

Transcending Time: The Resurrection of the Intangible Cultural Heritage of Sugar Painting through Human-Robot Dynamics in an “Everywhen” Perspective

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Abstract

Everywhen, as a conceptual framework, challenges the conventional linear perception of time and offers a perspective that is more akin to a continuous circle. Within this framework, it becomes evident that certain facets of Chinese cultural tradition face the risk of fading into obscurity in an age of intelligence and automation. This is particularly noticeable in the context of sugar painting, which has encountered numerous challenges in preservation with the passage of time. Conversely, innovative techniques, such as human-robot collaboration, breathe new life into these fading traditions. This research elucidates the technical process of preserving sugar painting through collaborative efforts between humans and robots, covering steps such as tool optimization, pattern design, printing test, and interaction design. The findings emphasize the innovative benefits of this approach, including the preservation of performativity and engagement, the evolution of content aesthetics, broader audience reach, and the transfer of skills to future generations. As such, this project demonstrates the potential of human-robot collaboration in the artistic revival of broader intangible cultural heritage, creating a dynamic circle and defying the limitations of linear time processes.

Keywords

Sugar Painting, Revitalization of Chinese Folk Art, Human-robot Collaboration, 3D printing, Transdisciplinary

Introduction

In the present era, where humans and robots coexist and collaborate, traditional craftsmanship faces an array of challenges. Yet, in all this change and adaptation, a unique opportunity arises to resurrect and revitalize intangible cultural heritage. At the heart of this resurgence lies the profound concept of “everywhen,” a unifying idea that seamlessly bridges the past, present, and future, offering a compelling pathway for the revival of our cultural treasures.

The 21st century has been irrevocably shaped by an unprecedented fusion of human ingenuity and robotic innovation. [1] Within this temporal landscape, we find ourselves firmly entrenched in a human-robot era, where the lines between human and machine have become increasingly blurred, establishing a dynamic realm where collaboration and synergy take center stage. [2] This epoch unfolds before us with a plethora of thrilling possibilities, spanning from the realms of artificial intelligence and automation to the augmentation of human capabilities. [3] The ramifications of this epoch extend across diverse industries, manifesting

in heightened automation that amplifies efficiency and productivity, as well as liberates humans from repetitive or hazardous tasks. [4] Moreover, this collaborative paradigm has ushered in a new era of precision and accuracy, particularly in areas necessitating exactitude, thereby mitigating errors and elevating overall quality. As proposed by Sheridan, current human-robot interaction can be divided roughly into four areas of application. These include the performance of routine tasks, remote control for nonroutine tasks in inaccessible environments, automated vehicles with humans as passengers, and devices designed for social interaction. [5] Yet, what proves to be equally remarkable is the transformative potential, particularly in breathing new life into age-old traditions that have shaped the cultural fabric of our world. Within the realm, the dynamics between humans and robots have opened novel avenues for creativity and expression.

Traditional craftsmanship, while imbued with rich heritage and profound cultural significance, confronts a myriad of challenges within our swiftly transforming society, characterized by rapid technological advancements and changing societal values. [6] The rationale behind these challenges lies in the tension between the imperative to preserve cultural heritage and the demand for adaptability in the face of contemporary dynamics, resulting in these time-honored practices often finding themselves at a crossroads, navigating the balance between preservation and adaptation. [7] It is suggested that the noble pursuit of safeguarding cultural heritage necessitates a discerning approach, one that ensures conservation without succumbing to stagnation or fading into obscurity. Tradition, in the perpetual flux of our evolving world, must dynamically evolve to remain pertinent. [8] In an era dominated by digital paradigms, characterized by abbreviated attention spans, traditional craftsmanship may occasionally appear remote and inaccessible. It is imperative that these cultural treasures devise strategies to resonate with younger audiences who are growing up in a world vastly different from that of their ancestors. [9]

It is against this backdrop of changing dynamics and contemporary challenges that the concept of “everywhen” comes to the forefront. “Everywhen” is a notion that transcends time, providing a conceptual bridge that connects the historical, the present, and the future. [10] It embodies a perspective that cherishes the enduring elements of culture while concurrently embracing the contemporary and the innovative. Essentially, this concept captures the idea that tradition can be reinvigorated, enabling the harmonious coexistence of the past with the present, and facilitating the

ongoing evolution of art and culture. Through a deeper understanding of “Everywhen”, this research aims to appreciate how traditional art forms can adapt, flourish, and remain relevant in a world where change is the only constant. It undertakes an in-depth exploration of the potential inherent in human-machine collaboration to rejuvenate artistic traditions, centering its investigation on the traditional Chinese art form of sugar painting. It begins with an introduction of its definition and artistic values, providing insights into the extensive historical and cultural significance of Chinese sugar painting, alongside an examination of contemporary challenges faced in the realm of heritage preservation. Subsequent sections explore the technical processes of sugar painting facilitated by human-robot collaboration, elucidating aspects such as tool optimization, software design, and interaction design. The narrative culminates by directing attention to the innovative advantages conferred by human-machine collaboration, emphasizing its capacity to inject newfound vitality into the conventional craft of Chinese sugar painting and envisioning its trajectory in alignment with the conceptual framework of “everywhen.” This research thus stands as an exploration of the intersection of design, art, culture, and technology, offering a paradigmatic illustration for the conservation and evolution of diverse intangible cultural heritage crafts within the evolving landscape of the human-machine era.

Diminishing Intangible Cultural Heritage: The Chinese Folk Art of Sugar Painting

Essence of Chinese Folk Art: Sugar Painting

Sugar painting, an ancient and distinctive form of folk art in China, embodies a dual nature as both an artistic and culinary creation, earning it the moniker “both sugar and painting, observable and edible.” [11] This unique attribute not only renders it visually captivating but also seamlessly integrates art into everyday life, hence bestowing upon it the title of “grassroots art.” [12] In 2008, the Chinese government formally designated sugar painting as an intangible cultural heritage, underscoring its cultural significance. Owing to the vast expanse of China, this intangible heritage art form is known by various regional names across the country, including “sugar molding,” “sugar pouring,” “sugar figurines,” and more, reflecting the diverse regional nuances.

While bearing different regional names, the craft of creating sugar painting follows a consistent process. It involves the use of raw materials such as sugarcane and malt extract, which are heated and boiled to create a pliable and highly resilient liquid. Subsequently, a small quantity of this sugar syrup is poured onto a pad placed on a stone surface using a copper spoon. This allows for the stretching and shaping of the syrup to complete the drawing of intricate patterns. In the final step, the property of sugar syrup to solidify easily is harnessed, enabling the adhesion of various sugar components using bamboo sticks and the careful removal of the completed sugar artwork. While the craft of sugar painting may appear simple at first glance, it entails a fusion of

complex artistic elements, particularly during the process of creating patterns, all against the backdrop of the challenging property of sugar syrup to solidify quickly. This necessitates artisans to work swiftly while maintaining the fluidity of their lines (See Figure 1). Furthermore, sugar painting is also a perfect representation of traditional Chinese ink painting, showcasing characteristics of three-dimensionality, extreme minimalism, and iconic figurative representation. [13] Artisans employ a copper spoon as their “brush” and sugar syrup as their “ink,” deftly maneuvering their hands with nimble and fluid motions to create the artwork in one continuous effort. The manipulation of line thickness, firmness, interplay of void and form, and variations in density bear a striking resemblance to the techniques used in Chinese ink painting, akin to “baimiao” (fine-line drawing), and also create a tactile effect reminiscent of bas-relief sculpture. [14] Thus, sugar painting possesses exceptional artistic and aesthetic value.



Figure 1 The artist is removing a dragon figure after it cooled and solidified. Source: Wikipedia, Photo by Andrea Lai, licensed under CC BY 2.0. https://en.wikipedia.org/wiki/Sugar_painting

The Historical and Cultural Values of Chinese Sugar Painting

Sugar painting has a rich and evolving history in Chinese folk culture and its development is closely tied to the advancement of ancient Chinese sugar-making techniques. The cultivation of sugarcane began during the Eastern Zhou period, while the extraction of sugar became evident during the Warring States period. The Tang Dynasty witnessed the introduction of new sugar-making techniques through cultural exchanges with ancient India, particularly the production of refined sugar, which laid the foundation for the materials used in sugar painting. During the Ming Dynasty, as sugar-making techniques matured, the art of sugar painting formally emerged and prospered in the Sichuan region, subsequently spreading throughout the country. In the Qing Dynasty, it reached its zenith, boasting a wide array of themes and exceptional craftsmanship, becoming a source of daily entertainment and offerings for the common people. [15] Following the establishment of the People’s Republic of China, in 1986, during a gathering organized by the Chengdu Cultural Bureau with folk artists, a unanimous decision was made to designate this popular regional folk art

form as “sugar painting.” It represents a stage of development in Chinese sugar-making technology, and each evolution in the sugar painting style chronicles societal changes in different eras, reflecting the transformation of historical and cultural customs.

This craft features a diverse array of themes, encompassing historical narratives of prominent figures and various animal motifs. It serves as a tangible repository for Chinese zodiac culture and a wealth of rich folk tales. Simultaneously, sugar painting embodies auspicious symbolism, conveying the profound Eastern philosophy of harmonious coexistence between humans and nature. It mirrors the aspirations of a harmonious, reunified, and blissful existence that permeates folk life. [16] Sugar paintings can often be found adorning the streets and alleys throughout the country, particularly during festivities like lantern festivals and temple fairs. It serves as a means for people to establish a connection with their cultural heritage and traditions. It is not only a living example of grassroots culture deeply rooted in people’s lives but also a vehicle for international cultural exchange. Since the 1990s, Chinese sugar painting artists have traveled to countries such as Spain, Singapore, Malaysia, and Brunei to showcase this traditional folk art, contributing to the enhancement of international cultural exchange and dissemination. [17]

The Contemporary Challenges and Cultural Inheritance of Sugar Painting

Therefore, sugar painting serves as a rich storehouse of artistic merit and cultural heritage. Despite its recognition as the second tranche of national-level intangible cultural heritage in 2008 and subsequent inclusion in the roster of representative project protection units for provincial-level intangible cultural heritage in Sichuan in 2022, it faces formidable challenges in terms of preservation, succession, and development. [18] Firstly, the diminishing availability of street vending locations, driven by urban management refinements, restricts the potential performance venues for sugar painting. [19] Secondly, the seemingly uncomplicated process of sugar painting demands substantial time investment from learners. Additionally, the limited income potential associated with this art dissuades younger individuals from pursuing its mastery. Furthermore, the physical preservation of sugar painting artworks poses inherent difficulties, and the constrained exhibition avenues in museum settings curtail its broader dissemination. [20] As a result, in alignment with Liao Xuneng’s viewpoint, the trajectory of sugar painting’s development appears to have reached a point of stagnation. Without innovative interventions, there is a looming risk of gradual obsolescence. [21]

With the ongoing advancement in digital technology, various technical approaches have been employed to explore strategies for addressing the challenges confronted by sugar painting. [22] However, these methods still exhibit certain limitations. While attempts have been made to utilize social media platforms for live-streaming performances and

transmitting artistic knowledge, they often lack the necessary depth of content innovation. Even when employing these techniques, if the inherent content of sugar painting fails to resonate with contemporary popular culture and struggles to engage the interest of the audience, keeping pace with the times becomes a difficult task. Consequently, it is implied that even with the utilization of diverse new media channels for promotional purposes, there remains the risk of marginalizing the art of sugar painting.

In the market, a new type of automatic sugar painting printer has emerged, which integrates heating, stirring, and printing functions into a single device. People need only pour sugar syrup into it, and patterns are automatically generated. Nevertheless, this method, while improving production efficiency and expanding the variety of patterns, lacks the performative aspect that is intrinsic to traditional sugar painting. Sugar painting is an art form that is best appreciated through both observation and live performance, contributing to the enrichment of people’s psychological state and recreational experiences. Such machines no longer have the capacity to foster a shared cultural consciousness among the audience concerning emotional experiences. Moreover, despite the increased efficiency offered by these smart machines, they entirely supplant artisans. [23] This severance of the connection between the past, present, and future fails to provide a sustainable framework for preserving the tradition. It might cause the art of sugar painting to lose its original allure and cultural significance.

In light of these constraints and challenges, the imperative for innovative strategies to preserve and advance the sugar painting tradition becomes apparent. Human-robot collaboration emerges as a promising avenue, transcending limitations faced by traditional artisans and fully automated machines. The following section explores this potential, revealing its capacity to revitalize this ancient art form in an ever-evolving technological landscape.

Exploring Human-Robot Collaboration in Sugar Painting Production

Overall Framework

In adherence to conventional procedures, this craft encompassed four distinct steps: sugar syrup boiling, sugar painting, affixing paintings, and lifting paintings. While all manual steps were retained, an exception was made for painting patterns (See Figure 2). This decision was based on two principal rationales. Firstly, it aimed to cultivate human-machine collaboration that surpassed interactions solely between designers and machines, envisioning a future where end-users could actively engage in interactions with machines. Secondly, the preservation of these traditional manual steps was seen as contributing to the maintenance and progression of craftsmanship, thereby supporting artisans in

the era of human-machine interaction by sustaining employment opportunities.



Figure 2 From left to right, the sequence includes simmering sugar syrup, employing a robotic arm to print patterns, lifting the sugar syrup design with a spatula, and finally, resin encapsulation. ©Shujiao.

The process of printing the patterns involved steps of tool-head optimization, digital model transmission, printing test, and interaction design (See Figure 3). Pattern models were generated in Grasshopper and subsequently transmitted to the control system of the KUKA kr1 100 robotic arm through the KUKA plugin. Finally, the tool head operated at high temperatures to print the sugar syrup.



Figure 3 The procedural steps of the project. ©Shujiao.

Tool Optimization: 3D Printed Sugar Syrup Extruder

The extrusion head for sugar syrup was a significant mechanical component in this project, as its design exerted a decisive impact on both the flow characteristics of the sugar syrup and the overall quality of the resulting sugar art. Engineered from stainless steel, it incorporated an internal funnel-shaped design, purposefully enhancing the seamless flow of the sugar syrup (See Figure 4). Internally, the extrusion head was equipped with two heating rods, which ensured precise temperature control aligned with the settings specified in the program files.



Figure 4 Design of the 3D printing extruder. ©Shujiao.

In terms of the connection components between the extrusion head and the robot arm flange, comprehensive consideration was given to both aesthetic and structural

integrity aspects. The selection of perforated acrylic material served as a strategic choice for establishing connections between various materials, including wood, metal, and acrylic. Considering the extrusion head's exposure to elevated temperatures during robot operations, safety measures had been meticulously implemented. These encompassed the utilization of insulating materials and the fabrication of a 3D-printed PLA shell, a measure designed to augment the visual appeal while simultaneously enhancing the safety and hygiene of the system (See Figure 4&5).

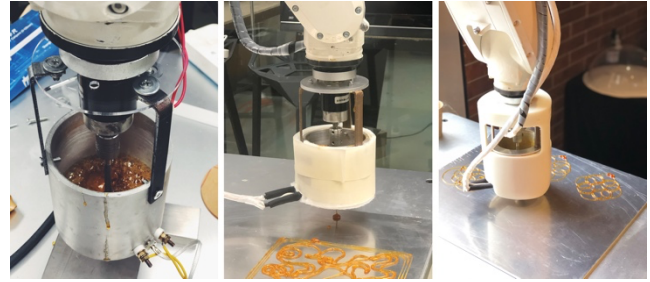


Figure 5 Arranged from left to right are as follows: a 3D printing extruder, enveloped in thermal insulation cotton and encased in a 3D printed shell. ©Shujiao.

Software Design: Image Processing for Printing Patterns

To begin with, pattern paths embodying distinctive elements of Chinese tradition were established within the Rhino software. These patterns involved the twelve commonly featured animals in traditional handicrafts, representing the Chinese zodiac, as well as the ornamental window designs prevalent in classical Chinese gardens (See Figure 6).



Figure 6 Rhino Models of Traditional Chinese Garden Window Decorations. ©Shujiao.

It revealed that the test result was constrained by the uniform dispensing speed of materials, making it challenging to fully capture the nuances of traditional sugar art, characterized by a graceful interplay of light and shade and an elegant essence. To address this, elementary mathematical logic within Grasshopper was employed to craft a second set of parametric patterns (See Figure 7), capitalizing on the distinct advantages of robotic arms in sugar art production.



Figure 7 Rhino models of parametric patterns. These patterns were generated based on simple mathematical logic. ©Shujiao.

The intricacy and refinement of these parametric patterns stemmed from the fact that traditional sugar artists were often bound by strict time constraints, leading to a preference for simpler designs. In contrast, the parametric patterns produced by robotic arms were not subject to time limitations, allowing for the creation of more intricate and exquisite mathematical effects (See Figure 8). This infusion of innovation and vitality from the contemporary era revitalized traditional sugar art, rendering it even more captivating and appealing.



Figure 8 Printing test of parametric patterns. ©Shujiao.

Interaction Design

Real-time audio-visual interaction. To enhance the interactive experience of the audience during the performance, the project incorporated an interactive mode of audio visualization (See Figure 9). The audio data was integrated into the system by utilizing the Firefly plugin in Grasshopper and transformed into parameters used for generating patterns. These patterns elegantly fused the rhythms of music with the artistic creative process. Following the step, the custom-designed patterns were transmitted to a robotic arm, which utilizes syrup to execute the printing process. The interaction mode not only stimulated their creativity but also kindled an interest in the convergence of music and visual art, providing the audience with a dual feast of audio and visual delight.

Potential interactive modes. The project has also evolved to offer a diverse range of audience engagement possibilities. At present, a series of exciting modes, one of which involves capturing real-time facial photographs of attending patrons, are being developed. Image processing techniques are employed to extract edge paths from audiences' facial photographs, imparting unique and personalized attributes to the resulting patterns. Additionally, it will allow the audience to craft their preferred patterns directly on tablet devices, which are promptly sent for printing by the robotic arm. In summary, this initiative harbors numerous untapped possibilities for audience interaction, adaptable to a broad spectrum of cultural preferences, thus injecting fresh vitality and charm into this time-honored craft.

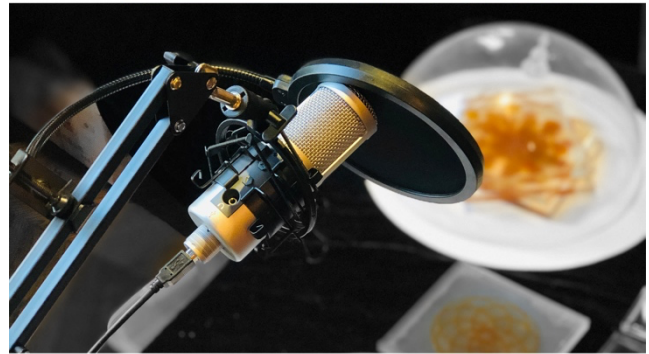


Figure 9 The visualization of sound in sugar painting. From top to bottom: The audience engaging with the microphone to produce sound, the microphone apparatus used, and the sugar painting pattern generated through sound printing. ©Shujiao.

Exhibitions: Gallery and Museum Presence of 3D-Printed Sugar Paintings

The inaugural presentation of the project took place at the Renren Market in Shanghai's Yangshupu Riverside from September 4th to September 6th, 2020, spanning the hours from 6:00 PM to 10:00 PM each day. Renren Market, with its thematic focus on "Street, Freedom, and Creativity," aspired to cultivate a sophisticated public space. The event showcased installations, performances, and works from art and design schools, establishing itself as a preliminary, integrated cultural landmark for the youth along Yangpu Riverside. Throughout the exhibition, numerous audiences were intrigued by the process of creating sugar paintings with a robot arm (See Figure 10). Its presence not only diversified the market's offerings but also fostered an environment where artistic experiments, technological

innovation, and cultural exploration converged, making a meaningful contribution to the broader cultural and economic vitality of the region.



Figure 10 A substantial audience is drawn to the project, gathering to observe. ©Shujiao.

During the subsequent National Day holiday, from October 1st to October 7th, the project was exhibited on the first floor of the Yifeng Bund Source Building situated along the iconic Bund in Shanghai (See Figure 11). The project occupied display windows to captivate the attention of visitors during the holiday, adding cultural and artistic vibrancy to the renowned Bund area.



Figure 11 The project displayed in the storefront, drawing pedestrians into the art gallery. ©Shujiao.

It has actively participated in numerous exhibitions hosted by professional institutions and festivals. Currently ongoing, the project has been featured in various events, including the 2020 Shanghai International Exhibition on Spatial Installations and Material Design Graduate Summer School, the December 2020 exhibition at the Yu Deyao Art Museum (See Figure 12), the inaugural Maker Faire in November 2020, Maker Faire in October 2021, the November 2022 Waste Planet Recyclable Frame Exhibition at the Shenzhen-Hong Kong Biennale Longgang Branch, the February 2023 Shanghai Expo Exhibition, the May 2023 Maker Faire, and the October 2023 Shanghai Family Music Festival at the inaugural Heat Fan Park.



Figure 12 The artworks displayed at Shenzhen-Hong Kong Biennale and Shanghai Expo Exhibition, featuring 800*800mm. © Kangyi Zheng.

Why Human-Robot Collaboration Shines: Cultural Preservation and Continuity through Everywhen Perspective

Bridging Temporal Boundaries: Reviving the Past in Robot Sugar Painting

Performance and Engagement. Traditional sugar painting is renowned for its immediate artistic appeal and has been a hallmark of craftsmanship suitable for live presentations in public settings. The utilization of human-robot printing effectively upholds this inherent essence of performativity. It satisfies the audience's inquisitiveness regarding the intricacies of sugar painting, while simultaneously introducing an engaging facet through audio-visual interaction, actively involving the spectators. Across various dimensions, such as the visual and imaginative realms, cognitive exchange, and interactive engagement, the human-robot collaborative approach contributes to the preservation of collective cultural identity within the audience. From these dual vantage points of performance and engagement, human-robot collaboration encapsulates the cultural essence of this art form, thereby facilitating its perpetuation in the modern context.

Evolving Aesthetics of Content. In the realm of content innovation, this project has undergone substantial enhancements through the integration of digital technology. It responds to the evolving aesthetic sensibilities of its audience and market demands by introducing intricate parametric pattern designs. Significantly, the embrace of digital modeling serves the dual purpose of preserving traditional patterns and addressing the dynamic aesthetic landscape of the digital age. This transformative approach satisfies contemporary society's quest for diversity and novelty in cultural products. It reflects the contemporary influence of digital aesthetics, regional cultural nuances, and evolving trends in societal artistry. This alignment with the concept of "everywhen" emphasized the living nature of culture, where traditions

evolve and adapt to modern demands while retaining core cultural significance.

Pioneering Cultural Continuity: Envisioning the Future Role of Human-Robot Collaboration in Sugar Painting Artistry

Preservation and Promotion. This project has addressed the historical challenge of preserving sugar painting artworks, traditionally hindered by material constraints. The solution involves the transformation of these artistic patterns into resin craft ornaments, ensuring the enduring conservation of sugar painting pieces for future observation and research. This novel display method not only introduces fresh possibilities for the artistic presentation of sugar painting but also facilitates its inclusion in prestigious institutions like museums and art galleries, thereby providing a professional platform for the exhibition of this traditional folk art. This transformative shift facilitates the evolution of sugar painting from a form of street art to culturally distinctive artworks, marking a significant transition from grassroots art to the refined spaces of art museums. The project's current participation in multiple exhibitions is a noteworthy accomplishment, previously unattainable for sugar painting. Moreover, this method allows sugar painting patterns to perform the role of cultural creative products. Resin-encased sugar paintings can now serve as household decorations, imparting broader societal influence. This preservation and promotional strategy not only contemporizes sugar painting but also guides its potential future roles as sought-after art collectibles and distinctive decorative items.

Skills to Future Generations. This project strategically preserves the roles of traditional artisans by not entirely displacing human involvement. The method retains essential manual steps integral to traditional sugar painting, such as the preparation of sugar syrup, pattern design, and exhibit crafting. Within the socio-cultural framework of China, a proposition is put forth for governmental intervention to endorse and invest in human-robot collaborative systems while also instituting comprehensive training programs for artisans. Such measures would provide artisans with ongoing engagement opportunities, thereby fostering the continuity of their craftsmanship. Such effort also promotes a synergistic balance between human dexterity and automated efficiency. In the era of advanced intelligent production, this reciprocal relationship is instrumental in perpetuating the culturally resonant practice of sugar painting. Furthermore, this initiative does not merely address the extant survival challenges of the artisans but rather redefines their role as innovators and custodians of tradition amidst the dynamic domain of craftsmanship. It ensures the perpetuity and relevance of these art forms, allowing them to remain vibrant and significant for future generations.

Conclusion

As an exemplary folk traditional craft, the art of sugar painting not only epitomizes the rich and diverse landscape of folk art but also encapsulates historical imprints and cultural essence. Nevertheless, amidst the progression of modern society, traditional sugar painting confronts a myriad of challenges, including limitations in production venues, the impending crisis of artisanal succession, and the contraction of the consumer market. Despite diverse technological attempts aimed at salvaging this intangible cultural heritage, each approach has exhibited intrinsic constraints on cultural transmission. In this project, we employed a collaborative human-machine approach to explore the revival of sugar painting. It retained manual processes such as boiling sugar syrup and pasting and peeling off patterns while utilizing a robotic arm for pattern drawing. This method preserves the performative aspect of sugar painting while introducing digitized pattern creation, skillfully blending the traditional and modern realms. Importantly, it avoids a simplistic dichotomy between tradition and contemporary industry, offering possibilities for artisans to be engaged. The innovative preservation method also allows sugar painting to be exhibited in museums and art galleries, reaching a wider audience for its future development. This approach adeptly intertwines historical, contemporary, and prospective dimensions, facilitating the rejuvenation of artistic expression and the perpetuation of cultural legacies.

In summary, the trajectory of sugar painting's development emerges as a representative microcosm within the broader evolution of numerous intangible cultural heritages. The shifting conditions for the survival of traditional handmade legacies, along with the emergence of advanced intelligent machines, inherently pose challenges to the continuity of these time-honored arts. This project, as an illustrative exemplar, elucidates the potential for contemporaneous revitalization of ancient artistic craftsmanship and the prospective transmission of cultural heritage. Its insights contribute to the scholarly discourse surrounding broader intangible cultural heritage initiatives, offering strategic considerations for achieving artistic rejuvenation in an era characterized by the concurrent existence of humans and machines.

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Appendices

Videos providing an in-depth view of our work can be accessed at:

1. Robotic Arm Sugar Painting: Design and Production Process:

https://drive.google.com/file/d/12KDri_Mz0r_V_noqgK_JR3mnHLDUUYVf/view?usp=sharing

2. Renren Market Project Exhibition:

https://drive.google.com/file/d/1IvD7_RmKOG0eFuvNOn38m8efwy-Y6OpW/view?usp=sharing

References

- [1] Teboho Pitso, “Shared Futures: An Exploration of the Collaborative Potential of Intelligent Machines and Human Ingenuity in Cocreating Value(2019),” in *Toward Super-Creativity-Improving Creativity in Humans, Machines, and Human-Machine Collaborations*(IntechOpen, 2020), 28-57.
- [2] Erica Orange, “Understanding the Human-Machine Interface in a Time of Change,” in *Handbook of Research on Technoself: Identity in a Technological Society*, ed. Rocci Luppigini (Hershey, PA: IGI Global, 2013), 703-719.
- [3] Mary Missy Cummings, “Man Versus Machine or Man+ Machine?,” *IEEE Intelligent Systems* 29, no. 5 (2014): 62-69.
- [4] Dieter Spath, Martin Braun, and Wilhelm Bauer, “Integrated Human and Automation Systems,” in *Springer Handbook of Automation*, ed. Shimon Y. Nof (Berlin: Springer, 2009), 571-598.
- [5] Thomas B. Sheridan, “Human–Robot Interaction: Status and Challenges,” *Human factors* 58, no. 4 (2016): 525-532.
- [6] Charu Lata Singh, “New Media and Cultural Identity,” *China Media Research* 6, no. 1 (2010).
- [7] Abdelhak Belhi, Abdelaziz Bouras, and Sebti Fofou. “Digitization and Preservation of Cultural Heritage: The CEPROQHA Approach.” in *Proceedings of the 2017 11th International Conference on Software, Knowledge, Information Management and Applications (SKIMA)*, (2017): 1-7.
- [8] Ronald Inglehart and Wayne E. Baker. “Modernization, Cultural Change, and the Persistence of Traditional Values,” *American Sociological Review* (2000): 19-51.
- [9] Amanda C. Neill, “Providing a Tailored Educational Interaction with Cultural Treasures: A Study of Museum Docents,” *Journal of Adult and Continuing Education* 16, no. 2 (2010): 67-82.
- [10] William Brian Bates (Badger), Long Chu, Hozaus Claire, Matthew J. Colloff, Robert Cotton, Ruby Davies, Libby Larsen, et al. “A Tale of Two Rivers – Baaka and Martuwarra, Australia: Shared Voices and Art Towards Water Justice,” *The Anthropocene Review* 11, no. 1 (2024): 228-261,
- [11] Ji Xiaoping, “中国民间糖画艺术的文化透视” [The Cultural Perspective of Chinese Folk Sugar Painting Art], *Journal of Shenyang Agricultural University (Social Sciences Edition)*19, no.4 (2017): 490-494.
- [12] Wei Wei, “糖为墨勺为笔 勾勒龙腾虎跃的甜蜜世界” [Using Sugar as Ink and Spoon as Pen to Sketch a Sweet World], *Tangshan Labor Daily*, July 13, 2022, p. 004.
- [13] Huang Weiqing, Cai Qian, and Chen Xincheng. “文化自信背景下中华才艺融入高校美育课程——以糖画为例” [Integration of Chinese Talent into University Art Education Courses under the Background of Cultural Confidence: A Case Study of Sugar Painting]. *Art Education Research*, no. 21 (2022): 113-115.
- [14] Li Cangyan, and Li Yan. “糖的艺术” [The Art of Sugar]. *Folk Art*, no. 2 (2022): 58-63.
- [15] Hao Liang, “非遗视域下的蔗糖作画技艺现状及发展策略” [Current Status and Development Strategies of Sugar Painting Techniques in the Intangible Cultural Heritage Perspective]. *Guangxi Sugar Industry*, no. 2 (2023): 42-46.
- [16] Huang Yuxi, and Zhang Wanyu, “成都糖画传承保护创新与应用研究” [Research on Inheritance, Protection, Innovation, and Application of Chengdu Sugar Painting]. *Silk Screen Printing*, no. 01 (2023): 15-18.
- [17] Liao Xuneng, “国家非物质文化遗产——糖画现状” [National Intangible Cultural Heritage - Current Status of Sugar Painting]. *Delta*, no. 17 (2022): 154-157.
- [18] Liu Keping, “成都糖画传承与发展研究” [Research on the Inheritance and Development of Sugar Painting in Chengdu]. *Sichuan Drama*, no. 1 (2020): 158-160.
- [19] Wang Yueheng. “社群时代非物质文化遗产商业化传承的探索与创新——以成都糖画和金钱板为例” [Exploration and Innovation of the Commercialization and Inheritance of Intangible Cultural Heritage in the Social Media Era - A Case Study of Chengdu Sugar Painting and Money Board], *Chinese Business Forum*, no. 35 (2018): 164-166.
- [20] Huang Weiqing, Cai Qian, & Chen Xincheng. “文化自信背景下中华才艺融入高校美育课程——以糖画为例” [Integration of Chinese Talent into University Fine Arts Education under the Background of Cultural Confidence - A Case Study of Sugar Painting], *Art Education Research*, no. 21 (2022): 113-115.
- [21] Liao Xuneng. “国家非物质文化遗产——糖画现状” [National Intangible Cultural Heritage - Current Status of Sugar Painting], *Delta*, no. 17 (2022): 154-157.
- [22] Wang Xinyu. “新媒体时代西南传统手工艺推广研究——以重庆糖画为例” [Research on the Promotion of Traditional Handicrafts in Southwest China in the New Media Era - A Case Study of Chongqing Sugar Painting], *Tiangong*, no. 4 (2021): 78-79.
- [23] Liao, Xuneng. “国家非物质文化遗产——糖画现状” [National Intangible Cultural Heritage - Current Status of Sugar Painting], *Delta*, no. 17 (2022): 154-157.

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Shujiao is a doctoral candidate at Nanyang Technological University’s School of Art, Design, and Media in Singapore, specializing in urban media art. Her research intersects urban surface mapping and media façades, with a critical focus on the social and cultural narratives of urban media art in mainland China.

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Zheng Kangyi serves as the leader of the digitalization division at the Innovation Field within the College of Design and Innovation at Tongji University. His expertise encompasses intelligent manufacturing, parametric and extensible design, interactive design, and digital visualization.