International Symposium on World Ecological Design
F. Ying et al. (Eds.)

doi:10.3233/FAIA240055

Understanding Paintings Through Scent: A Chinoiserie Painting Digital Olfactory Environment Interactive System

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Abstract. The Chinoiserie of the 17th and 18th centuries, which caused a cultural exchange between China and the West, is an important cultural heritage; therefore, its preservation, publicity, and dissemination are crucial. However, traditional exhibition methods fail to satisfy visitors who desire interactive experiences and considerable knowledge acquisition. In this study, a digital olfactory environment interactive system was used to enhance the user experience in an exhibition where scent served as an interactive medium. This system provides different scented environments for visitors by determining the relative locations and distance between visitors and Chinoiserie paintings to satisfy their diverse needs. A minimalist concept was implemented for the investigation during group collaboration. The user research results showed that the Chinoiserie painting digital olfactory environment interactive system (COIS) effectively garnered the attention of participants and improved their understanding of the Chinoiserie paintings. This study emphasizes the importance of digital environmental representation in exhibitions focused on cross-cultural exchange.

Keywords: Interactive System, Olfactory Environment, Chinoiserie Painting, Cultural Exchanges Between China and the West

1. Introduction

Enhancement in visitor experience has increasingly become a focal point of museum exhibition planning, especially in the exhibition of the Chinoiserie paintings of the 17th and 18th centuries. Traditional exhibitions limited to "tangible" displays no longer satisfy the requirements of contemporary visitors for interactive experiences and knowledge acquisition. Currently, more exhibitions are leveraging digital technology, offering visitors an immersive experience and bolstering their role in cultural dissemination. Consequently, the digital presentation of artworks in a museum setting has attracted widespread attention and research.

Digital presentations can serve as a potent learning medium; however, their

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utilization by museums is markedly insufficient. Several important institutions, such as the British Museum, Louvre, and Metropolitan Museum of Art, provide digital environments using virtual reality (VR) and augmented reality (AR) technologies. However, they typically limit sensory experiences to visual and auditory stimuli and lack interactive experiences, thereby failing to stimulate learning enthusiasm.

The Chinoiserie painting digital olfactory environment interactive system (COIS), introduced in this paper, is an interactive system comprised of a hardware peripheral, positional sensors, and a software system. This system provides real-time feedback on scent by determining the relative position of a user from an artwork (the hardware and software systems can be connected via Bluetooth or Wi-Fi). Depending on their position and distance, visitors can experience different olfactory environments, catering to diverse user needs. During the initial design and creation of COIS, we consulted various artificial intelligence (AI) experts, art professors, and product design professors, conducted in-depth interviews and discussions, and developed system models to test the user understanding of COIS. To understand the user experience regarding the interactive system, we selected a representative sample of visitors for preliminary user research. The results indicated that visitors showed high acceptance during the system design and usage, demonstrating their considerable interest in novel interactive methods and digital environment presentations. The main contributions of this research are as follows:

- We designed an interactive system comprising a hardware peripheral with an odour generator, a position sensor, and a software The system replay an olfactory environment within the artwork based on the relative position of the visitor from the artwork, enabling visitors to form an optimal comprehension and understanding of the Chinoiserie painting.
- Through research into the "sniffable" presentation of individual elements in artworks, we could assist visitors in initiating interactive activities based on their olfactory sense, stimulating learning enthusiasm through novel sensory experiences.
- To demonstrate the effectiveness of the digital interactive system, we interviewed many AI experts, art professors, and product design professors in addition to receiving positive feedback from visitors during discussions regarding user participation and experience in the preliminary and later stages of the design process.

2. Related Work

The software has introduced a new era for cultural heritage exhibitions. The Chinoiserie paintings are supported by various media and technologies, resulting in increasingly diverse display modes and broader audiences. Digital technology is crucial for preserving cultural heritage and presenting real scenes in museums. Furthermore, research on olfactory interaction has become sophisticated.

2.1. Digital Protection and Communication of Cultural Heritage

Digital technology has substantial advantages over traditional cultural heritage protection technologies; thus, it has been extensively employed in restoring and protecting cultural heritage, including the European "Chinoiserie" works. The application of digital technology in the preservation of cultural heritage is primarily

reflected in three-dimensional (3D) mapping, 3D simulation, and database establishment [1]. The constructed digital resources remarkably contribute to preserving and disseminating cultural heritage using 3S technology, cloud computing, and other technical methods [2]. Yiannoutsou et al. examined the use of mobile devices in educational activities in museum education, indicating that the method allows students to clearly understand the main concept of every exhibit [3]. Thus, digitalization facilitates the cultural protection of Chinoiserie paintings and the dissemination of Chinoiserie culture among the younger generation. The inclusion of mobile devices in museum education will further enhance user experience.

2.2. Realization of Real Museum Scenes

Virtual museums have been studied for decades; however, current digital approaches do not offer the same experience quality comparable to their physical counterparts [4]. Real-scene digitization is accomplished primarily through the rapid development of 3D simulation technology, computer graphics, VR and mixed reality (MR), and other modern techniques [5]. Immersive digital learning in museums using powerful interactive tools, from 2D displays with interactive audios to extended reality media forms such as VR and (AR), is increasingly used to create immersive educational experiences [6]. It provides visitors with the illusion of being in a real place instead of visiting an exhibit [7]. In a virtual setting, interacting with digital avatars enhances the user's engagement and presence [8].

2.3. Olfactory Interaction

With the rapid advancement of digital technology, people are no longer satisfied with human-computer interaction solely based on visual and auditory senses. Anthropological research has demonstrated that smell is linked to deep cultural meanings [9], making us believe that the inclusion of olfactory elements could enhance user experience. Through research, experts have discovered that the development of multisensory digital interaction environments can capture attention, increase motivation, and improve overall learning [10]. Moreover, some experts maintain that the integration of olfactory and vision indicates a new era of spatial presence [11]. Therefore, we propose that the introduction of an additional sensory dimension in the interactive system of a Chinoiserie painting exhibition will enrich the experience of the user and enhance the sense of spatial presence, ultimately increasing immersion.

The olfactory environment presentation interactive system, developed using relevant literature search and target user interviews, offers the following three advantages over traditional exhibition methods: (1) the diversity in exhibition methods, providing visitors with increased freshness and a better viewing experience; (2) more information loading, offering visitors with more customized and expanded knowledge; and (3) better sustainability and environmental protection performance, enabling visitors to learn about contents of Chinoiserie painting through the shared equipment provided at the exhibition site. Thus, this system also helps avoid the pressure on the ecological environment caused by the distribution of numerous paper promotional leaflets and brochures, which are often used in traditional exhibition methods.

3. Design and Implementation

While designing and creating COIS, we invited AI experts, art professors, and product design professors for a collaborative exploration of design and technology.

3.1. Expert Discussions on Design and Technology

We engaged in comprehensive discussions with Professors D1 and D2, who specialize in AI from the South China University of Technology, Professor D3 from East China Normal University's School of Arts, as well as Professors D4 and D5 from the School of Arts and Design at Zhongkai University of Agriculture and Engineering. The symposium spanned over 3 h, encompassing topics from the introduction of design concepts to the interpretation of art imagery, encapsulating Sino-Western cultural exchanges in the artwork, and sharing of design experiences. A meticulous examination and analysis of our design model were conducted. They collectively acknowledged the foundational premise of our design proposal: "The increasing prevalence of cross-cultural exchanges and the diversified presentation methods of Chinoiserie paintings have emerged as undeniable trends. Incorporating digital technology in the design and development of human–computer interactive systems in exhibitions holds significant potential and is marked by its innovation." Their recommendations are as follows:

- Professors D1, D2, D3, D4, and D5 believed that the general audience, when confronted with Chinoiserie paintings, often grapples with comprehending the content and historical context of the pieces.
- D3 and D4 advocated for the promotion of the pivotal historical role and artistic value of Chinoiserie paintings in the westward transmission of Chinese culture to Europe among the public.
- Professors D3, D4, and D5 underscore that incorporating digital methodologies, especially the use of digital olfactory environment technology, is one of the most effective strategies to enhance the audience's comprehension of Chinoiserie paintings.
- Professors D1, D2, and D5 noted that the efficacy of interactive systems will become a focal point for visitors. Concurrently, the accessibility and user experience of such products will pose challenges in the design of interactive systems.

3.2. Design Objectives

- In light of the diversified presentation methods for the Chinoiserie paintings, we established the following key objectives to ensure the rational design of the interactive system based on the research, analysis, and discussions of experts in the relevant fields:
- Execute targeted design innovations for introducing the historical context of the Chinoiserie paintings and for providing a digital environment to art pieces to realize a novel exhibition method. As mentioned in Section 3.1 (3), adopting various presentation techniques, including digital means, will enhance the exhibition experience of the audience. The digital olfactory environment technology is one of the most effective strategies to assist the audience in comprehending the Chinoiserie paintings.

- Implement interactive experiences, data feedback, and popularization education of the Chinoiserie art in the software. This will remarkably enrich the interactivity, enhancing the visitors' exhibition experience and their cognitive understanding of the paintings. As proposed in Section 3.1 (1, 2, and 4), cognition, user experience, applicability, and exhibition feedback will emerge as essential objectives for the innovative design of the interactive system.
- The product medium of the interactive system should fulfil design objectives of low cost, advanced technology, high quality, and aesthetic appeal, given its pivotal role in determining the success or failure of system production and commercial operation.

4. Interactive System Description

Building on the preliminary design research, we developed the conceptual framework of the COIS (Figure 1). Herein, the hardware can ascertain the positional relationship between visitors and the artwork for releasing targeted odours. Meanwhile, the software allows curators to transform the visual elements into olfactory ones, enabling visitors to receive feedback from the interactive system, with software and hardware interfacing via Bluetooth or Wi-Fi connectivity.

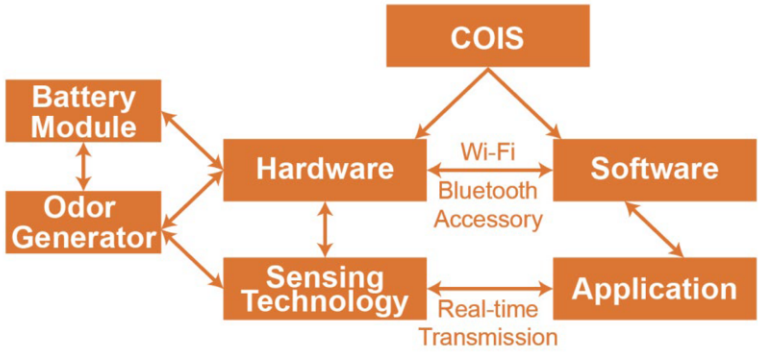

Figure 1. Conceptual framework of the Chinoiserie painting digital olfactory environment interactive system (COIS).

4.1. Hardware Design

The hardware apparatus primarily encompasses an ION hardware peripheral equipped with an odour generator, which is paired with positional sensors located around the artwork (Figure 2). As visitors approach the artwork from various angles, these sensors can transmit commands to the hardware via Bluetooth or Wi-Fi, directing it to release precise scent volumes from the aroma cartridge at suitable times. This system adeptly simulates naturally occurring scent emissions and exhibits a rapid response time. Unlike other olfactory technologies, scent manifests only when necessary and vanishes

immediately afterwards.

Figure 2. The design of the hardware system.

4.2. Software Design

The operation of the COIS software system is divided into two segments: computer-oriented and audience-centric. Initially, the system must transmute the visual elements of the Chinoiserie painting into machine olfaction. Subsequently, as visitors approach the artwork and engage with the COIS, the software translates the olfaction of the machine back into natural aromas, which can be comprehended by visitors. Moreover, visitors navigate through the exhibition using scent as their guide, which is in stark contrast to the prevalent visually-driven exhibition approaches. Visitors can participate in interactions delving into the visual elements of artwork through autonomous aroma selections During their entire visit, vitors can utilize this software system, immersing themselves in the olfactory ambience portrayed by the artwork, even discerning between the distinct aromatic characteristics of each item within the artwork. This digital olfactory interactive environment system substantially augments the user experience during exhibition tours (Figure 3).

Figure 3. Digital olfactory environment interface.

4.3. Functionality and Principles

The system deploys positional sensors to ascertain individuals' relative proximity and orientation to the artwork. By dispersing aromas, it guides visitors in exploring and learning about Chinoiserie paintings, thereby enhancing memory retention and enriching the user experience. By utilizing cameras, the product's sensors continually capture user positioning data and other depth-specific information. Depending on the user's proximity to specific elements within the artwork, the hardware peripheral releases designated scents. Moreover, the system can adjust scent intensity based on varying distances. During interactions within this digital olfactory environment, a secure and tranquil setting is requisite.

5. Preliminary User Research

To evaluate the efficacy of COIS, we tested the system's usability in helping the general audience to effectively understand the meaning and historical background of Chinoiserie paintings, as well as its ability to enhance the user experience through digital technology. Fifty-three initial visitors were interviewed, 47 of whom completed the study. The average age of the sample was 32.36 years, including 7 being 0-18 years old, 13 being 19-30 years old, 19 being 31-40 years old, 6 being 41-50 years old, and 2 being 51+ years old. The sample consisted of 26 males and 21 females. All participants were recorded using the COIS system for the Chinoiserie exhibition viewing experience.

5.1. Research Process

User research and feedback interviews were conducted in the studio. First, we briefed the user on how to use the product. Subsequently, the visitors interacted without the device while we carefully observed and recorded the entire process, compiling the results on a transcript. During the interviews, we focused on three main themes: (1) Impressions on COIS; (2) Expectations for the future development of exhibiting Chinoiserie paintings; (3) Differences between traditional exhibition methods and the digital olfactory environment interactive system. We aim to gather objective information and insights to inform the future R&D.

5.2. Research Findings

We used a 5-point Likert Scale analysis to evaluate the user's atisfaction with the COIS system. The questionnaire received 47 responses (from 26 males and 21 females).

We conducted in-depth interviews with five of them: M1, M2, M3, M4, and M5 (with an average age of 32.5). M1 remarked, "Having been acquainted with the olfactory interaction technology before, I now finally have the opportunity to experience the genuine application of a digital olfactory environment. It greatly aids in understanding the Chinoiserie paintings." M3 expressed, "This exhibition method feels as if one is immersed within the very scene depicted in the artwork, rendering an exceptional experience." Meanwhile, M2 and M4 are hopeful of future refinements, such as a more precise and nuanced scent presentation. M2 added, "I wonder how the effect would be if

there were many visitors simultaneously," to which M5 responded, "This probably poses the primary challenge that the digital olfactory interactive system needs to address next." Meanwhile, M4 stated, "I find COIS to be more engaging and effective than existing exhibition methods. With such an interactive system, one can better grasp the essence of what the artwork conveys."

Based on Table 1, we can draw the following conclusions: (1) the average score in the 5-point Likert Scale analysis is 4.604, which is over 4.5. This result shows that visitors are generally satisfied with the COIS; (2) user satisfaction owing to their increased understanding of the Chinoiserie paintings via the COIS is high; (3) visitors prefer utilizing the COIS compared to traditional exhibition methods; (4)only 31.91% users selected very satisfied of Q3. It means that the digital interaction of the system still needs improvement.

Table 1. User survey results.

Questions (1–5 points) 1: very dissatisfied, 5: satisfied	1 Very dissatisfied	2 Dissatisfied	3 Average	4 Satisfied	5 Very satisfied	Average
1. Would you like to use the digital environment technology when you visit an exhibition of the Chinoiserie paintings?	0	0	2.13%	14.89%	82.98	4.809
2. Does the inclusion of an olfactory environment enhance the exhibition viewing experience?	0	2.13%	6.38%	19.15%	72.34%	4.617
3. Is it easy for you to use this system?	0	4.26%	12.77%	51.06%	31.91%	4.106
4. Is there an immersive experience when using the interactive system?	0	2.13%	2.13%	34.04%	61.70%	4.553
5. Does it aid in the memorization of new knowledge?	0	0	0	23.40%	76.60%	4.766
6. Does it increase the understanding of the history of Chinoiserie?	0	2.13%	6.38%	38.30%	53.29%	4.426
7. Does it increase the understanding of elements in the Chinoiserie paintings?	0	0	2.13%	27.66%	70.21%	4.681
8. Compared with traditional exhibition methods, is it more preferable to use the COIS when visiting an exhibition of Chinoiserie paintings	0	0	0	12.77%	87.23%	4.872

6. Limitations and Future Work

The utilization of olfactory environments in exhibition scenarios remains in a transition stage, i.e., from the technology stage to the product stage, in the foreseeable future. This is due to the current discrepancy in the accuracy of odour generation. Given this limitation, the COIS will be used for presenting specific works in Chinoiserie painting exhibitions in an olfactory environment. Once the technology and product reach a certain maturity, the technology can be effectively applied to the entire exhibition site to improve user experience.

Based on the user feedback, we plan to improve our system to improve (1) the ease of using the COIS system, (2) the information load of the COIS system, and (3) the

accuracy of odour generation in multiuser scenarios. In addition, we aim to increase the number of test visitors and promote our system in public.

7. Conclusion

We designed, fabricated, and detailed the use of the COIS in Chinoiserie painting exhibitions, enabling the general audience to effectively understand the connotations and historical background of the Chinoiserie paintings. During the exhibition, visitors can interact with the elements in the artwork in real time using digital technology to enhance their viewing experience. The Chinoiserie paintings can convey history, culture, and other information through the COIS. Viewers can synergize their olfactory perceptions with knowledge acquisition, thereby aiding in memory consolidation. User testing outcomes underscore the pivotal role of the COIS in augmenting viewer engagement and realizing accurate appreciation of the Chinoiserie paintings. Moreover, this provides additional possibilities and reference data for further design, development, and research in the field of digital exhibitions. Additionally, COIS can offer shared devices to visitors at the exhibition site to disseminate information about the exhibition and paintings, avoiding the pressure on the ecological environment caused by numerous paper-based promotional flyers and brochures used in traditional exhibition methods. We believe that the COIS is crucial to the study of improving the viewing experience of Chinoiserie painting exhibitions.

8. Acknowledgements

The authors would like to sincerely thank all members who have participated in this project and the experts who have provided insight and expertise that greatly assisted the completion of this project with their valuable comments. This work was supported by the 2023 Guangdong Provincial Philosophy and Social Science Planning Project “A Study of 18th Century French Chinoiserie Painting in the Context of the China Culture Munication to the West” (Project No.GD23XYS067).

References

[1] L. Zhang, X. Li, W. Yan, Z. yao, B. Su, Research on digital communication of Chinese traditional garden, *International Conference on Human-Computer Interaction* (2023), 311–321.
[2] T. Fang, F. Zhao, F, 2021. Research on digital dissemination of Chinese classical garden culture, *International Conference on Human-Computer Interaction* (2021), 63–73.
[3] N. Yiannoutsou, I. Papadimitriou, V. Komis, N. Avouris, Playing with’ museum exhibits: designing educational games mediated by mobile technology. *Proceedings of the 8th International Conference on Interaction Design and Children* (2009), 230–233.
[4] P.P. Li, P.L. Chang, A study of virtual reality experience value and learning efficiency of museum-using shihsanhang museum as an example, *Proceedings of the International Conference on Applied System Innovation (ICASI)* (2017), 1158–1161.
[5] P. Liu, Prospect and direction of online virtual tourism from the perspective of new residential life, *Scientia Geographica Sinica* (China) **40** (2020), 1403–1411.
[6] A. Barry, On interactivity: consumers, citizens and culture, *The Politics of Display: Museums, Sciences, Culture* (1998), 98–117.
[7] A.G. Sooai, A. Nugroho, M.N. Al Azam, S. Sumpeno, S. Purnomo, Virtual artifact: enhancing museum exhibit using 3D virtual reality, *Proceedings of the TRON Symposium (TRONSHOW)* (2017), 1–5.
[8] A. Dasgupta, N. Buckingham, D. Gra˘canin, M. Handosa, R. Tasooji, A mixed reality based social interactions testbed: a game theory approach, *Health, Cultural Heritage, and Industry: 10th International*

Conference, VAMR (2018) , 40–56.
[9] C. Classen, D. Howes, A. Synnott, Aroma: The cultural history of smell, *Taylor & Francis* (1994).
[10] R. Di Fuccio, M. Ponticorvo, F. Ferrara, O. Miglino, Digital and multisensory storytelling: narration with smell, taste and touch, *Adaptive and Adaptable Learning: 11th European Conference on Technology Enhanced Learning (EC-TEL)* (2016), 509–512.
[11] J.K. Olofsson, S. Niedenthal, M. Ehrndal, M. Zakrzewska, Beyond smell-o-vision: Possibilities for smell-based digital media, *Simulation & Gaming*, **48** (2017), 455–479.