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Preserving the Sacred In Situ: A Scalable Model for Hybrid Religious Heritage Documentation

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Abstract

An interdisciplinary approach underpins the PaReS project (Painted Relic Shrines in Situ), which explores medieval painted reliquary shrines preserved in situ in Belgian churches. Combining high-resolution 3D photogrammetry, non-invasive scientific imaging (IRR, X-ray, MA-XRF), physically based rendering (PBR), art historical and archival reasearch, the project documents and analyses these fragile, hybrid heritage objects situated at the intersection of materiality, devotion, and historical memory. A methodological contribution lies in the integration of three complementary domains—historical documentation, digital acquisition, and scientific analysis—into a reproducible, site-specific protocol. This framework has already revealed material and stylistic transformations over time. For instance, modelling of the Shrine of St Eucherius indicated phased construction, while IRR findings on the Shrine of St Livinus challenge its conventional dating. By making data accessible via open-access platform and engaging students and local communities, PaReS combines academic rigour with public outreach. Its workflow offers a transferable model for the documentation and conservation of sacred heritage.

CCS Concepts

• ***Computing methodologies*** → ***Image-based rendering;*** • ***Information systems*** → ***Document collection models;***

1. Introduction

Wooden painted reliquaries, material witnesses to medieval devotion, remain largely understudied and endangered. These objects embody a long and complex history, intersecting ritual, artistic, and social functions, while exhibiting exceptional material complexity. Often still preserved in the churches for which they were originally created, they have endured the ravages of time, evolving devotional practices, undocumented or poorly documented restorations, and sometimes harmful environmental conditions. In Belgium, only fourteen painted reliquaries predating 1566 (between 1292 and 1566) have survived the iconoclastic destructions and the wear of time. Eleven of them remain preserved in churches in their original context, granting their study unique heritage and scientific value.

Beyond their rarity, these reliquaries stand out due to their hybrid nature: polychrome wooden caskets, sometimes adorned with metal, designed to enshrine sacred relics while conveying hagiographic narratives through painted imagery. Their analysis requires an interdisciplinary methodology combining heritage science, art history, conservation-restoration, scientific imaging, and advanced digitization technologies. Due to their fragility and historical significance, these objects cannot be moved—their study must be conducted entirely in situ, often under challenging conditions (confined spaces, uncontrolled lighting, limited access). This technical difficulty lies at the heart of the PaReS project (Painted Relic Shrines in Situ), which aims to develop a rigorous, reproducible, and adaptable analytical protocol that respects both material and heritage constraints.

The research conducted within this framework seeks to restore visibility and understanding to these neglected objects by integrating visual examination and photographic documentation with structured technical approaches across three complementary axes:

- Archival and historical documentation, drawing from ancient sources and past photographic campaigns;
- High-resolution photogrammetry, serving as a common foundation for modeling and correlation;
- Scientific imaging, revealing hidden material compositions and paint layers imperceptible to the naked eye.

These investigative domains continuously interact, with each dataset reinforcing and illuminating the others. Additionally, ecclesiastical archives, restoration records preserved at KIK-IRPA, historical photographs, and stylistic research help trace the successive transformations these works have undergone. It is within this interplay of material and immaterial sources that the PaReS project

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finds its full significance, uncovering layers of meaning and matter accumulated over centuries. The challenge is not only to better understand these reliquaries in their (art) historical and material entirety but also to establish a transferable methodology applicable to other heritage objects with similar characteristics. This approach ensures that these fragile yet invaluable artifacts are preserved, studied, and appreciated as both religious treasures and historical testimonies—bridging history and devotion with contemporary scholarship.

2. Interdisciplinary methodology: between archives, digital and materials

The protocol implemented is based on a rigorous articulation of three complementary domains, each playing a specific role in the collection, interpretation and development of data related to the studied reliquaries. This structuring guarantees a comprehensive approach to these complex objects, taking into account their materiality, their historicity and their visibility.

2.1. Historical Documentation, Archival Research, and Contextual Interpretation

A key component of the project involves mining historical sources—parish archives, past restoration reports, and the extensive photographic archives of KIK-IRPA. These records serve as a critical foundation for reconstructing the formal, material, and symbolic evolution of the reliquaries. By cross-referencing these sources, researchers can trace each object's biography: its original production context, liturgical placement, potential relocations or physical transformations, and how it was perceived and used over centuries.

Specifically, these archival materials:

- Shed light on prior restoration campaigns and contextual changes, helping distinguish original features from later interventions.
- Track modifications to form, iconography and style, such as physical reductions (e.g., resized panels) or alterations in decorative schemes.
- Anchor each reliquary within its liturgical, spatial, and symbolic context, clarifying display conditions (e.g., wall niches, choir placements, altars) and how these influenced design choices and narrative functions.

This archival dimension not only deepens historical understanding but also provides critical context for technical observations. For instance, documented (or undocumented) past restorations can be correlated with photogrammetric models or scientific imaging data (e.g., MA-XRF, IRR). Such synergy between historical sources and analytical techniques enables a diachronic and material reading of the objects—revealing layers of meaning hidden beneath the surface.

2.2. 3D Photogrammetry and Physically Based Rendering

Photogrammetry campaigns have produced high-resolution 3D models of the reliquaries that comply with international heritage documentation standards. Each object was captured with 80% overlap from multiple angles, under both polarized and non-polarized lighting to cross-reference results and reconstruct specular reflections on varnished or metallic surfaces [FMS*23].

One major challenge in this context is precise color calibration, which is crucial to ensure documentation reliability for use by conservators, art historians, and restoration teams. This involves the use of color charts and ICC profiles tailored to complex in situ lighting environments—narrow spaces, inconsistent natural light, and visual obstruction by architectural elements or furnishings.

The image sets are processed to generate several types of maps: diffuse map (base color texture, color-accurate without shadowing effects), normal map (partially ia-based generated to combine object orientation and relief details, enriched with scientific imaging data to enhance surface geometry (ridges, grooves, fine relief)), ambient occlusion map (baked mapping of local shadows and recesses), and specular map (surface highlights based on non-polarized and cross-polarized images).

The final PBR model, like Figure 1, serves not only as a visual tool but also as a cross-disciplinary reference hub. It could allow superimposition of pigment maps (MA-XRF), infrared or radiographic imagery, enabling an integrated reading of scientific, historical, and visual data.

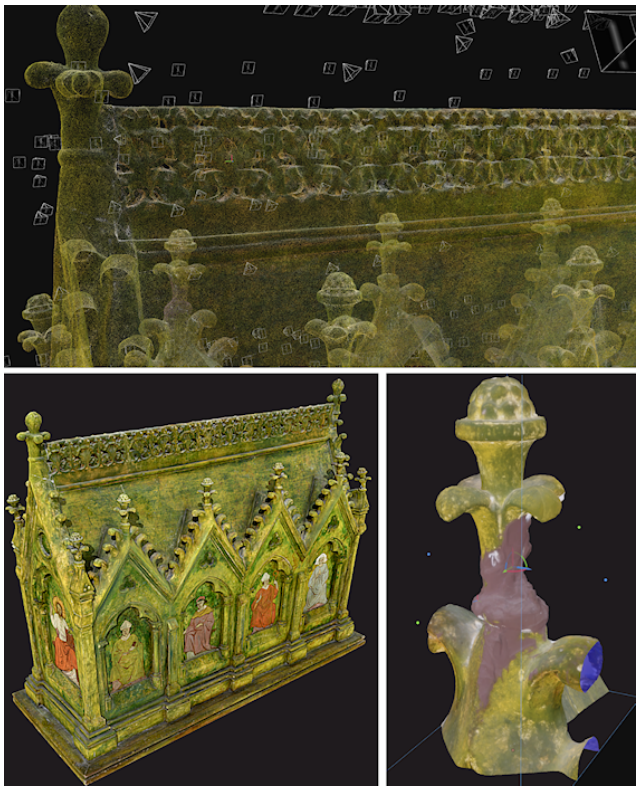

Figure 1: *Reconstruction of of the shrine of St Livinus (Sint-Lievens-Houtem, Church of St Michael), Sketchfab rendering (200.1k triangles simplified model) for public presentation of the collection, and the 3D detail of a problematic restoration.*

2.3. Scientific Imaging and the Study of Material Stratigraphy

This component of the project focused on the scientific examination of the reliquary shrines in situ. Digital data collection was complemented by a range of non-invasive techniques to analyze the structure and material composition of the objects, including their wooden cores, paint layers, pigments, and binding media. These investigations revealed significant differences in materials and artistic techniques across time periods and individual works.

To gain insight into the construction of the shrines, the wooden boards were systematically examined. Measurements and photographic documentation captured tool marks, structural transformations, and signs of use. Joinery analysis was also conducted, revealing later modifications such as reductions, reinforcements, or additions. Dating the supports was essential, and visual stylistic studies alone were insufficient. Thus, a multi-step approach was used:

Each panel was assessed for dendrochronological suitability [ALC*25], taking into account wood species, number of visible rings, orientation, conservation state, and the presence of surface treatments. Rings were photographed using a DSLR camera with a macro lens, and growth patterns were matched against reference chronologies. If dendrochronology was not feasible, radiocarbon dating (^{14}C) was considered. This isotopic method provides calibrated age ranges, helping establish a terminus post quem for each object.

Infrared reflectography (IRR) [Cur09] was employed to investigate underdrawings, using an Apollo IR camera from Opus Instruments. This technique reveals carbon-based sketches beneath the paint, showing whether the artist altered the design during the early stages of execution (e.g. Figure 2). Complementing this, X-ray radiography (using a Baltograph XMD 160kV generator) was used to detect hidden compositions and internal construction details. It provided crucial insights into both the creation process and later restorations. Importantly, X-rays also served as a non-invasive means of detecting relic contents without opening the shrines, in accordance with owner permissions.

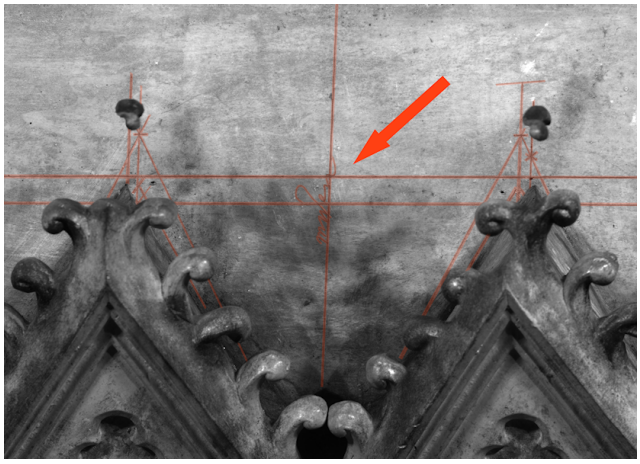

Figure 2: *Detail of IRR capture of the shrine of St Livinus (upper section) revealing visible tool marks (highlighted in red) and what appears to be a signature of the artisan (indicated by the arrow).*

Macro X-ray fluorescence (MA-XRF) [LRNJ18,DHS*24] scanning enabled the chemical mapping of surfaces. This technique was conducted entirely in situ, respecting the immovability of the objects. MA-XRF revealed pigment compositions, overpaintings, and compositional changes invisible to the naked eye. Though highly informative, MA-XRF presents practical challenges: it is optimized for flat surfaces, which are rare on painted reliquary shrines with ornaments, and scanning large or complex areas can take up to 20 hours. Nonetheless, its value lies in its ability to uncover hidden layers and material histories, supporting informed conservation planning. Figure 3 illustrates the MA-XRF acquisition of the shrine of St Petronilla (Rekem, Church of St Petrus).

Figure 3: *MA-XRF acquisition of the shrine of St Petronilla.*

These complementary datasets contribute to reconstructing the reliquaries' full lifecycle: initial creation, devotional use, transformations, and later interventions. Importantly, they also inform conservation decisions by highlighting fragile areas, incompatible materials, and historical overpaints. These cross-validated imaging results could be integrate into the 3D documentation and linked with the archival data, forming a comprehensive interpretative framework. The integration of scientific imaging into heritage research on painted shrines has not only expanded the knowledge of individual objects but has contributed to broader methodological standards for studying immovable liturgical artworks.

3. Methodological Advances and Domain-Specific Adaptations

Rather than inventing entirely new tools, the PaReS project distinguishes itself through the strategic adaptation and integration of well-established methods, tailored to the specific challenges posed by in situ, immovable, and hybrid devotional heritage. Its primary innovation lies in orchestrating a tightly interwoven workflow—combining historical documentation, photogrammetry, and scientific imaging—into a coherent, site-based process. While each component has proven valuable in previous heritage contexts, they

are rarely applied together with this level of precision and interoperability to such fragile, liturgical objects still preserved in their original locations.

A notable advance is the refinement of photogrammetric acquisition protocols to accommodate reflective, polychrome, and irregular surfaces. The use of both cross-polarised and non-polarised lighting, combined with rigorous colour calibration and the generation of normal maps informed by surface data, enables an unusually high level of accuracy in rendering materiality. These practices, though available in the digital heritage toolbox, are not commonly employed at this degree of resolution for complex, religious micro-architecture.

The project also demonstrates the feasibility and value of deploying advanced imaging techniques—such as IRR, X-ray, and MA-XRF—entirely in situ. Though widely used in museum settings, these methods are rarely adapted for rural or architecturally constrained ecclesiastical spaces. PaReS shows that with appropriate logistical planning, deep technical analysis can be conducted without removing the artefact from its context. The integration of the resulting datasets within an interactive 3D interface not only enhances interdisciplinary collaboration but also sets a precedent for visualising multisource data in a manner accessible to scholars and the public alike.

Historical documentation, meanwhile, is not treated as supplementary but as a critical analytic layer. By cross-referencing archival photographs, inventories, and previous restoration records with newly acquired technical data, the project reconstructs object biographies, tracks material transformations, and refines dating hypotheses. This triangulation—though conceptually established—is here applied rigorously to small-scale ecclesiastical furnishings, a category often overlooked in digital heritage programs.

The project's findings have already begun to reshape scholarly understanding. For instance, 3D modelling of the Shrine of St Eucherius in Sint-Truiden (Church of Our Lady) revealed subtle chromatic differences between the lid and the base, suggesting that the components may have been produced at different times. In another case, infrared reflectography on the Shrine of St Livinus in Sint-Lievens-Houtem (Church of St Michael) unveiled carbon underdrawings that diverge markedly from the style previously attributed to the object. These findings now call into question the established dating of the shrine and prompt further investigation.

Finally, by embedding the documentation within a national open-access platform (BALaT - Belgian Art Links and Tools), and through careful metadata standardisation, PaReS delivers a replicable, scalable framework for the study of sacred heritage. While its core components exist independently in other domains, the project's strength lies in assembling them into a tailored, field-tested workflow for immovable devotional objects. It offers a methodological model that can inspire other European initiatives facing similar conservation and access challenges.

4. Conclusion

The PaReS project demonstrates how a focused, interdisciplinary strategy can reframe the way we study, conserve, and transmit knowledge about complex religious heritage. By concentrating on painted reliquary shrines—objects that are fragile, immovable, and long under-researched—PaReS has developed a robust approach that bridges technical imaging, archival inquiry, and high-fidelity 3D documentation.

What makes this methodology effective is not only its breadth, but its internal coherence: from data collection to public dissemination, every stage is calibrated to respect both the material integrity and the ritual significance of these artefacts. This holistic framework can be adapted to other hybrid devotional objects such as tabernacles, painted altarpieces, or polychrome sculpture—especially when mobility, fragility, or spatial constraints limit access to traditional lab-based analysis.

Crucially, PaReS prioritises accessibility. By making data available through BALaT, producing public-facing media, and engaging students and local communities, the project extends its impact beyond academia. It encourages shared stewardship of religious heritage and fosters a broader understanding of sacred artworks still housed in their original contexts.

In doing so, PaReS offers more than a successful case study: it models a standard for documenting, interpreting, and safeguarding in situ sacred heritage. Its transferable methodology and commitment to open knowledge make it a valuable reference for institutions across Europe and beyond.

Acknowledgements

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