Virtualization for Kintsugi Art: Damaged Porcelain Figurine Recreation Supported by 3D Modeling Computer Technology

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Abstract—This paper describes the application of 3D virtualisation for the traditional Japanese art of Kintsugi to recreate a seriously damaged vintage porcelain figurine. We use the figurine "Pantalettes" (HN1412) produced by Royal Doulton between 1930 and 1949 to demonstrate the approach from both practical and cultural perspectives. The phases of technology-enhanced restoration involve high-precision 3D scanning, 3D modeling, 3D printing, and virtual rendering, and the latter can be beneficial for further integration of the artwork into virtual environments. The project bridges several insightful perspectives of cultural interinfluence and technological innovation, including the dialogue between English and Japanese pottery-making and restoration traditions, the connection between the cutting-edge 3D modeling technology and the time-honored traditional techniques, as well as educational and training potential for Kintsugi simulation in virtual environments.

Keywords—computer 3D modelling, 3D scanning, 3D printing, virtual rendering, decorative art, Kintsugi, restoration

I. INTRODUCTION

The traditional Japanese Kintsugi technique, a transformative repair of broken ceramics using *urushi* lacquer infused with precious metals, has been an art, a craft, and a philosophy since the 15th century. It's a part of a rich cultural heritage that celebrates the beauty of imperfection and impermanence. In this paper, we aim to bridge this historical and cultural significance with the modern world through the restoration of a fine porcelain figurine using 3D modelling computer technology.

Applying Kintsugi art to damaged pottery or porcelain objects is not only about partially restoring their diminished value but also about the (re)creation of new artifacts with their unique value. In the book *"Kintsugi: Finding Strength in Imperfection"* [2], its author, Celine Santini so´ eloquently and almost poetically describes this concept as *"Even more beautiful, even more resilient, even more precious, even more...present!"*.

A. Object

Fig. 1. Damaged Figurine.

Our interest in Kintsugi art was kindled by the story of the "Pantalettes" (Royal Doulton code HN1412), a renowned creation by Leslie Harradine, which Royal Doulton produced between 1930 and 1949. Unfortunately, the figurine suffered severe damage (Fig. 1), prompting a thoughtful exploration of its restoration using the traditional Japanese Kintsugi technique.

B. Background

Applying this remarkable Japanese pottery restoration technique to an object of English fine porcelain traditions presents an interesting way to fuse two distinct cultural traditions, especially in the context of the existing links between these traditions. Thus, our idea has been grounded not only on a straightforward attempt at cross-cultural interaction but also on the long-ago inter-influential contacts between English and Japanese pottery makers, mutual discovery and interchange of the art language idioms [3], a trend existing in various domains of arts [4]. Such a cross-cultural synthesis strengthens the story of

English porcelain traditions brought to Japan at the beginning of the 20th century, including, for example, the famous willow pattern which became one of the flagship designs of Nikko Ceramics, or the founding of the first British pottery studios in Mashiko town, now a noted pottery region in Tochigi prefecture [5], [6]. Naturally, during an exceptionally long and successful history of Japanese ceramic production, one of the oldest in the world, Japanese masters, while introducing their own unique approaches, have been influenced by many other traditions, mainly from China and Korea. From the start of the Meiji Restoration, foreign influence and trade increased, and Japanese ceramics appeared in the collections in European countries. Japanese ceramic artistry inevitably influenced English and continental European traditions [7].

Kintsugi has a historical and cultural significance. The philosophy of *Wabi-Sabi* celebrates the beauty of imperfection and impermanence and underpins the techniques and materials used in Kintsugi. By illustrating how Kintsugi transcends mere repair to become a form of art, Mochinaga [8] establishes a foundation for understanding how this ancient craft can be combined with modern technology to create new, unique artefacts.

The paper [9] presents "Kintsugi VR," a project exploiting the concept of "Fractured Objects" to design virtual and mixed-reality experiences. Through a qualitative analysis of artistic activities, the study explores how reconnecting fractured parts enhances the overall object, drawing on principles of *Seamful Design* and *Wabi-Sabi*. This approach highlights the aesthetic and philosophical aspects of visible repair [10] while introducing new possibilities for artistic interaction within virtual environments, demonstrating how traditional techniques can inspire modern design practices drawing on digital technology, virtualisation, and AI.

C. Positioning

Our project harnesses the synergy between cultural heritage and technological innovation. Through the high-precision virtualisation of Kintsugi, we showcase a harmonious blend of historical artistry and contemporary digital techniques. By integrating advanced 3D scanning, modeling, printing, and virtual rendering, we preserve and enhance the value of the "Pantalettes" figurine while creating a platform for educational and training applications in virtual reality. This interdisciplinary approach offers unique insights into cultural inter-influence and technological improvements, thus contributing to the broader discussion on the impact of technology on traditional art forms, highlighting the potential for virtualization to transform and innovate art restoration and creation practices.

II. METHOD AT A GLANCE

Figure 2 illustrates the major phases of the restoration process involving the following activities:

1) High-precision 3D scanning to capture the object's details, with particular focus on the edges of the fragments;
2) 3D modelling enabling the reconstruction of the damaged elements in a virtual environment;
3) Kintsugi design simulation in the 3D modelling environment;
4) 3D printing of the modelled and reconstructed elements;
5) Assembly of the 3D printed models using the Kintsugi technique, which validates the precision of reconstructed parts and provides a trial before handling actual porcelain pieces;
6) Validation from the 3D modeling and simulation guide the application of Kintsugi to the actual damaged objects.

Additionally, virtual rendering can help use the reconstructed art in virtual environments.

III. TECHNOLOGY IMPLEMENTATION

This section discusses the central computer technology-supported processes, tools, algorithms, and produced artifacts in detail.

A. Capture the Essential – 3D Scanning

For 3D scanning, we used the RevoScan MINI 2[1] scanner and its software. (Fig. 3) shows the key stages in the scanning process.

More significant parts are usually scanned using feature tracking.

(Fig. 3 (a–b)), while for smaller parts, marker tracking (Fig. 3 (c–d)) is usually required. The raw scanned point clouds are then processed using the merge/mesh/fill holes algorithms supported by the scanning software, creating clean, high-precision models. The merging process can mess up the captured colors; however, in our case, the captured geometry and not the colors of the models are critically important.

Several scans might be required from different angles to capture the wafer-thin edges of the damaged parts (especially the smallest fragments) and further work on the scanned models in 3D modeling software. The mesh files produced by the scan post-processing software are exported as PLY files for further geometrical adjustments in Blender[2].

B. Mixing Realities – 3D Modeling

In the Blender environment, the models are brushed up to make them suitable for 3D printing. To enable printing, the model must meet the following requirements:

- Models must-have *volume* (i.e., no plane mesh on the model). Since the 3D printers can print only solid geometry, if there is a hole in the mesh, it must be filled manually in Edit mode.

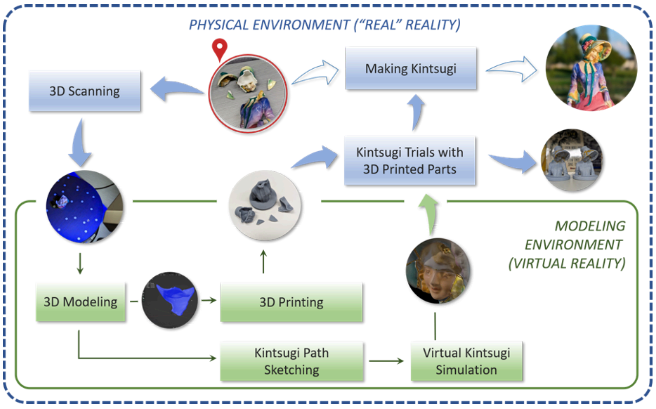

Fig. 2. Project Workflow.

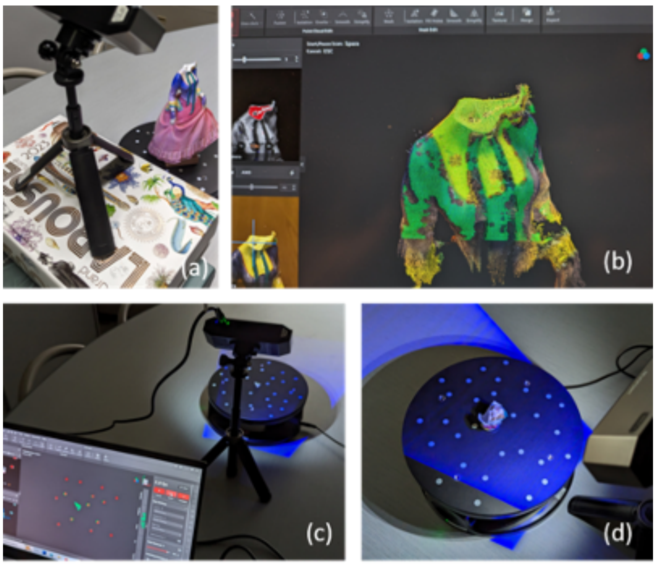

Fig. 3. 3D scanning process.

- Align face in normal directions. In 3D modeling, *normals*, which are vectors extending perpendicular from the face of a polygon used to determine which direction the face is "pointing," must be correctly aligned (see Fig. 4). Specifically for 3D printing, ensuring that all face normals are pointing outward is crucial for proper printing because this defines the inside and outside of the 3D model.
- Complex floating parts may need supporters to be produced by the printer. The supporters are to be carefully

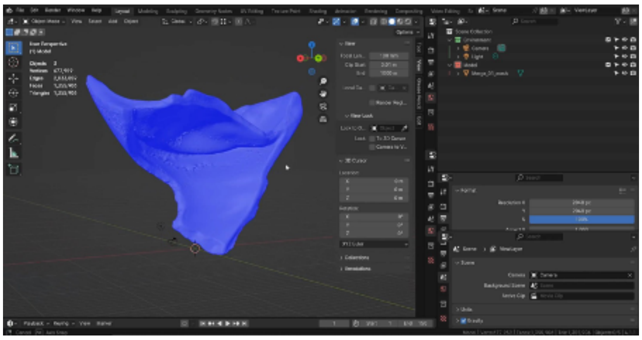

Fig. 4. Finishing models in Blender for further 3D printing.

Removed manually after 3D printing. One needs to decide about the most suitable places for supporters (for example, one must avoid connecting the supporters to the most critical surfaces, such as broken edges, where the highest degree of modeling accuracy is required).

The model is exported as an STL file for the printing software.

C. The Virtual Materialized – 3D Printing

Before 3D printing, the model has to be converted into multiple layers with a slicing application. For this project, Photon Mono 2[2] (SLA type, resin liquid filament) is used for 3D printing, while the slicing software Anycubic Photon Workshop[3] was selected. After importing the STL files from Blender, further preparation is required (especially for the intricately detailed fragments), namely, the generation of the necessary supporting scaffolding to ensure structural integrity during the printing process.

Figure 5 depicts the 3D-printed parts, while the inset image shows two original ceramic fragments.

Fig. 5. 3D printed parts.

D. Virtualized Aesthetics – Kintsugi Simulation in a Modeling Environment

Fig. 6. Kintsugi simulation in a virtual environment.

A geometry nodes modifier is used to implement virtual Kintsugi simulation in Blender (Fig. 6), which provides procedural node-based modeling and automatic mesh generating with the help of the visual scripting language (Fig. 7).

Hence, the paths sketched on the model surface automatically convert to golden and volumetric glue mesh objects simulating the Kintsugi junctures. It enables the use of simulation features even by beginners who can use the stylus device of an LCD tablet. Thus, with the help of the intuitive interface, designers and digital artists can model the Kintsugi technique in the virtual environment. However, for 3D printing and further trials with replica models, the geometry of fragments is more essential than colors and decorations. For virtual Kintsugu, the scanned color data can be visualized on the model with material (shader) node assets. Since the colors scanned for different fragments can vary due to the lighting conditions and the scanning modes (such as feature or marker-based tracking), some noise may be generated by merging point clouds in RevoScan software. The RGB curve nodes are applied to the model material to interpolate and adjust the colors.

E. Test Drive – Assembling 3D Printed Parts

The 3D-printed parts enable a trial assembly that would help the Kintsugi designer to be better prepared for real-world operations and to pay attention to a variety of factors such as operation time, amount of glue composition required for each step, the possible order of steps, glue drying time, the fragment orientation while assembling, the stickiness of the junctures for gilding, etc. (Fig. 8).

F. The Beauty Reborn – Assembling Original Fragments with Kintsugi Technique

We are prepared to recreate the shape from the original porcelain fragments based on the knowledge acquired during the virtual modeling and prototyping stage using 3D-printed parts. Figure 9 highlights some of the most interesting areas of the restored figurine.

IV. ART OBJECT

Figure 10 shows the final result of applying the Kintsugi technique to the broken porcelain fragments. The new concept name “Transfigured Reminiscence” complements the original name of Leslie Harradine’s design to portray metaphorically our experience of restoring this vintage porcelain figurine, which has been more than repaired; it has been recreated with the help of 3D modeling and virtualization technology supporting the traditional Japanese art of ceramics restoration, and with an artistic idea to express the subtle dynamics and fragility of human memories and relationships.

V. DISCUSSION

This work reflects a broader trend of blending technology with traditional arts, specifically by integrating 3D modeling with the ancient Japanese art of Kintsugi. This fusion not only preserves the cultural heritage but also makes it accessible to new generations and cultures in a novel and engaging manner.

A. Enhancements and Challenges

The application of 3D scanning, modeling, and printing in this project allowed for high-precision re-constructions of damaged ceramic pieces, capturing intricate details that are often challenging to replicate manually. This can serve as a blueprint for restoration, enhancing the repaired artifacts' accuracy and aesthetic fidelity. Challenges include the selection of appropriate 3D scanning cameras and

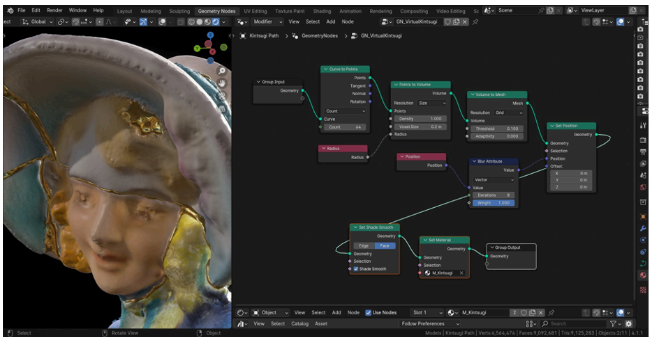

Fig. 7. Kintsugi Virtualisation in Blender.

Fig. 8. Assembling 3D printed parts.

The difficulty of scanning small parts. While increasingly affordable, access to high-quality 3D printing equipment remains a barrier, particularly in regions with limited technological infrastructure.

B. Cultural and Ethical Considerations

A potential criticism from Kintsugi purists is that including a digital restoration step might overshadow traditional skills and artistry inherent in Kintsugi. Kintsugi is not merely a repair technique but an art form that embodies the *Wabi-Sabi* philosophy of finding beauty in imperfection and transience. Virtualization and 3D modeling practices may seem at odds with the essence of Kintsugi, as they could be perceived as detracting from the authenticity and the intimate, hands-on nature of the traditional craft. This disjuncture raises essential questions about the balance between preserving the spirit of Kintsugi and embracing modern technological advancements.

Fig. 9. Assembling the original fragments.

While digital techniques can prevent physical intervention on fragile artifacts, thereby preserving their original state, the use of synthetic materials in 3D printing raises environmental concerns. Unlike traditional Kintsugi, which uses natural, biodegradable materials, 3D printing may contribute to plastic pollution.

C. Hybrid Approaches

A hybrid approach that combines digital precision with traditional crafts could offer a balanced solution, leveraging modern technology's and age-old techniques' strengths. Such an approach would ensure the preservation of cultural essence while utilizing the advancements in digital technology.

Fig. 10. *Transfigured Reminiscence* – The beauty reborn through Kintsugi and virtualization technology.

Future developments in digital restoration techniques promise further innovations. Enhanced precision in 3D scanning and modeling, improved materials for 3D printing, and the evolving capabilities of Virtual Reality (VR) for simulation and training can potentially lead to new forms of artistic expression that honor traditional practices while embracing modern technological capabilities.

D. Broader Implications

Although art objects are usually assumed to be unique [11] (thus, the possibility of reproduction is naturally not a primary property of an art object), the presented technological solution may be incorporated into a reproducible restoration workflow. In a broader sense, using VR and 3D modeling opens up new avenues for the education and training of traditional crafts. By providing a virtual environment for practice, these technologies can make learning more accessible and less resource-intensive. Studies have shown that immersive technologies such as VR can effectively teach complex skills in various disciplines, from surgery [12] to traditional crafts like Kintsugi [13].

Furthermore, digital techniques revolutionize how cultural heritage is preserved and experienced [14]. Technologies like 3D modeling and VR support the conservation of physical artifacts and enable the digital recreation of cultural assets for archival and exhibition purposes [15]. This allows for a broader dissemination of cultural knowledge and the potential for future generations to experience cultural heritage in immersive and interactive ways.

Integrating 3D modeling with Kintsugi art represents a step forward in the intersection of technology and traditional crafts. It offers a promising pathway for preserving and revitalizing cultural heritage in the digital age, fostering a deeper appreciation and understanding of traditional practices through a modern technological lens.

VI. CONCLUSION

The study [16] investigates how metaphors from the domains of literature and fine arts can enhance the teaching approaches and understanding of software concepts. The current paper contributes to the discourse in a different direction – how digital modeling technology can support artistic manifestations even in centuries-old traditional practices to increase the number of connoisseurs, connect knowledge available in other disciplines, and rediscover the links between modernity and antiquity.

While conveying the historical, cultural, technological, and educational implications and addressing the manifold aspects of reality and virtuality, this project is a good effort to contribute to the themes and perspectives of the *2024 Artefacto* conference.

This interplay explores the artistic experience employing cutting-edge technologies for traditional techniques and enriching collective and collaborative cross-disciplinary findings.

REFERENCES

[1] G. Keulemans, "The geo-cultural conditions of kintsugi," *The Journal of Modern Craft*, vol. 9, no. 1, pp. 15–34, 2016.

[2] C. Santini, *Kintsugi: Finding strength in imperfection*. Andrews McMeel Publishing, 2019.

[3] M. Barasch, *The language of art: studies in interpretation*. NYU Press, 1997.

[4] E. Pyshkin, "Alvar Aalto and Japan: Mutual discovery of environmental integration architecture idioms," *Academia Letters*, 2021.

[5] S. Olding, M. Odundo, Y. Matsuzaki, and S. Suzuki, *Bernard Leach: discovered archives*. Crafts Study Centre, University for the Creative Arts, 2020.

[6] S. Peterson, *Shoji Hamada: a potter's way and work*. Bloomsbury Publishing, 2023.

[7] A. S. Morton, *The Japanese Influence in Late Nineteenth Century British Art, 1862-1880*. University of Glasgow (United Kingdom), 2000.

[8] K. Mochinaga, *Kintsugi: The Wabi Sabi Art of Japanese Ceramic Repair*. Tuttle Publishing, 2023.

[9] A. Rostami, K. Karlgren, and D. McMillan, "Kintsugi VR: Designing with fractured objects," in *Proceedings of the 2022 ACM International Conference on Interactive Media Experiences*, 2022, pp. 95–108.

[10] Y. Saito, "Aesthetics of visible repair: The challenge of kintsugi," in *Repair*. Routledge, 2022, pp. 58–65.

[11] R. Meager, "The uniqueness of a work of art," in *Proceedings of the Aristotelian Society*, vol. 59. JSTOR, 1958, pp. 49–70.

[12] S. Yoganathan, D. A. Finch, E. Parkin, and J. Pollard, "360 virtual reality video for the acquisition of knot tying skills: A randomized controlled trial," *International Journal of Surgery*, vol. 54, pp. 24–27, 2018.

[13] S. Ban, M. R. Ferrara, *et al.*, "Promoting a teaching platform for "traditional skills c virtual reality technology." *Applied Human Factors and Ergonomics International*, vol. 44, pp. 117–124, 2022.

[14] A. Georgopoulos, "Contemporary digital technologies at the service of cultural heritage," *Heritage Preservation: A Computational Approach*, pp. 1–20, 2018.

[15] K. Reaver, "Three case studies in virtual preservation. Applying virtual reality to cultural heritage," *Agathon—International Journal of Architecture, Art and Design*, vol. 6, pp. 210–217, 2019.

[16] E. Pyshkin and J. Blake, "A metaphoric bridge: Understanding software engineering education through literature and fine arts," *Terra Linguistica*, vol. 11, no. 3, pp. 59–77, 2020.

[1] https://www.revopoint3d.jp/products/industry-3d-scanner-mini

[2]https://www.blender.org/

[2] https://store.anycubic.com/products/photon-mono-2-3d-printer

[3]https://store.anycubic.com/pages/anycubic-photon-workshop-3d-slicersoftware