VIRTUAL PRESERVATION: THE ROLE OF VR AND AR IN SUSTAINABLE FINE ARTS PRACTICES

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Abstract

In the realm of fine-art preservation, the long used and abused method of physical preservation—by the preventive treatment, documentation and controlled exposure/handling of the artefact—is still in use. None of these practices can address the issues of limited access, insecure facilities; of no performance aspects derived from born-digital works; of no safe transportation; of even "obsolescence of born-digital works." The mini project seeks answers to the question: what is virtual preservation, how can this be a viable and sustainable way of guardianship? It calls for a 'preservation package' that is to be created with Virtual Reality (VR), Augmented reality (AR) and Web experiences, also known as 'derivatives' which could be replaced if needed, it says, the high-resolution imaging, Photogrammetry, laser scanning, spatial audio and conservation and oral history records, are to be produced simultaneously. VR can freeze time – simulate the history of an exhibition, time-based work etc. without having to move an original from place to place, but also the spatial context. AR include pieces of evidence to support the condition and the past stage as well as the actual artefact and may be the artists' comment or accessible interpretation of the past stage. However, there are environmental, cultural, social, economic and technical aspects as well which are evaluated on how sustainable they are in addition to digitization. The outcome is a framework, which also demonstrates impact in the areas of capture, processing and storage, network, devices, avoided travel, handling and temporary reconstruction, authenticity and uncertainty, and IP/authority of community, accessibility and interoperability/migration. A sample methodology and governance matrix, and an illustrative comparison of all of the above (physical, VR and AR or light weight web access) is provided for the use of the gallery, to determine a combination that it considers appropriate. The project's conclusions are that fine-arts practice can be sustained by the use of immersive technology, it has to be taken out of a platform specific experience, it is necessary to connect the claims with evidence and it is important to integrate affected communities in decision-making and differential the cost of the environment through the life cycles of a project.

Keywords The use of Virtual preservation, Virtual Reality, Augmented Reality in the Fine Arts, Digital heritage and sustainability, museum ethics, 3D digitization.,

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I. INTRODUCTION

However, the semantics of one or multiple paintings, sculptures, installations and/or performances does not come to images but is material, spatial and historical in nature, and is social. These meanings are saved in museums and by artists in their practices of storage, conservation, cataloguing, exhibition and research. Originals: are also light-sensitive, damaged, structurally unsound; in some cases, not accessible or too far to go to those who can't travel; public ones without private owners. The ephemeral additions this community made and the live art they produced will most likely be the thing they remember – in their mind and for their time. Preservation: Preserve as a piece of work, provide as much evidence as possible for future people to access, study and interpret. As it is pointed out by UNESCO the 'rapid changes in technologies' make the digital heritage—also within the framework of appropriate legal limits' [1]—a changing heritage, and hence all three criteria of 'continuous, authentic and accessible' need to be fulfilled. Immersion technologies make opportunities for responses LARGE. The 3D construction of VR enables the visitor to immerse in an existing gallery, studio or installation, while AR enables the possibility of the overlay of digital content that has been registered in the 3D space with the visitor's perception of the actual object. The cultural-heritage applications that have been surveyed are: education, reconstruction, exploration and conservation and visitor engagement [5,7]. When the context, rather than the object, is meaningful these technologies are particularly helpful. However, that's not the case with the virtual experience or a digital project that can't be preserved. If any changes in hardware and/or software have been made then a headset app may not function. Models can be quite fine grained,

and must be stored, manipulated and networked. Reconstruction can be photorealistic and allow the uncertainty and/or voice of artists/communities to be hidden and/or erased. As a result, HRVAC is investigating these possibilities in VR and AR, in addition to an already solid foundation of proof. It is a movement to gain real-world uses of concrete knowledge fostered via an interdisciplinary process while maintaining and in no way superseding the social responsibility of the preservation of the fine arts.

II. CONCEPTUAL FOUNDATIONS AND PROJECT SCOPE

A. Virtual Preservation

Allocated production, maintenance and use of digital images, which are virtual objects containing relevant data on the state-of-the-art object, its application, its role or its interpretations. It facilitates the capture, containment, documentation, software dependencies/migration and provenance. In fact, just because it's "virtual" does not mean that the original does not need to be substituted. Instead, a digital record has been utilized for accessing the material, researching and as has been directed by the artist to assist with the conservation planning process, and also for a disaster response/re-creation. A preservation-metadata object-oriented model, as proposed by PREMIS is helpful [4].

B. VR, AR, and Conventional Digital Media

What is built on-site is combined with VR/AR and Digital Media elements. VR can replace a lot of what the user will encounter in reality – VR works best, when scale, movement, succession or spatial relationships are wanted to be "experienced". AR when used with its real object / location is quite effective in keeping the real context. The traditional (pervious) web and 2D media have low impressiveness, but high compatibility and searchability, easily distributed and play an important part in inclusiveness of access. A sustainable project does not use all these media as a condition to raise each and every tourist a headset, but rather as a media portfolio.

Table 2: mediums roles in a virtual preservation.

Medium	Preservation value	Best fine-arts use	Main constraint
High-fidelity record	Evidence for research, conservation and migration	Colour-calibrated image, geometry, condition and process	Large files; specialist interpretation
Virtual reality	Reconstructs scale, space, sequence and lost context	Installations, studios, exhibitions and performance environments	Headset access, comfort and platform churn
Augmented reality	Connects digital evidence to a present object or site	Prior states, hidden layers, artist voice and in-gallery learning	Tracking, distraction and device variance

C. Aim, Objectives, and Scope

The project will focus on developing Fine Art Selection System Capturing Preservation and presentation system Museum/Airport and Artist centred generating VR/AR technology. To eliminate preservation masters while maintaining trying to keep artisitic aspects in capturing method, to be intentional on the authenticity, uncertainty, to quantify Life cycle impacts, stopped physical activity aspects, to add Rights and Consent aspects and involve participation of the community, and to develop a viable prototype and evaluation process. It is a design study and NOT a "full experiment of a gallery system" or NOT a "controlled visitor experiment".

III. REVIEW OF RELATED WORK

The project will focus on developing Fine Art Selection system Capturing Preservation and presentation system Museum/Airport and Artist centred generating VR/AR technology. To eliminate preservation masters while maintaining trying to keep artisitic aspects in capturing method, to be intentional on the authenticity, uncertainty, to quantify Life cycle impacts, stopped physical activity aspects, to add Rights and Consent aspects and involve participation of the community, and to develop a viable prototype and evaluation process. It is a design study and NOT a "full experiment of a gallery system" or NOT a "controlled visitor experiment".

B. Fine-Arts Learning and Visitor Value

The studies of these stakeholders showed that there is a correlation between AR at heritage sites with learning [8] as well as satisfaction/generation of new value for the visitors. A study involving wearable AR was used in an art gallery as a way to follow information and to make the information personalized to the viewer, but problems existed concerning social acceptability, and the social interaction between different viewers. Apart from that, in a feasibility study conducted in the museum, technical novelty, trust, aesthetics, perceptions of

the educational value of the museum, and the museum's perceived authenticity can affect the decision of staying in the museum and satisfaction [18]. In this particular instance the success isn't visible – within the areas of trust, accessibility, learning and social experience.

C. Capture, Reconstruction, and Standards

In this regard, two different methods can be used to conduct the geometric and photographic documentation: Digital photogrammetry and laser scanning can complement each other here [9]. In cultural-heritage application, Portalés et al. proposed a hybrid approach of photogrammetry (3D image acquisition) and AR [10] and Shih et al. reconstructed/hybridized all the older cultural elements based on AR [11, 12] integrated 3D scanning technique with AR using the smartphone for cultural-heritage application in the fields of tourism and pedagogy. There are a number of points that can be distinguished like purpose, complexity, quality, documentation and long-term usage as listed in the European Commission's guidance on 3D digitization [3]. However, there is literature that is tailored to the specific use and with this project you have one additional stewardship cycle plus a "Sustainability balance", you can check.

Figure 1: Proposed lifecycle for evidence-based and sustainable virtual preservation.

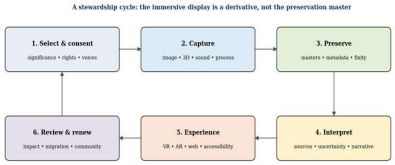

Table 2: Related-work synthesis and project response

Evidence area	Established contribution	Remaining risk	Framework response
VR museums [5], [6]	Presence, spatial interpretation and remote access	Experience may be tied to one platform	Preserve source assets and rebuild derivatives
AR heritage [7], [8]	Contextual overlays and situated learning	Tracking, distraction and uneven usability	Object-anchored, optional and tested layers
Art-gallery AR [17], [18]	Connections, learning and satisfaction	Trust, social and acceptance factors	Visitor-centred evaluation with alternatives
3D recording [3], [9]	Measurable geometry and appearance	Purpose and quality are not always documented	Capture plan, calibration and quality report
AR reconstruction [10]–[12]	Links evidence to visible historical states	Conjecture can appear factual	Source mapping and visible uncertainty levels

IV. DESIGN REQUIREMENTS

The following functions are described: selection of art works, assessment of art work significance, rights and consent collection, multimodal art work capture (snapshot), art work quality control, art work preservation packaging, creation of derivatives, delivery of VR/AR versions, accessibility and collection of visitor's feedback and periodic art work migration. Colour and scale are both part of the non-functional requirements when the purpose is to preserve them, the purpose of ability to convert to master is a non-functional requirement, as well as exporting interoperable files, performing at low bandwidth/low offline, protecting sensitive material, measurable energy and storage and documented ownership. The system can be used for painting and sculpture, installation, time-based media/performance and NOT ALL PAINTING.

V. PROPOSED VIRTUAL PRESERVATION FRAMEWORK

A. Lifecycle Overview

The details of the 6 stages will be explained in figure 1. The first consideration to go towards selection is whether or not it has meanings, whether or not it has conservation importance, and who will be interested in recording it and under whose authority it will be recorded. Capture generates calibrated media, and is able to log the equipment, settings, environment and operator. The preservation packages include masters, metadata, checksum and rights. Uncertainty in the data is represented and conveyed in the interpretive map. Package is experienced in VR / AR and/or Web.

B. Roles

Artist/righs holder provides intentions, specific uses and restrictions of re-use. The material risk and the evidence of condition is defined by the Conservators. Contexts and contested interpretations are set up by the curators and representatives of the community. The imagists are masters in 3D and show phases of uncertainty, of doubts about processes. There will be sustainability staff engaged that can help set boundaries around measuring the learning and/or usability of the experience, in addition to the responsibility of the interactions on the experience being accessible, there will be experience designer and digital-preservators required to manage packages and migrations. In a small institution one can, be assigned to several different roles—it's easy to see who's making the decisions and for which items.

VI. DIGITISATION AND PRESERVATION PIPELINE

A. Significance-Led Capture

Table 3: Capture strategy by fine-art form

Art form	Core evidence	Suitable capture	Critical caution
Painting / works on paper	Colour, surface, scale, frame and condition	Calibrated photography; raking or multispectral views were justified	Light exposure, colour management and rights
Sculpture	Geometry, material, texture, underside and setting	Photogrammetry, structured light or laser scanning	Reflective/transparent surfaces and handling
Installation / site-specific work	Spatial relations, assembly, light, sound and visitor path	3D survey, 360 video, spatial audio and installation plan	Capture the environment and artist rules

B. Quality Control and Reconstruction

Determination of the quality target is related to the intended use of the product. Geometric Error is given as the number of scale bars/number of independent control (check) points (nonscale points) over number of photogrammetric control points (scale points). Assume that P_i is the measured checkpoint, and that Q_i are the model checkpoint. Root-mean-square error is:

$$RMSE = [(\Sigma_i \|p_i - q_i\|^2) / n] \hat{}(1/2) \quad (1)$$

Other things that are documented in the quality report are Camera/Scanner calibration, colour target, lighting, occlusions, missing areas, mesh repair and texture processing. The certainty category (measured, documented, analogous or conjectural) is assigned to reconstructed parts and these are stored in a separate semantic layer. The viewer should be able to turn these on and study the sources independently without one source being so predominant that the other are unintelligible.

C. Preservation Package and Delivery Derivatives

Preservation package includes high-value source files and normalised open or widely documented formats (where applicable) and technical and descriptive metadata, rights and provenance, artist instructions, checksums, software dependency and event history. The split will enable the design of another "Headset" app to avoid the need to re-capture or employ the only document that remains, the legacy EXE.

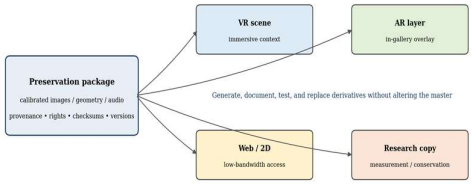

Figure 2: Preservation masters and replaceable access derivatives.

The masters for the preservation and the Replaceable Access Derivatives (figure 2). Initial estimate of storage: Pred - capture cost. If the average size of each image N_i is r_i bytes, of the video streams $N\hat{}$ is $b\hat{}$ bytes / second (for $t\hat{}$ seconds), of the 3D streams S_3D is the size, of the audio streams S_a is the size and of the metadata S_m is the size, then the size of a project is:

$$S_{total} = N_i r_i + \Sigma_v(b_v t_v / 8) + S_3D + S_a + S_m \quad (2)$$

This is done for the number of replicas, and estimated number of versions. The integrity is checked at the time of ingestion and, time to time, after that. Migration Tests are a collection of tests designed to ensure various important appearance, geometry, timing and interaction characteristics remain consistent between two or more formats and/or platform. Preserved - has been located /understood/sized, and could be lawfully used its intended purpose, reconstructed /rendered.

VII. VR AND AR EXPERIENCE DESIGN

A. Virtual-Reality Experiences

VR use can be for places where you can't, can't afford to or can't recreate, such as Artist Studios, time-based installations or space-based installations. Visitor should be made aware of direction and status of each rebuilding, and also be aware of the size

scale of each rebuilding. Locomotion can be used in conjunction with different modes of movement, moving around, teleporting and sitting. The overview map, stable horizon and adjustable movement speed and short sessions limit the discomfort. All interpretations should be carried out as layers – it is possible to have an uninterrupted encounter; if this is not possible this should be noted with the opportunities to demonstrate and/or a caption/commentary as required.

Table 4: Inclusive experience patterns

Design need	VR response	AR response	Required alternative
Mobility and fatigue	Seated mode, teleport and reachable controls	Stationary viewpoints and adjustable device height	Keyboard/touch 2D tour
Vision	Scalable text, contrast, audio description and zoom	High-contrast labels; avoid colour-only meaning	Structured text and downloadable images
Hearing	Captions, transcripts and visual sound cues	Captioned audio/video overlays	Full transcript
Cognition / language	Simple navigation and layered explanations	Short prompts and plain-language mode	Linear guided version

C. Evaluation of Experience

The Evaluation is based on: Task completion, Navigation errors, Comfort, Accessibility Audit, Presence, Perceived Authenticity, Learning, Recall, Social interaction and Qualitative interpretation. One of the funniest of technologies is the question in which you ask a question for the visitor. They are asked to find out what they think they see in the artwork that they trust, what they find difficult to see in the artwork and if they think that it helps them to see the physical artwork. If an access need is provided and the size of the sample is appropriate, then the gender of the people shall appear - provided some information about the subject is also provided.

VIII. AUTHENTICITY, RIGHTS, ETHICS, AND GOVERNANCE

A. Authenticity and Transparency

Develop and foster relationship that are authentic and transparent. Traceable" connections are made between capturing, processing & interpreting that leads to the exhibition of art and its authenticity. Special attention is paid to the presentation of all the transformations with their agent, Date, Software, Parameters, Source and the Reason. A reconstruction interface is used to separate observing/inferring and exploring the capabilities for key sources. Colour, geometry and sounds are used to talk about the missing information about the truth of History. This method is in line with UNESCO's concern about the integrity and authenticity [1] and the London Charter's demand that the outcomes of visualisation need to be understandable and evaluable [2].

B. Rights, Consent, and Cultural Authority

Because copyright, moral rights, privacy rights or culturally specific rights of authority are not inhered by a digital image of an artwork through the act of digitalizing it. The work and any digital asset is under the control of the project (OWNERSHIP), the territory is capitalized, as well as the duration, commercial use, modification, public, takedown and arrangement. Working artists' approval of process/intent. Ensuring the appropriate informing of the performer/actor, visitors and interviewees. Who has access to it, how and when it is given back and/or limited, etc., will be dictated by Indigenous and source communities, one of the priorities in the 2026 ICOM Code [13]

Table 6: Ethical and technical risks with controls

Risk	Possible harm	Preventive control	Review / response
False reconstruction	Visitors accept speculation as fact	Evidence layers, certainty labels and expert/community review	Correct version; retain change note
Rights overreach	Unauthorised copying, adaptation or commercial use	Machine-readable terms, access tiers and watermarking where justified	Takedown and rights audit
Cultural extraction	Community knowledge is detached from authority or benefit	Free, prior and informed participation; benefit agreement	Community-led restriction or return

IX. PROTOTYPE METHODOLOGY

A. Prototype Case

A. Prototype Case That prototype fabricated for the academic consists of an installation of light and ambient sounds in a large room, that will be reversible with light projections and added sounds to the ambient ones, on which the artist will sketch the

path of the viewers. This could include a series of images, calibrated with the appropriate geometry, room size and speed of the lasers, a video reference with a 360-degree overview, an installation plan, a condition survey and interviews with the artist as video/recording. VR mode is able to reconstruct the spatial situation at the original place, AR mode displays the assembly steps and/or the selected states of the assembly process in advance on a small physical maquette or the markers displayed in a gallery, Web mode offers a wide access. Each of the three have the same

B. Procedure

The process is made up of 7 steps – sign off on the significance and consent brief; setup capture and sustainability baselines; gather and validate media; develop the preservation package; develop derivatives for performance; perform expert, artist, accessibility and visitor evaluation; and deposit versioned outputs with maintenance plan. A user study is performed with the same learning objectives where a web catalogue, a VR and an AR as well as a hybrid route is compared. Comfort/trust and perceived authenticity and perceived barriers are reported and orientation and interpretation activities are provided. Energy (in Joules), processing time (in seconds) along with data transfer hours & device hours are captured for a given period of tests performed.

.C. Acceptance Criteria

Prototype satisfies Prototype and Geometrics (specified); colour, sound and equivalents to physical activity readily available; artist agrees to the representation of intent; derivatives can be reproduced from documented inputs/s and equivalents to physical activity are readily available to produce derivative and derivatives can be reproduced from documented inputs/s. A score achieved by a visitor is NOT a judgement on the barriers to a rights, authenticity or preservation gate but is intended to give ideas to improve.

X. ILLUSTRATIVE RESULTS AND ANALYSIS

A. Simulated Comparison

A simulated decision profile that is an example of the analysis is included in Table 7 and Figure 3. In order for the numbers to be "finalized" they would have to be the result of an experiment of a finished visitor. The scores are based on predesigned indicators, and range from 0 to 100. Well the 2D catalogue is good – in terms of performance and also access to the catalogue at a spectrum of devices – but does not bring to light the spatial context so much. VR is the most immersive of the various contexts, but is not the most energy efficient nor most efficient on device. We will retain the original object and you will be discussing it and judging it by yourself and others in AR. It is the most well-balanced of them all, features a light-weight Web core and has an optional AR / scheduled VR interface.

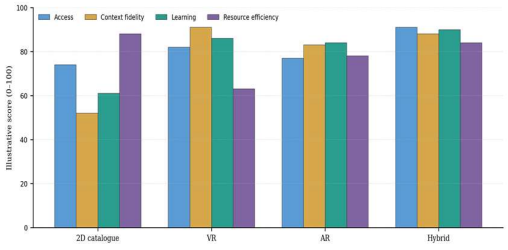

Figure 3: Illustrative simulated comparison of access modes; not experimental findings.

Table 7: Illustrative simulated scores for project analysis

Mode	Access	Context fidelity	Learning	Resource efficiency	Illustrative SSI
2D catalogue	74	52	61	88	69.0
VR	82	91	86	63	80.5
AR	77	83	84	78	80.5
Hybrid	91	88	90	84	88.3

B. Interpretation and Sensitivity

In the SSI each of the four criteria (illustrated) is given equal weight. VR might be more important the more people determine the spatial meaning, web and AR might be more important if there's less read access to VR headsets and/or if carbon intensive use of electricity occurs. Thus, the hybrid recommendation is not required, but is voluntary. Important, and result will be: "What is the tradeoff: maximum immersion not necessarily shared with maximum stewardship." In a live study, values and uncertainty ranges would be given and accessibility findings/assumptions would be made for each group prior to the procurement and/or prior to an exhibition decision was made.

XI. IMPLEMENTATION PLAN

Table 8: Twelve-week prototype plan and evidence

Stage	Weeks	Main activity	Completion evidence
1. Brief and governance	1–2	Significance, stakeholders, rights, access and baseline definition	Approved brief, risk register and consent matrix

Stage	Weeks	Main activity	Completion evidence
2. Capture	3–4	Imaging, 3D, audio, interview and condition recording	Capture log, calibration and quality report
3. Preservation package	5	Normalisation, metadata, fixity, rights and storage replicas	Validated package and restore test
4. Experience build	6–8	VR, AR and accessible web derivatives	Versioned builds and source-to-output record
5. Evaluation	9–10	Artist/expert review, accessibility test, visitor pilot and impact logging	Issue log, measures and approved corrections

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XII. DISCUSSION, LIMITATIONS, AND FUTURE SCOPE

A. Discussion

Detaching stewardship from show is most important that the framework provides. Aside from the technology of the catalogue picture, the accompanying history – the artists' statements – and knowledge about the way of assembling the exhibition as well as the spatial relations can be preserved with the support of the immersion media. They can also decrease the number of times that sensitive originals are accessed, and help with conservation planning. It truly is what's pushing the experience which makes it worthwhile. Master Package for either: Great to facilitate study & teaching, accessibility & future platforms, master package durable, delivery layer can easily be replaced, no capturing required. This is in line with the European cultural heritage data space strategy [15] that aims at the quality foundations of the data – accessible and interoperable.

B. Limitations

The mini project will be one of design/simulation of an evaluation NOT design and build of a system. Where tolerances, consents and borders of authenticity are concerned, they are specific to the particular type of fine art form and cultural context – these need to be adjusted accordingly. Environmental data utilized to make gadgets, network and cloud services can be inadequate or averages. Thus, it is difficult to measure the "avoided travel" as virtual visits may be in addition to, and not necessarily a substitute for, actual travel. The comfort, tracking and accessibility of the headsets relies on their equipment. Finally, ‘digital surrogates' might actually be more valuable as they contribute to the sensors, but lack touch, smell and the social aspects of learning about material and some deterioration skills.

C. Future Scope

Future developments will be building towards the incorporation of the "live artist" with the prototype and on-going comparisons of expert, community and visitor judgements. The research test should be designed so that long-term retention, ko-presence in social settings, low cost of haptics, and web based XR which is easily accessible, can all be achieved. These and other issues like the interface of real-time engines and born-digital art emulation, as meaningful uses of a work, and environments of physical exhibition, should be explored and answered. Ensuring there is no duplicating of captures within and between institutions through open pipelines, controlled vocabularies and shared interoperable data spaces.

D. Practical Recommendations

It is imperative that this first service is not a ‘show case' service by the pupils, rather the service must be small – ‘expandable' and conducted by the school. An initial programme could select two pieces that are opposed to each other, determine a common event and rights schema, then establish a repository to hold the materials and provide three program offerings: research master, efficient web presentation and an immersive experience. Each proposal should answer the following five questions BEFORE you begin to look for suppliers: What important evidence is at risk of being lost? To whom will you baptize? Which one of the physical activities one can reasonably avoid out of the following options: But what platform will be ending and how will the package be restored? Who is going to get Ok to represent/reuse? Projekte that don't even respond to these questions ought not be proceeded with but towards the continuation of discovery.

XIII. CONCLUSION

A Mini Project – Sustainable practice in Fine Arts – Using VR/AR – A Full VR-preservation framework. The starting points of the framework are significance, consent, defined purpose, material collection, spatial evidence, temporal evidence and evidence of context, documentation of masters with

provenance, rights and fixity, documentation of version history, generation of replaceable VR, AR and Web derivatives and of course, examination of cultural, social, environmental, economic and technical outcomes. VR can be of greatest help in purposes of spatial and temporal reconstruction. Furthermore, AR might be most effectively employed in an in-situ interpretation – in service of a particular art work. Both can be developed if they are ‘realistic human possibilities', possible in the community and restrict platform dependence and monetisation based on sustainability. It's not "art" in a digital "replica", it is a long term, multifaceted, responsible system that will allow future user of the work, conservators and preservationists to learn from it: and that will continue to preserve the physical and cultural life of the work.and conservators/preservationists to learn from it and which will continue to preserve the physical and cultural life of the work itself.

REFERENCES

[1] UNESCO, “Charter on the Preservation of Digital Heritage,” 32nd General Conference, 2003. Available: https://www.unesco.org/en/legal-affairs/charter-preservation-digital-heritage.

[2] H. Denard, ed., “The London Charter for the Computer-Based Visualisation of Cultural Heritage,” ver. 2.1, 2009. Available: https://londoncharter.org/.

[3] European Commission, “Study on Quality in 3D Digitisation of Tangible Cultural Heritage,” 2022. Available: https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage.

[4] Library of Congress, “PREMIS Data Dictionary for Preservation Metadata,” ver. 3.0, 2015. Available: https://www.loc.gov/standards/premis/v3/.

[5] M. K. Bekele, R. Pierdicca, E. Frontoni, E. S. Malinverni, and J. Gain, “A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage,” Journal on Computing and Cultural Heritage, vol. 11, no. 2, article 7, pp. 1–36, 2018, DOI: 10.1145/3145534.

[6] M. Carrozzino and M. Bergamasco, “Beyond Virtual Museums: Experiencing Immersive Virtual Reality in Real Museums,” Journal of Cultural Heritage, vol. 11, no. 4, pp. 452–458, 2010, DOI: 10.1016/j.culher.2010.04.001.

[7] R. G. Boboc, E. Băutu, F. Gîrbacia, N. Popovici, and D.-M. Popovici, “Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications,” Applied Sciences, vol. 12, no. 19, article 9859, 2022, DOI: 10.3390/app12199859.

[8] M. C. tom Dieck and T. H. Jung, “Value of Augmented Reality at Cultural Heritage Sites: A Stakeholder Approach,” Journal of Destination Marketing & Management, vol. 6, no. 2, pp. 110–117, 2017, DOI: 10.1016/j.jdmm.2017.03.002.

[9] N. Yastikli, “Documentation of Cultural Heritage Using Digital Photogrammetry and Laser Scanning,” Journal of Cultural Heritage, vol. 8, no. 4, pp. 423–427, 2007, DOI: 10.1016/j.culher.2007.06.003.

[10] C. Portalés, J. L. Lerma, and C. Pérez, “Photogrammetry and Augmented Reality for Cultural Heritage Applications,” The Photogrammetric Record, vol. 24, no. 128, pp. 316–331, 2009, DOI: 10.1111/j.1477-9730.2009.00549.x.

[11] N.-J. Shih, H.-X. Chen, T.-Y. Chen, and Y.-T. Qiu, “Digital Preservation and Reconstruction of Old Cultural Elements in Augmented Reality,” Sustainability, vol. 12, no. 21, article 9262, 2020, DOI: 10.3390/su12219262.

[12] N.-J. Shih, P.-H. Diao, and Y. Chen, “ARTS, an AR Tourism System, for the Integration of 3D Scanning and Smartphone AR in Cultural Heritage Tourism and Pedagogy,” Sensors, vol. 19, no. 17, article 3725, 2019, DOI: 10.3390/s19173725.

[13] International Council of Museums, “ICOM Code of Ethics for Museums,” revised ed., 2026. Available: https://icom.museum/en/resources/standards-guidelines/code-of-ethics/.

[14] Green Software Foundation, “Software Carbon Intensity Specification,” ISO/IEC 21031:2024. Available: https://sci.greensoftware.foundation/.

[15] European Commission, “The Common European Data Space for Cultural Heritage: Strategy 2025–2030,” 2026. Available: https://digital-strategy.ec.europa.eu/en/library/common-european-data-space-cultural-heritage-strategy-2025-2030.

[16] International Council of Museums, “Museum Definition,” adopted 2022. Available: https://icom.museum/en/resources/standards-guidelines/museum-definition/.

[17] M. C. tom Dieck, T. H. Jung, and D. tom Dieck, “Enhancing Art Gallery Visitors’ Learning Experience Using Wearable Augmented Reality,” Current Issues in Tourism, vol. 21, no. 17, pp. 2014–2034, 2018, DOI: 10.1080/13683500.2016.1224818.