated by the AI can be further developed into specific cultural and creative product concepts. At this stage, the generated images are regarded as one of the design resources. According to the structural and functional requirements of different product types, patterns with cultural recognition are selected and their composition, proportion, colour relationships, and visual hierarchy are optimised. Subsequently, the selected visual elements can be adapted to handbags, scarves, packaging, stationery, and other cultural and creative applications.



Figure 2. Example of AI-Assisted Bian Embroidery Cultural Product Design

As shown in Figure 2, the visual and craft-related characteristics of the selected Bian embroidery bird-and-flower motif are first extracted and translated into prompt keywords, including five birds on branches, delicate stitch texture, silk-thread lustre, a beige silk background, a soft earth-tone palette, leaves and red berries, and fine tonal gradation. These descriptors are then used to generate an AI-assisted design concept that retains the principal compositional and embroidery-related features of the original motif while introducing a more refined and contemporary visual arrangement. The selected concept is subsequently adapted to a traditional round fan, with further adjustments to the scale, placement, and composition of the motif in response to the circular product form. This process illustrates how AI-generated visual outputs can be further refined and integrated into cultural and creative products while maintaining the recognisable aesthetic characteristics of Bian embroidery.

Proposed Evaluation and Feedback Mechanism

The evaluation and feedback stage constitutes the final component of the proposed AI-assisted design framework. It is intended to assess the cultural appropriateness, visual quality, craft-related characteristics, and product applicability of AI-assisted Bian embroidery design outputs. However, the evaluation mechanism outlined in this study was not empirically implemented; rather, it is proposed as a protocol for subsequent validation of the framework. The proposed mechanism combines expert-based assessment with supplementary image-based evaluation.

Future empirical validation could involve Bian embroidery practitioners, cultural and creative product designers, and researchers specialising in intangible cultural heritage. Expert assessment may focus on cultural recognisability, motif accuracy, colour appropriateness, the representation of stitch and textile characteristics, cultural meaning, aesthetic quality, innovation, and product applicability. Such assessment would provide qualitative evidence regarding whether AI-assisted outputs retain identifiable characteristics of Bian embroidery while remaining suitable for contemporary product development.

As a supplementary computational measure, the Fréchet Inception Distance (FID) may be considered in future empirical studies to compare the feature distributions of AI-generated images with those of a reference dataset of authentic Bian embroidery images (Jayasumana et al., 2024). Such comparison may provide an additional indication of visual distributional similarity between generated and reference images. However, FID alone cannot determine cultural appropriateness, symbolic accuracy, craft feasibility, or the overall quality of cultural and creative product design.

Expert assessment and computational image evaluation should therefore be regarded as complementary rather than interchangeable components of the proposed evaluation mechanism. Expert judgement is particularly important for assessing cultural recognisability, symbolic meaning, craft-related appropriateness, and product applicability, whereas image-based metrics may provide supplementary information concerning visual similarity. Future empirical studies could integrate these approaches to examine the proposed framework more systematically.

Discussion

Potential Contributions of AI-Assisted Design for Bian Embroidery

AI-based generative models offer considerable potential for the visual exploration and reinterpretation of complex cultural symbols. By enabling the generation of alternative patterns, colour schemes, textures, and compositional arrangements, such models can broaden the range of possibilities available to designers during the conceptual development stage (Zhang et al., 2023). Domain-adapted generative

approaches may further support the representation of structural, stylistic, and visual characteristics associated with Bian embroidery, thereby contributing to the digital transformation of heritage-related visual resources. Nevertheless, AI-generated outputs should be regarded as exploratory design resources rather than final design solutions and therefore require further selection, refinement, and assessment by designers and craft practitioners.

Within the context of Bian embroidery, generative AI should not be positioned as a substitute for traditional craftsmanship. Its principal value lies in supporting visual ideation and iterative design exploration, allowing designers and artisans to examine alternative combinations of motifs, colours, textures, and compositions during the early stages of development. AI-assisted tools may also provide more accessible means of engaging with Bian embroidery-related visual content and create additional opportunities for cultural exploration and creative participation. In this sense, generative processes may contribute to the contemporary presentation and digital communication of Bian embroidery. However, such potential depends on the extent to which generated content is appropriately guided, interpreted, and refined within its specific cultural and craft context.

Limitations and Challenges of AI-Assisted Bian Embroidery Design

Despite its potential for cultural and creative product development, AI-assisted generation presents several limitations. First, generative models may reproduce the general visual appearance of embroidery without adequately representing the deeper cultural meanings, regional identity, and pictorial traditions associated with Bian embroidery. Consequently, generated images may display a broadly Chinese or embroidery-inspired aesthetic while lacking the cultural specificity and craft logic that distinguish Bian embroidery from other forms of Chinese embroidery. Such visual generalisation may weaken the cultural recognisability and perceived authenticity of the resulting designs.

Second, the artistic qualities of Bian embroidery are closely associated with refined stitch techniques, material properties, and the tacit knowledge accumulated through skilled craftsmanship. Although AI-generated images can visually simulate silk-thread lustre, stitch direction, tonal gradation, and textile texture, these representations do not reproduce the material processes or technical requirements of actual embroidery. A visually convincing generated image may therefore remain difficult to translate directly into a physical embroidered product. Further intervention by designers and craft practitioners is required to assess stitch feasibility, material suitability, structural constraints, and production requirements before an AI-generated concept can be developed into a tangible cultural and creative product.

Third, the quality and cultural specificity of AI-generated outputs are strongly influenced by prompt construction and subsequent iterative refinement. Insufficiently defined cultural descriptors may cause generated results to converge towards generic Chinese-style imagery rather than the distinctive visual characteristics of Bian embroidery. Generative processes also retain a degree of variability, meaning that similar prompts may produce outputs of differing cultural and visual quality. Designers therefore require both an understanding of generative AI and sufficient knowledge of Bian embroidery to evaluate, select, and refine the resulting visual concepts.

For these reasons, generative AI is most appropriately regarded as an exploratory and supportive tool within the early and intermediate stages of the design process. AI-generated images should not be treated as production-ready outcomes; instead, they require further cultural interpretation, design refinement, and craft-related assessment before being translated into appropriate Bian embroidery cultural and creative products. A human–AI collaborative approach is therefore essential for balancing technological innovation with the cultural and technical integrity of traditional craftsmanship.

Future Research

Future research should further investigate the translation of AI-generated Bian embroidery concepts into tangible cultural and creative products, including scarves, packaging, stationery, handbags, and other lifestyle products. Such studies could assess design outcomes in terms of visual quality, material suitability, usability, production feasibility, cultural recognisability, and market applicability. Physical prototyping would be particularly valuable for examining the extent to which digitally represented embroidery characteristics can be translated into actual materials, stitch structures, and production processes.

The participation of Bian embroidery practitioners, intangible cultural heritage specialists, and cultural and creative product designers should also be strengthened throughout the AI-assisted design process. Rather than involving domain experts only at the final evaluation stage, future studies could incorporate their expertise into cultural element extraction, the development of AI-readable descriptors, prompt refinement, generated-output selection, and product adaptation. Such collaborative participation may help reduce the risk of cultural generalisation and improve the cultural and craft-related appropriateness of AI-assisted design outcomes.

Further empirical research is also required to examine how users perceive and respond to AI-assisted Bian embroidery products. Future studies may investigate cultural recognisability, aesthetic preference, perceived authenticity, product acceptance, cultural awareness, and cultural identification

among different user groups. Expert assessment, user studies, and supplementary image-based evaluation methods may also be employed to evaluate the proposed framework more systematically. Such research would provide stronger empirical evidence regarding both the potential and the limitations of AI-assisted design in supporting the contemporary transformation and dissemination of Bian embroidery.

Conclusion

This study proposes a conceptual framework for the AI-assisted design of Bian embroidery cultural and creative products. By identifying and organising the subject matter, colours, stitch techniques, patterns, and cultural meanings of Bian embroidery, the study establishes a structured process comprising Cultural Element Extraction, Cultural Element Translation and AI-Assisted Generation, Product Application and Design Refinement, and a Proposed Evaluation and Feedback Mechanism. Through the illustrative design application, selected characteristics of Bian embroidery are translated into AI-readable design information, developed through generative visual exploration, and subsequently adapted to a contemporary cultural and creative product. The demonstration further indicates that AI-generated outputs are more appropriately treated as intermediate design resources requiring designer selection, refinement, and product-specific adaptation rather than as final design solutions.

The principal contribution of the study lies in establishing a methodological connection between the cultural characteristics of Bian embroidery and AI-assisted design processes. Rather than relying on the direct replication or surface application of traditional motifs, the proposed framework emphasises the systematic translation of visual, craft-related, and cultural information into generative design descriptors, followed by further refinement in response to specific product contexts. Within this process, generative AI is positioned as a supportive tool for visual exploration and concept development, while designers and craft practitioners remain essential for maintaining cultural appropriateness, craft feasibility, and coherence between cultural expression and product form.

Several limitations should nevertheless be acknowledged. The proposed evaluation and feedback mechanism has not yet been empirically implemented, and the present study does not include expert assessment or FID-based evaluation. The illustrative application should therefore be understood as a demonstration of how the framework can be operationalised rather than as empirical evidence of its effectiveness. In addition, the current application is limited in terms of reference materials, visual themes, stitch techniques, and product categories, and therefore does not represent the full diversity of Bian embroidery or the broader range of possible production conditions.

Future research should empirically evaluate the proposed framework through expert assessment, user studies, and supplementary image-based evaluation methods where appropriate. Further studies should also expand the range of Bian embroidery reference materials and product applications, compare different AI-assisted generation strategies, and investigate the translation of digital concepts into physical prototypes. Such research would provide stronger evidence regarding the cultural recognisability, aesthetic quality, craft feasibility, usability, and practical applicability of AI-assisted Bian embroidery design.

References

- [1] Jayasumana, S., Ramalingam, S., Veit, A., Glasner, D., Chakrabarti, A., & Kumar, S. (2024). Rethinking fid: Towards a better evaluation metric for image generation. *In Proceedings of the IEEE/CVF conference on computer vision and pattern recognition* (pp. 9307-9315). <https://doi.org/10.48550/arXiv.2401.09603>.
- [2] Ji, R., & Ghazali, M. M. B. M. (2023). The application of traditional Bian embroidery in modern fashion design. *Frontiers in Art Research*, 5(9), 22-29. <https://doi.org/10.25236/FAR.2023.050905>.
- [3] Li, Y., & Li, J. (2022). The Influence of Design Aesthetics on Consumers' Purchase Intention Toward Cultural and Creative Products: Evidence From the Palace Museum in China. *Front. Psychol.* 13:939403. <https://doi.org/10.3389/fpsyg.2022.939403>.
- [4] Li, H., Zhu, Y., Guo, Q., Wang, J., Shi, M., & Liu, W. (2024). Unveiling consumer satisfaction with AI-generated museum cultural and creative products design: using importance–performance analysis. *Sustainability*, 16(18), 8203. <https://doi.org/10.3390/su16188203>.
- [5] Li, X., Lin, J., & Zhang, X. (2025). Dynamic Transmission and Innovative Transformation of Cultural Heritage: Generative Artificial Intelligence Practices Based on Cultural Cognitive Models. *Applied Sciences*, 15(23), 12651. <https://doi.org/10.3390/app152312651>
- [6] Liu, L., & Zhao, H. (2024). Research on consumers' purchase intention of cultural and creative products—Metaphor design based on traditional cultural symbols. *PLoS ONE* 19(5): e0301678. <https://doi.org/10.1371/journal.pone.0301678>.
- [7] Liu, X., & Cai, L. (2026). Bian xiu yu Hang xiu de yishu tezheng ji fazhan dongyin bijiao yanjiu [A comparative study on the artistic characteristics and development motivations of Bian embroidery and Hang embroidery]. *Journal of Silk*, 63(4), 107–116.
- [8] Wang, Z., & Yao, L. (2016). Innovation in evaluating the cultural value of Bian embroidery heritage. *International Journal of Innovation Science*, 8(3), 217-229. <https://doi.org/10.1108/IJIS-09-2016-024>.

- [9] Xiang Z-R, Li M, Wu Y-M, Xu X-F, Zhang F, Zhao X (2025). Cultural product design: an approach for identifying cultural carriers, transforming cultural elements and applying cultural features. *Design Science*. 2025;11:e39. <https://doi.org/10.1017/dsj.2025.10031>.
- [10] Yu, Q.; Tao, X.; Wang, J (2025). Sustainable Design on Intangible Cultural Heritage: Miao Embroidery Pattern Generation and Application Based on Diffusion Models. *Sustainability* 2025, 17, 7657. <https://doi.org/10.3390/su17177657>.
- [11] Zhang, Y., & Yang, D. (2023). Research on the inheritance and development of Bian embroidery in the context of regional characteristics development. *Journal of Sociology and Ethnology*, 5(6), 11–16. <https://doi.org/10.23977/jsoce.2023.050603>.
- [12] Zhang, L., & Wan, J. (2024). The Impact of Cultural and Creative Products Arising from Intangible Cultural Heritage on Economic Development: A Case Study of Ebian County, China. *Journal of Resources and Ecology* 15(4), 1106-1112. <https://doi.org/10.5814/j.issn.1674-764x.2024.04.028>.
- [13] Zhang, B., Cheng, P., Deng, L., Romainoor, N. H., Han, J., Luo, G., & Gao, T. (2023). Can AI-generated art stimulate the sustainability of intangible cultural heritage? A quantitative research on cultural and creative products of New Year Prints generated by AI. *Heliyon*, 9(10). <https://doi.org/10.1016/j.heliyon.2023.e20477>.

Acknowledgment

The authors independently conducted the conceptualisation, literature review, framework development, design demonstration, and manuscript preparation. We would like to express our gratitude to Dr Catherina Anak Ugap for providing the necessary academic environment and guidance. Special thanks are also extended to the Universiti Pendidikan Sultan Idris for the studio space and archival access that supported the analysis of embroidery.

Funding Information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

AI and LLM Disclosure (Limited Use)

Limited use of generative AI/LLMs supported language editing and clarity. All AI-assisted edits were critically reviewed and validated by the author, who assumes full responsibility for the submission.

Authors' Bio

Li Yibo holds a Master's degree and is currently pursuing a PhD in New Media at Sultan Idris Education University in Perak, Malaysia. Since 2023, he has been engaged in research on the preservation of intangible cultural heritage and teaching specialised courses in product design. In his teaching and research work, he has published one paper in a core journal, led a university-level special project in the humanities and social sciences, and participated in two research projects at various levels.

Dr. Catherina Anak Ugap is a lecturer at the Faculty of Art, Sustainability and Creative Industry, Sultan Idris Education University (UPSI). She specialises in Communication and Media Studies, Television, Animation and Film. Her recent achievements include research into innovative practices in artificial intelligence and art and design education. Outside the academic sphere, she is also very active in Malaysia's creative sector.