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 virtualization for the traditional Japanese art of Kintsugi to recreate a seriously damaged vintage porcelain figurine. To demonstrate the approach from both practical and cultural perspectives, we use the figurine "Pantalettes" (HN1412) produced by Royal Doulton between 1930 and 1949. The phases of technology-enhanced restoration involve high-precision 3D scanning, 3D modeling, 3D printing, and virtual rendering; the latter being beneficial for further integration of the artwork into virtual environments. The project bridges several insightful perspectives of cultural inter-influence 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.**

***Index Terms*—computer 3D modeling, 3D scanning, 3D printing, virtual rendering, decorative art, Kintsugi, restoration**

I. INTRODUCTION

The traditional Japanese Kintsugi technique of transformative [1] repair of broken ceramics using *urushi* lacquer infused with precious metals such as silver, gold, or platinum has been practiced since at least the 15th century as an art, a craft and a philosophy in equal parts. It may seem surprising to view Kintsugi art from the perspective of its virtualization through the 3D modeling computer technology. In this paper, we unveil this connection through the restoration of a fine porcelain figurine.

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 own unique value. In the book *"Kintsugi: Finding Strength in Imperfection"* [2], its author Céline 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 was produced by Royal Doulton between 1930 and 1949. Unfortunately, the figurine suffered severe damage (Figure 1), prompting a thoughtful exploration of its restoration using the traditional Japanese Kintsugi technique adapted to contemporary materials and technology.

B. Background

The concept of applying the 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 [3]. Thus, our idea has been

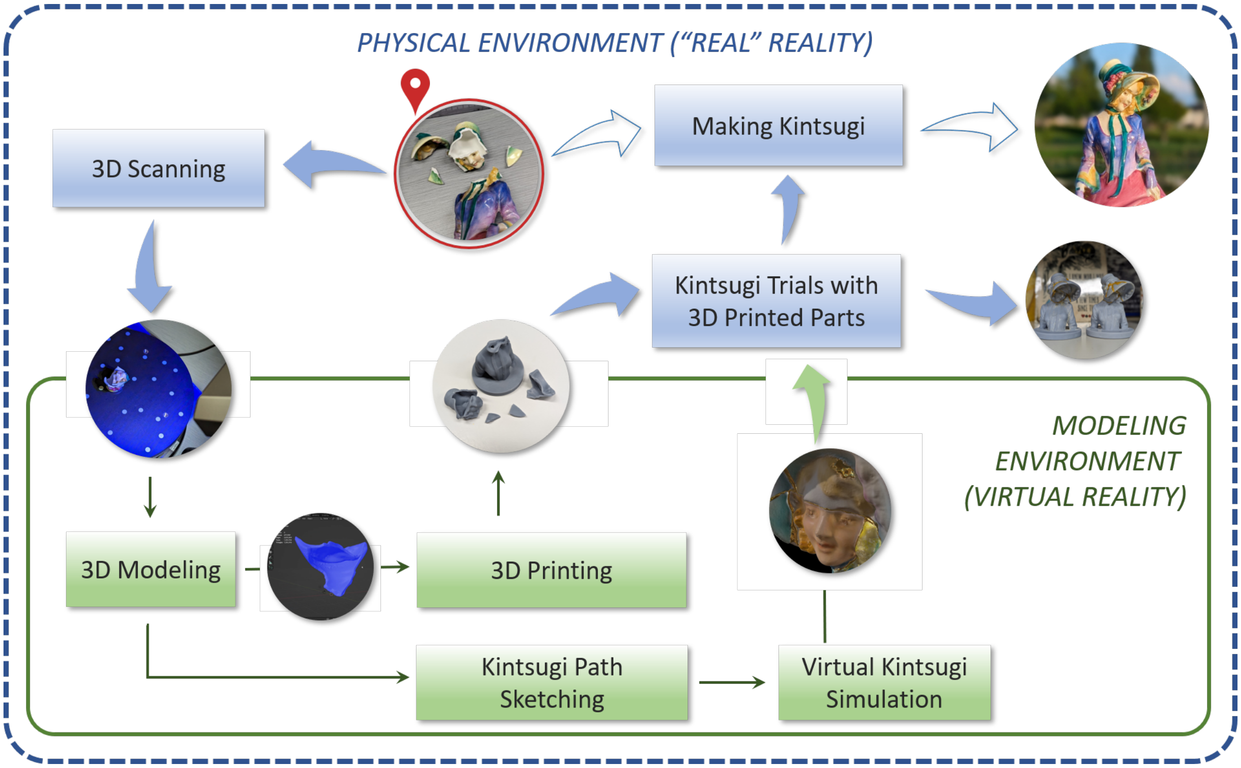

Fig. 2. Project Workflow.

grounded also on the historical inter-influential contacts between English and Japanese pottery makers, mutual discovery and interchange of the art language idioms [4], a trend existing in various domains of arts [5]. Such a cross-cultural synthesis strengthens the story of English porcelain traditions brought to Japan in the beginning of the 20th century including, for example, the founding of the first British pottery studios in Mashiko town, now a noted pottery region in Tochigi prefecture [6], [7].

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, mostly 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 [8].

Kintsugi has a historical and cultural significance. The philosophy of *Wabi-Sabi*, which 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 [9] establishes a foundation for understanding how this ancient craft can be combined with modern technology to create new, unique artifacts.

The paper [10] 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 [11] while introducing new possibilities for artistic interaction within virtual environments, demonstrating how traditional techniques can inspire modern design practices drawing on digital technology, virtualization, and AI.

C. Positioning

Our project harnesses the synergy between cultural heritage and technological innovation. Through the high-precision virtualization 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 simultaneously creating a platform for educational and training applications in virtual reality. This interdisciplinary approach offer unique insights on 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

The artistic aspects of the project are detailed in our previous publication [3]. This paper, however, focuses on providing a clear explanation of the technology-supported workflow illustrated in Figure 2 introducing the major phases of the restoration process, including 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 modeling enabling the reconstruction of the damaged elements in a virtual environment;
3) Kintsugi design simulation with 3D modeling;
4) 3D printing of the modeled and reconstructed elements;
5) Assembly of the 3D printed models using Kintsugi technique, which validates the precision of reconstructed parts and provides a trial before handling actual porcelain pieces;
6) Application of Kintsugi to the actual damaged object, guided by the modeling and simulation validations.

Additionally, virtual rendering enables the integration of the reconstructed art in virtual environments.

III. Technological Implementation

This section provides a detailed discussion of the major computer technology-supported processes, tools, algorithms, and produced artifacts. These artifacts include physical original artifacts such as the figurine and its fragments, digital artifacts such as virtual models, and reproducible digitally fabricated artifacts. The latter serve as a foundation for safe trial runs as well as for educational purposes.

A. ***Capture the Essential*** *– 3D Scanning*

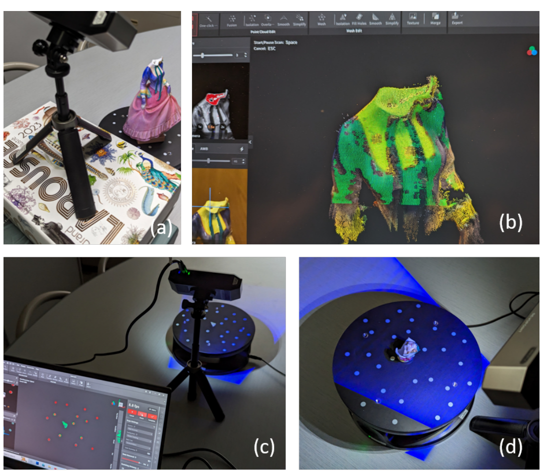

Fig. 3. 3D scanning process.

For 3D scanning, we used RevoScan MINI 2[1] scanner and its software. Figure 3 shows the key stages.

Larger parts are normally scanned using feature tracking (Figure 3 (a–b)), while for smaller parts, marker tracking (Figure 3 (c–d)) is usually required. The raw clouds of points are then processed using the merge/mesh/fill holes algorithms supported by the scanning software, enabling the creation of clean high-precision models. Merging process can sometimes distort 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), as well as the 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*

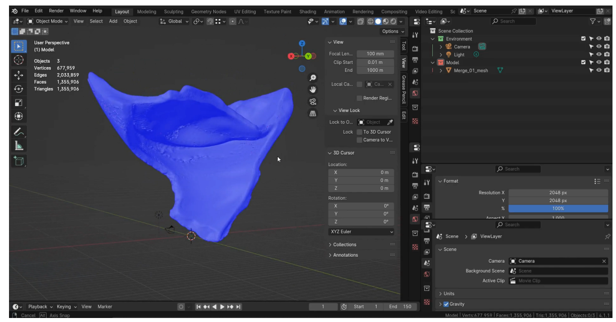

Fig. 4. Finishing models in Blender for further 3D printing.

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 on the mesh, it must be filled manually in Edit mode.
- In 3D modeling, *normals*, which are vectors extending perpendicular from the face of a polygon that are used to determine which direction the face is "pointing", must be correctly aligned (see Figure 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 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 3D printing.

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[3] (SLA type, resin liquid filament) is used

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

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

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

Fig. 5. 3D printed parts.

for 3D printing, while the slicing software Anycubic Photon Workshop[4] was selected. After importing the STL files from Blender, further preparation is required (especially for the intricately detailed fragments), namely, 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 a single 3D-printed part against the original ceramic fragment.

D. ***Virtualized Aesthetics*** *– Kintsugi Simulation*

Fig. 6. Kintsugi simulation in a virtual environment.

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

Hence, the paths sketched on the model surface are automatically converted to golden and volumetric glue mesh objects simulating the Kintsugi junctures. This 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 Kintsugi technique in a virtual environment. Though for 3D printing and further trials with replica models, the geometry of fragments is more essential than colors and decorations. For virtual Kintsugi, 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. To interpolate and adjust the colors, the RGB curve nodes are applied to the model material.

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, and so forth (Figure 8).

F. ***The Beauty Reborn*** *– Assembling the Original Fragments*

The knowledge gained during the virtual modeling and prototyping stage with 3D-printed parts enables us to recreate the original shape using the porcelain fragments. Figure 9 highlights some of the most interesting areas of the restored figurine.

IV. Art Object

Figure 10 shows the final result of applying Kintsugi technique to the broken porcelain fragments. The new concept name "Transfigured Reminiscence" complements the original name of the Leslie Harradine's design to portray metaphorically our experience of restoration, which has been more than just a repair; the decorative object 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 through the integration of 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.

We acknowledge that our methodology leans more towards a descriptive rather than an experimental approach. Since the findings are based on a single case study, there is insufficient quantitative data or empirical analysis. However, this highlights the need for future steps to generalize the results discussed in this contribution. These steps can be further detailed in connection to the major aspects that follow this discussion.

[4]https://store.anycubic.com/pages/anycubic-photon-workshop-3d-slicer-software

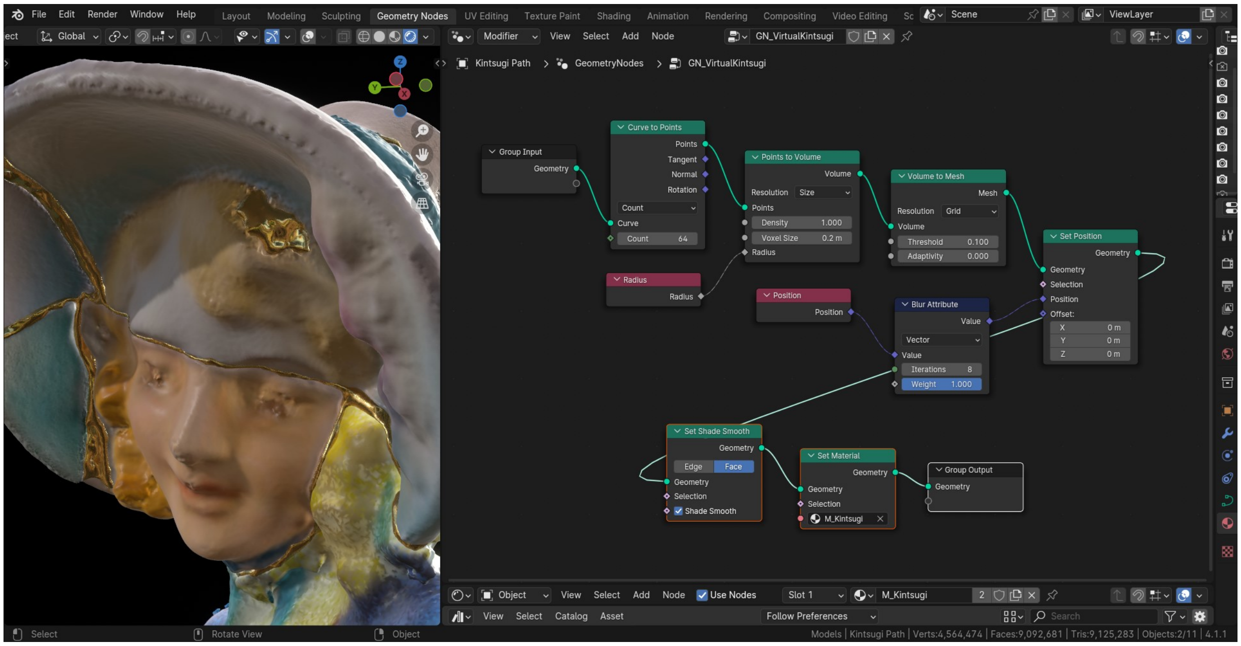

Fig. 7. Kintsugi Virtualisation in Blender.

Fig. 8. Assembling 3D printed parts.

Fig. 9. Assembling the original fragments.

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, thereby enhancing both the accuracy and the aesthetic fidelity of the repaired artifacts. Challenges include the selection of appropriate 3D scanning cameras and the difficulty of scanning small parts. Access to high-quality 3D printing equipment, while increasingly affordable, remains a barrier in regions with limited technological infrastructure.

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

B. Cultural and Ethical Considerations

A potential criticism from Kintsugi purists is that the inclusion of a digital restoration step might overshadow traditional skills and artistry inherent in Kintsugi. Kintsugi is not merely a repair technique; it is an art form that embodies the *Wabi-Sabi* philosophy of finding beauty in imperfection and transience. The inclusion of virtualization and 3D modeling practices may seem at odds with the essence of Kintsugi, as it could be perceived as detracting from the authenticity and the intimate, hands-on nature of the traditional craft. This disjuncture raises important questions about the balance between preserving the spirit of Kintsugi and embracing modern technological advancements. 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, the 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 the strengths of both modern technology and age-old techniques. Such an approach would ensure the preservation of cultural essence while utilizing the advancements in digital 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 [12] (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, the use of 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 [13] to traditional crafts like Kintsugi [14].

Furthermore, digital techniques are revolutionizing the way cultural heritage is preserved and experienced [15]. Technologies like 3D modeling and VR not only support the conservation of physical artifacts but also enable the digital recreation of cultural assets for archival and exhibition purposes [16]. This allows for a broader dissemination of cultural knowledge and the potential for future generations to experience cultural heritage in immersive and interactive ways.

The integration of 3D modeling with Kintsugi art represents a step forward in the intersection of technology and traditional crafts. It offers a promising pathway for both 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 [17] 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 in order to increase the number of their connoisseurs, to connect knowledge available in different disciplines, and to rediscover the links between modernity and antiquity.

While conveying the historical, cultural, technological, and educational implications, as well as addressing the manifold aspects of reality and virtuality, we believe that this project is a good effort to contribute to the themes and perspectives of the ARTeFACTo conference.

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

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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] E. Pyshkin, R. Sato, A. Nassani, and J. Blake, ""Transfigured Reminiscence": A vintage porcelain figurine reborn through 3D virtualization and Kintsugi art," in *The 5th Kyoto Conference on Arts, Media & Culture 2024: Official Conference Proceedings*, 2024, in press.

[4] M. Barasch, *The Language of Art: Studies in Interpretation*. NYU Press, 1997.

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

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

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

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

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

[10] 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.

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

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

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

[14] 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.

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

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

[17] 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.