Scan-to-Scoring: An Algorithmic Model for Conservation Maintenance Records

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Abstract

This paper presents a Scan-to-Scoring framework supporting the Conservation Maintenance Record (CMR). The proposed methodological approach integrates expert-based assessment with interoperable digital environments (XLS, VPL, CAD/E-HBIM) to compute, manage and visualize a synthetic conservation risk index directly on semantically defined point clouds and 3D feature-based models. The main goal of the proposed evaluation system is the operational formalization and spatial mapping of a repeatable and transparent risk scoring process, enabling cross-asset comparison, periodic monitoring and maintenance planning. Geometric processing, including manual and semi-automatic segmentation, supports score attribution and visualisation at different scales. The XLS/VPL algorithm produces numerical and colour-coded outputs synchronized with the 3D representation. The workflow is suitable for both artefacts and architectural contexts. The innovation lies in the algorithmic and repeatable formalization of a traditionally qualitative assessment process, demonstrating adaptability, feasibility and operational applicability to support preventive conservation, monitoring and maintenance planning through an operational and accessible digital workflow.

1. Introduction

In recent years, research in Cultural Heritage documentation, analysis and management has been reshaped by advanced algorithms for heterogeneous data processing, classification and semantic enrichment, enabling integrated workflows as cognitive and operational infrastructures for preventive conservation, planned maintenance, monitoring and long-term management.

While these approaches have produced increasingly rich and structured object-based and multilevel digital representations, conservation assessment, risk evaluation and maintenance planning are still largely based on qualitative expert judgment, and digital models are rarely used as reproducible, comparable and decision-oriented tools.

To address this gap, this study proposes a Scan-to-Scoring Modeling approach based on an algorithmic scoring system supporting the Conservation Maintenance Record (CMR), aimed at transforming expert-based qualitative assessments into a computable, repeatable and comparable decision support tool. Geometry is tightly linked to semantic and evaluative parameters, turning digital surveys and 3D models into active tools for conservation, management and communication.

The approach was tested on multiscale case studies, from artworks to architecture, to assess its flexibility and robustness. The proposed framework does not introduce new modelling or segmentation techniques, but a new way of using 3D representations as operational supports for formalized conservation assessment.

A key aspect is the conceptual separation between the decision model and the geometric representation: the scoring system is geometry-independent and can be anchored to different spatial supports (e.g. point clouds, BRep models and HBIM environments) as complementary layers, according to the required level of detail and operational needs.

2. Theoretical Background

2.1 Research context and main approaches

Preventive conservation and routine maintenance represent smart strategies to safeguarding CH (della Torre, 2003; Gasparoli, 2011).

In recent decades, research has increasingly adopted ICT and AI solutions for degradation detection through advanced imaging, diagnostics and decision support systems (Zhang et al., 2024; Mishra et al., 2024; Del Bue et al., 2023; Fiorucci et al., 2020; Moropoulou et al., 2018), as well as deep learning-based image analysis for crack detection (Kim et al., 2020).

Further applications concern management and communication (Perles et al., 2024; Borg et al., 2020; Boesgaard et al., 2022), pilot systems for large-scale and time-series risk monitoring (Gong et al., 2025; Buglisi et al., 2025; Pasupuleti et al., 2025) and web-based multilevel platforms (Masciotta et al., 2021), integrating AI and IoT technologies (Laohaviraphap and Waroonkun, 2024) aiming to ensure a proper and proactive documentation, management and conservation of CH.

AI for digitalisation (Croce et al., 2024; Basso et al., 2024), semantic segmentation aimed at information modeling (Buldo et al., 2025; Figueiredo et al., 2025; Avena et al., 2024; Croce et al., 2022; Grilli et al., 2019), as well as data monitoring, storage, labelling and mapping of damage and degradation on point clouds and 3D models (Clini et al., 2024; Nespeca et al., 2024; Scandurra et al., 2024; Lanzara et al., 2022; Lanzara et al., 2021; Giovannini et al., 2021) and multimodal information modeling, increasingly support CH acquisition, documentation and management.

Despite technological progress, there remains a demand for low-cost operational approaches accessible to a broad range of professionals (restorers, conservators and diagnostic experts) and adaptable to diverse contexts, including GLAM institutions, monuments, archaeological sites and places of worship, often marked by limited controllability and complex accessibility conditions.

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2.2 Operational frameworks for preventive conservation

Over recent decades, risk assessment for CH has evolved into a heterogeneous ecosystem of conceptual models, operational frameworks and research initiatives spanning multiple scales and levels of formalization.
Foundational preventive conservation approaches, such as the ABC Method, the 10 Agents of Deterioration and quantitative models (Michalski, 2016), established the theoretical basis for analysing degradation causes, value loss and risk comparison, while remaining mainly conceptual.
At larger scales, HERACLES and STORM projects introduced multiscale risk-based frameworks integrating climatic hazards, vulnerability and exposure, while ISO 31000 and ISO 22301 provide general risk and business continuity standards applicable to CH. More recently, territorial and multi-site tools (e.g. ProteCHt2save-STRENCH, Copernicus EMS Risk and Recovery Mapping, PROCULTHER-NET) support risk screening and prioritisation using geospatial data and composite indicators, alongside collection and building-scale systems (e.g. CollectionCare, SensMat, APACHE) integrating monitoring, degradation models and decision support.
Complementarily, projects such as WARMEST, MAIN10ANCE, HeritageCare and Scan4Reco address planned maintenance, site-scale risk analysis and multi-source diagnostics, outlining a structured landscape where conceptual models, territorial tools and decision-support systems coexist to meet complementary CH management needs.

3. Main Goal

The proposed system integrates mathematical formulation and expert-based scoring to compute a synthetic risk index. Implemented in an interoperable environment (XLS/VPL), the algorithm fits within the Scan-to-Scoring paradigm and integrates CAD–HBIM–VPL interoperability, point clouds semantic enrichment and algorithmic scoring for preventive conservation in heterogeneous contexts.
Artefact digitisation (point clouds, meshes), geometric processing (from point clouds to BReps) and typological classification (GhPython RANSAC) are performed through semi-automated processes, while conservation parameters are compiled by experts (XLS CMR) and processed through automatic scoring and numerical and colour-coded annotation.

The main contributions can be summarized as follows:
- formalization of conservation assessment into an algorithmic scoring model, from a descriptive expert-based form into a computable, repeatable and comparable scoring system;
- introduction of a geometry-independent decision layer. The scoring model is conceptually independent from the geometric representation and can be consistently anchored to point clouds, simplified BRep models or HBIM objects;
- operational prioritization. Unlike most existing approaches that mainly provide measurements and thematic maps, the proposed method produces a synthetic and comparable index that directly supports intervention prioritization, maintenance planning and long-term monitoring;
- scalability across different asset types and scales. The same scoring logic is applied to both individual artworks and architectural environments, showing the generality and robustness of the proposed approach.

This work focuses on the algorithmic and repeatable formalization of a traditionally qualitative assessment process, supported by a 3D representation, in line with conservation practice and designed to be accessible also to non-expert users.

4. Tools and Methods

4.1 The XLS/CMR Algorithm

The main goal of the XLS CMR is to integrate outcomes of inspection activities and risk index, creating a standardized foundation for decision-making in preventive conservation. The algorithm assesses conservation risk through six key parameters carefully selected by the expert to capture critical factors influencing the long-term stability of assets.

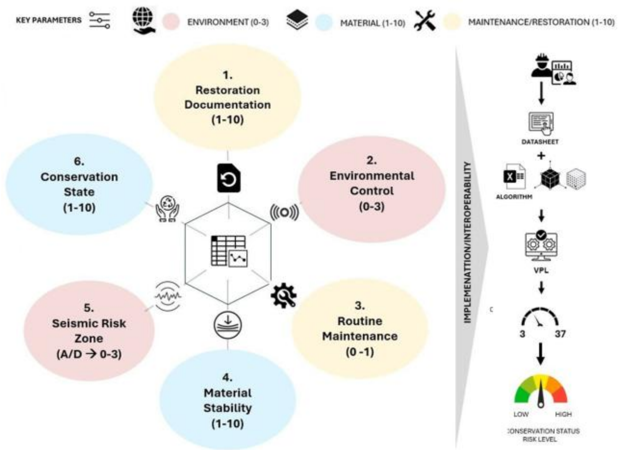

Figure 1. CMR: parameters and scoring scales. Higher values correspond to higher conservation risk; the overall CMR index is computed as the unweighted sum of the six parameters.

The combined score generates a quantifiable conservation risk index, ranging from 3 (minimum risk) to 37 (maximum risk). Each parameter plays a distinct role in shaping the overall assessment (Fig. 1):
1. *Restoration Documentation*: assesses the quality and recency of restoration records. Documented recent interventions lower risk scores by enabling informed preventive planning;
2. *Environmental Control*: evaluates presence and effectiveness of environmental monitoring and management (temperature, relative humidity and light exposure);
3. *Execution of Routine Maintenance*: verifies whether regular maintenance activities are performed. The absence of such actions contributes to higher risk scores;
4. *Material Stability*: analyses the inherent stability of the materials and techniques used in the artwork;
5. *Seismic Risk Zone*: incorporates the seismic classification of the object's location;
6. *Current Conservation State*: provides a current assessment of the artwork's physical condition, visible deterioration, structural instability and environmental stress, reflecting conservation status and intervention urgency.
The proposed methodology, inspired by established approaches (Pedersoli et al., 2016, Michalski 2016), is designed to be transparent, repeatable and adaptable across different contexts. The first testing activity was on artworks restored between 2016 and 2022, systematically monitored through direct inspections and environmental analyses between December 2023 and February 2024 (Improta et al. 2024).
The selection of artwork (9 assets) was based on diversified criteria, i.e. support/material (wooden panel, canvas, stone) and specific conservation challenges and requirements. During the on-site inspections, detailed analyses of the artworks' conservation states were conducted, with particular attention to the cumulative effects of past restorations and the absence of preventive conservation measures (Fig. 2).

Object	Restoration (Years)	Microclimatic Control	Routine Maintenance	Material Stability	Seismic Risk	Conservation State	Risk Score (3–35)
Processional Silver Cross	1	TC–RH–LI	no	1	B	1	6
Portrait of Pope Paul III without Camauro	1	no	yes	1	B	2	9
Meeting between St. Charles Borromeo and St. Philip Neri	1	no	yes	2	B	2	10
Earthly Trinity	1	no	no	2	B	2	11
Monumental Chandelier	1	no	no	2	B	2	11
Façade of Palazzo Orsini di Gravina	1	no	yes	3	B	5	14
Portrait of Bernardo de' Rossi	1	no	yes	4	B	4	14
Paving and perimeter benches	1	no	no	5	D	5	15
Christ the Redeemer	1	no	no	7	B	7	21

↓ + ↓ + ↓ + x + ↓ + x = R

1 (recent_10 years) / 10 (non recent_100 years)
Sì = 0 / No = 1-3
Sì = 0 / No = 1
A = +3 / B = +2 / C = +1 / D = 0

Figure 2. CMR risk scores for the analysed case studies (9 artworks, 2 operators). The results show a wide variability: low-risk situations (e.g., *Processional Silver Cross*, score = 6); critical cases (e.g., *Christ the Redeemer*, score = 21); intermediate conditions (e.g., *Portrait of Bernardo de' Rossi* = 14; *Paving, benches and Fontana della Vittoria* = 15).

The variety of execution techniques provided a detailed overview of the methodologies and associated conservation challenges, further underscoring the importance of ongoing monitoring and targeted interventions to mitigate degradation and ensure the long-term preservation of cultural assets.
The analysis contributed to defining a preventive conservation protocol (*e.g.* periodic inspections of conservation states, environmental monitoring, implementation of protective measures against external threats) grounded in empirical evidence and practical experience to minimize the identified risks and preserve the artworks' integrity over time.
The analysis revealed marked differences in conservation risk between movable artworks in climate-controlled museum environments and those exposed to outdoor or unstable conditions, also depending on material nature (organic vs. inorganic) and the presence of execution flaws affecting long-term stability. The results confirm the algorithm's ability to support consistent and transparent conservation risk diagnosis.

4.2 Algorithmic scoring logic and reference criteria

The CMR risk score is calculated through a simple aggregation of the values assigned to the individual indicators, compiled by specialized professionals (restorers, conservators, curators).
No weighting coefficients are applied: the overall risk value derives directly from the sum of the individual parameter contributions. The overall index is computed as:

$$R = \sum_{i=1}^{6} P_i$$

where $R \in [3,37]$
P_i = scores assigned by the expert

This choice ensures transparency, readability and ease of updating overtime, particularly in relation to periodic monitoring activities. Although the calculation structure is homogeneous, not all indicators follow the same scoring logic.
In particular, the seismic indicator is based on the reference seismic class. The definition of score classes and risk levels (articulated into A-B-C classes or low-medium-high intervals) was inspired by consolidated risk assessment practices in the field of conservation and hazard analysis, including seismic risk classification systems and comparative risk models used in preventive conservation. These references provide an operator-oriented framework supporting intervention planning.
The algorithm therefore combines experience-based indicators with context-related ones, preserving model coherence while making risk components explicit. The resulting score is not an absolute measure but a comparative and repeatable tool supporting preventive conservation, planned maintenance and long-term monitoring decisions.

4.3 XLS/VPL integration: an Operational Framework for 3D-Supported Conservation Assessment

Within existing frameworks (see section 2.2), XLS/VPL CMR is proposed as an object-scale, semantically driven method that integrates six parameters into a single, interpretable quantitative index for comparison, monitoring and maintenance planning, supported by 3D modelling and point clouds as backbone for the complete annotation and visualisation workflow.
The geometric reconstruction is intentionally simplified, since visualisation and annotation of conservation scoring does not require high geometric fidelity, but stable spatial partitioning and persistent object identities. Although BIM represents the natural target for structured information management, in this work, a simplified point cloud and BRep representation is proposed as an intermediate and lightweight geometric structuring layer between unstructured point clouds and fully semantic information models.
The proposed workflow is based on a multi-level geometric representation strategy, in which different spatial models play complementary roles. The point cloud represents the metric and documentary reference, while its geometric segmentation provides a first spatial structuring into meaningful regions. From this segmented data, a simplified BRep model is derived to introduce stable, object-like spatial entities, suitable for information annotation over time. When required, this structured representation can be further integrated or translated into richer semantic an HBIM environment. The XLS CMR scoring system is conceptually independent from the geometric representation but are spatially anchored to it: risk values can be associated to segmented point clusters, BReps or HBIM objects, depending on the required level of modelling detail and operational needs.

5. Methodological Workflow

The algorithm is designed and structured as a XLS datasheet ready for use/fillable on-site (first step), uploaded to a dedicated database, shared through a web-based platform (intermediate step) and integrable into VPL (second step), aimed at mapping the conservation status/risk level of assets.

The parametric system manages the output (both value and colour) by combining data through visual survey and information manually recorded by the operator. The colour component works as a visual/geometric alert system, indicating the degree of damage and the associated level of risk and making the conservation status and risk level immediately visible on 3D model, allowing for quick and intuitive interpretation (red=high state/risk; green=optimal state).
The aim of this research activity is to test the effectiveness of a rapid tool for the recording, combination and visualisation of heterogeneous descriptive data.
The algorithm is tested through the interoperability of the following software: Rhino, McNeel (CAD), Grasshopper (VPL Rhino plug-in) and GhPython (Gh component), Edificius and usBIMplatform (BIM software), ACCA software.
The proposed system is framed within a methodological framework already oriented toward the interoperability of VPL approaches independent of the reference information environment.
The operational architecture integrates different levels of automation, balancing the indispensable role of human expertise with advanced computational procedures. The pipeline is composed of the following steps:

- digitalization of assets;
- compilation of the XLS CMR and uploading of point clouds/models to the VPL environment and/or to the platform;
- semi-automatic risk-score computation using the XLS CMR assessment form/algorithm for selected elements;
- manual or semi-automatic geometric/semantic classification of point clouds (VPL-RANSAC);
- semi-automatic CAD or E-HBIM of the container/content (museum hall, historical palace room, church, archaeological evidence, artefact);
- automatic VPL uploading and assignment of XLS/CSV datasheets to related models of assessed elements or parts (synchronized update) via XLS/CSV reader (Python script), based on index-based list correspondence between classified elements and their associated CMR records;
- display of the chromatic gradient and annotation of the numerical results corresponding to the total or partial output score on the point clouds or 3D models.

The periodic update of the XLS datasheet, synchronized and updatable in the VPL algorithm, enables monitoring of variations in the conservation state with respect to the reference container of the artworks.
In summary, the initial critical assessment and the compilation of the analysis sheet are manually carried out by specialists (e.g. restorers, conservators, curators). This provides the basis for semi-automated processes of risk score computation and semantic classification supported by VPL algorithms.
The semi-automatic linking of descriptive data to objects and the colour-coded visualisation of risk levels enable an immediate and shareable reading of the results.
The structure and functioning of the GhPython (RANSAC-based) algorithm for geometric classification and segmentation of the virtual models are described in Section 7.

6. Case Studies

Following a multiscale approach, the artefacts were selected using diversified criteria (e.g., material/support type, previous conservation issues and specific display requirements) to test the algorithm under different levels of geometric, semantic and operational complexity and to compare different degrees of automation. The comparison highlights the adaptability of the system. However, final classification and annotation still require expert validation.

All classified elements are enriched in a VPL environment by linking the XLS CMR compiled by the conservator. The case studies thus provide a test to analyze the balance between process automation and human control and to verify that the scoring algorithm can operate on heterogeneous entities within an information modelling process.

6.1 Case Study 1: movable and immovable artworks

A significant opportunity to collect data and test preventive conservation measures arose during the exhibition *Naples in Paris. The Louvre invites the Capodimonte Museum* (June 7, 2023 – January 8, 2024), (Improta et al. 2024).
Among the restored works, an exemplary case is the Portrait of Bernardo de' Rossi (54.7 × 41.3 cm) by Lorenzo Lotto (1505), displayed in Room II of the Farnese Gallery at the Museo di Capodimonte. This case study was used to test the interoperability VPL/CAD/HBIM (Fig. 3).

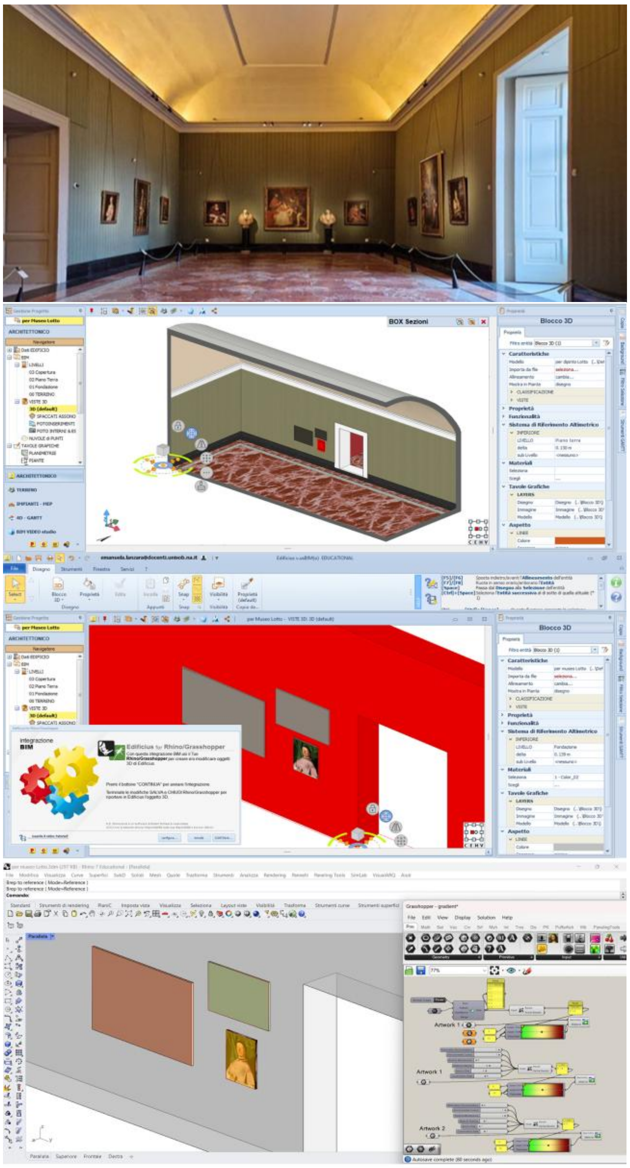

Figure 3. Lorenzo Lotto painting: on the top, the Room II of the Farnese Gallery at the Museo di Capodimonte; on the bottom, E-HBIM/CAD-VPL interoperability for importing reality-based models of movable artworks and virtual container into the digital scoring environment.

The restoration was supported by a detailed diagnostic campaign. Following its return from Paris in January 2024, the painting was reinstated in its permanent location.
The post-exhibition inspection revealed no significant changes in the conservation condition compared to the previous year and allowed for application of CMR to evaluate the effectiveness of the preventive measures undertaken.
The algorithm assigned the painting and its frame an overall risk score of 14 (medium risk/state), reflecting an intermediate level of preventive conservation implementation (Fig. 4 and Fig. 5).
While some preventive measures are already in place, the result highlights the need for further interventions, i.e. improved environmental control, to ensure long-term protection of the artwork. The algorithm was also applied to the other artefacts of the examined collection (see section 4), a sculpture, an urban object and a decorative /apparatus (Fig. 6).

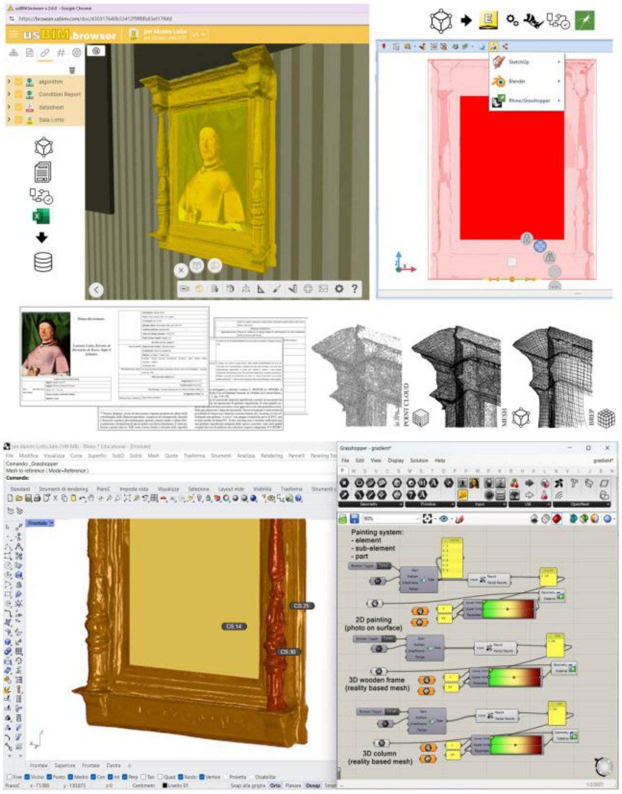

Figure 4. Lorenzo Lotto painting: HBIM/CAD-VPL interoperability and CMR risk score/conservation condition mapping (frame = 25, high level; columns = 30, high level; canvas = 14, medium-law level).

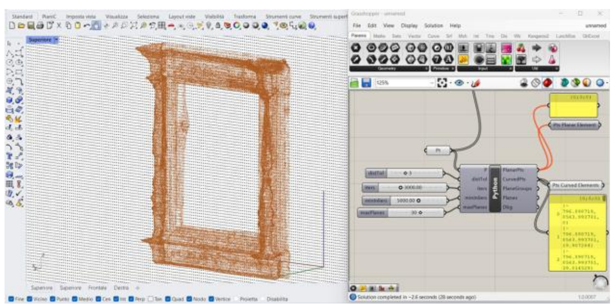

Figure 5. Movable artworks (Lorenzo Lotto painting): RANSAC-based geometric segmentation showing the selection of non-planar frame and related CMR score visualisation.

6.2 Case Study 2: architectural system

The crypt of the Church of San Francesco in Irsina (MT), preserves an exceptional cycle of 14th-century frescoes, expressing Gothic and Byzantine influences (Sileo et al. 2015; Improta et al. 2025). The paintings, executed between approximately 1370 and 1373, entirely cover the walls and the barrel vault of the crypt (Fig. 7 and Fig. 8). The crypt develops beneath the apse, in a space originally belonging to the basement level of the tower of a Norman castle. The commission of the painted cycle is attributed to Margherita Del Balzo and her daughter Antonia. Since its rediscovery, the pictorial cycle has undergone several restoration campaigns and was found to be in a mediocre state of conservation, affected by moisture infiltration and degradation phenomena and lack of monitoring systems. The diagnostic campaign employed non-invasive techniques to characterize the constituent materials and to define the operational strategies. The conservation of medieval decorative systems represents one of the most complex challenges in the field of restoration, requiring a balance between scientific investigation and historical-artistic sensitivity, where the restoration approach seeks solutions based on contextual interpretation, dialogue among the involved stakeholders and engagement with the local community.

7. Implementation and preliminary results

Testing of CMR (XLS/VPL) semi-automatic geometric segmentation (RANSAC approach) and risk/conservation score annotation (synchronised Python XLS/CSV reader) for classification/evaluation directly on point clouds or 3D models is in progress. This section describes the two main steps of CMR algorithm application in VPL environment: data list management for score annotation/classification of assets and geometric/typological segmentation and classification of point clouds/3D model to allow the scoring of 3D support, *i.e.* point clouds or 3D models and XLS CMR. In addition, the pipeline explores a possible solution for the semi-automatic BRep modelling from point clouds (the implementation is *in progress*). These two steps are designed to simplify digital conservation activity for restorers and conservators and to highlight adaptability and versatility of the proposed pipeline, which can be integrated with conformed segmentation algorithms and classification models (see section 2.1).
The implemented script enables the upload of XLS/CSV data stored in the web-based platform within the VPL environment. It extracts the element and score fields, converting the score values into numerical format and organising the data into two synchronised lists: one for combined visual inspection (element name and score) and one for numerical selection. This structure allows direct indexed access to the scores while maintaining a clear correspondence with their associated elements.
Through *List Management* tools the solution allows the simultaneous display of multiple risk scores for each geometric element; the procedure is in progress to enforce one-to-one correspondence based on element IDs.
Two distinct approaches for geometric segmentation and classification of point clouds/3D models (artefacts and architectural systems), were tested. The first approach consisted of manual point cloud segmentation or textured mesh, as in the case of the oil painting by Lorenzo Lotto and its complex wooden frame (Fig. 4). The second approach is aimed at testing semi-automatic point clouds segmentation, where each segment is classified to distinguish planar and complex elements as whole object and as specific parts in artwork compositions or in architectural systems. The proposed solution was tested on several case studies (Fig. 5 and Fig. 6).

Figure 6. Movable artworks: RANSAC-based geometric segmentation showing the selection of generic non-planar assets and related CMR risk scores; on the left: *Processional Silver Cross*, score = 6 (low level); on the right: *Fontana della Vittoria*, score = 15 (medium-low level). All scoring values assigned to the inspected artefacts are shown in Figure 2.

The solution implements an iterative RANSAC-based approach for segmentation and classification of point clouds. The main goal is to perform a geometric pre-segmentation of the dataset by separating planar regions from non-planar areas (curved or irregular), which is particularly relevant for the discrimination between planar elements and curved or complex shapes in architectural (e.g. walls vs vaults) and artworks (e.g. panel vs frames) point clouds (Fig. 7).

In accordance with the overall risk-scoring classification, the assets (artwork or architecture) can be considered as whole objects without distinguishing superimposed decorations or complementary parts. In this case, it is directly possible to manually load the compiled XLS/CSV CMR into the VPL algorithm and associate it with the related point clouds or 3D elements to visualize related chromatic results (Figg. 4-6).

The CMR XLS file/algorithm, manually filled by conservator and restorer and uploaded/stored in a dedicated database, is then imported into the VPL environment via *File path* in the XLS/CSV reader (Python script), then the score values are fed into a *Color Gradient* settable with a numerical range (red=high state/risk; green=optimal state) and linked to the *Custom Preview* component. In addition, the approach proposes a solution in progress aimed at the semi-automatic construction of BRep models from the point cloud segments.

Focusing on planar surface extraction, the script takes as input a point cloud P extracted from an ideal model and imported in the algorithm as a Point Group and a set of control parameters, including a distance tolerance (*distTol*) for point-to-plane classification, number of iterations (*iters*), minimum number of inliers required to accept a plane hypothesis (*minInliers*) and maximum number of extractable planes (*maxPlanes*). At each iteration, plane hypotheses are generated from minimal samples of three points, evaluated by counting inliers within the given tolerance and subsequently refined through a least-squares plane fitting. As output, the algorithm generates a set of estimated planes and corresponding groups of inlier points, together with a global classification of the original point cloud into planar and non-planar sections (Fig. 8). A more extensive quantitative assessment of segmentation accuracy and semi-automatic BRep modelling on point cloud datasets is planned as future work.

In conclusion, the proposed solution provides an algorithmic Scan-to-Scoring framework for the formalisation and conservation assessment and decision making.

XLS CMR and VPL support are combined in an XLS/VPL toolkit specifically designed to independently interoperate with heterogeneous systems; therefore, the proposed solution can be also tested with other algorithms and models for the segmentation and classification of point clouds and models.

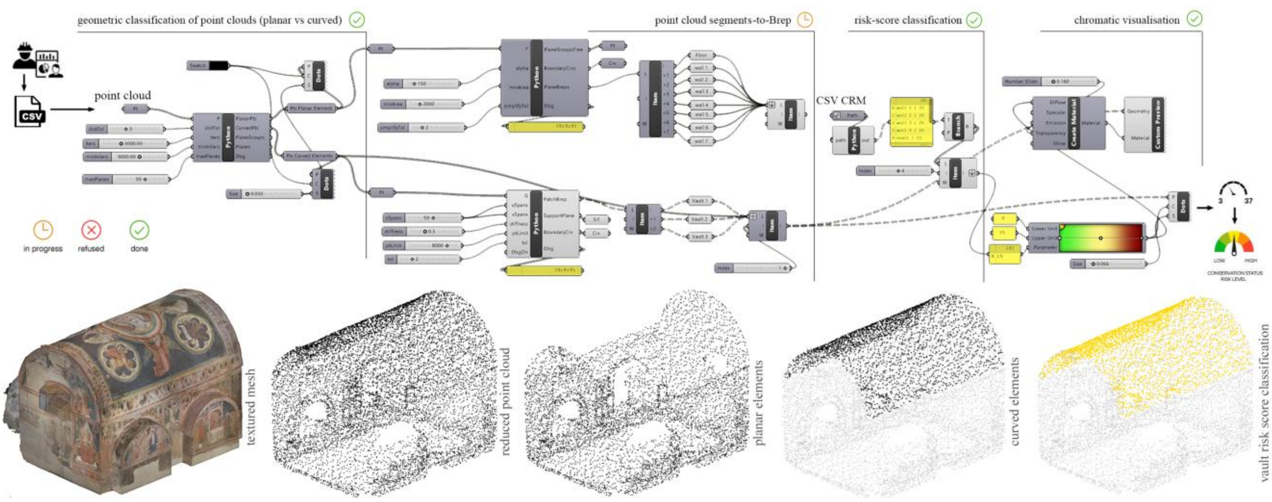

Figure 7. The frescoed crypt in Irsina: RANSAC-based geometric segmentation of the point cloud showing the separation between planar (walls) and non-planar (vault) elements and chromatic visualisation of the vault score = 15 (medium-low level).

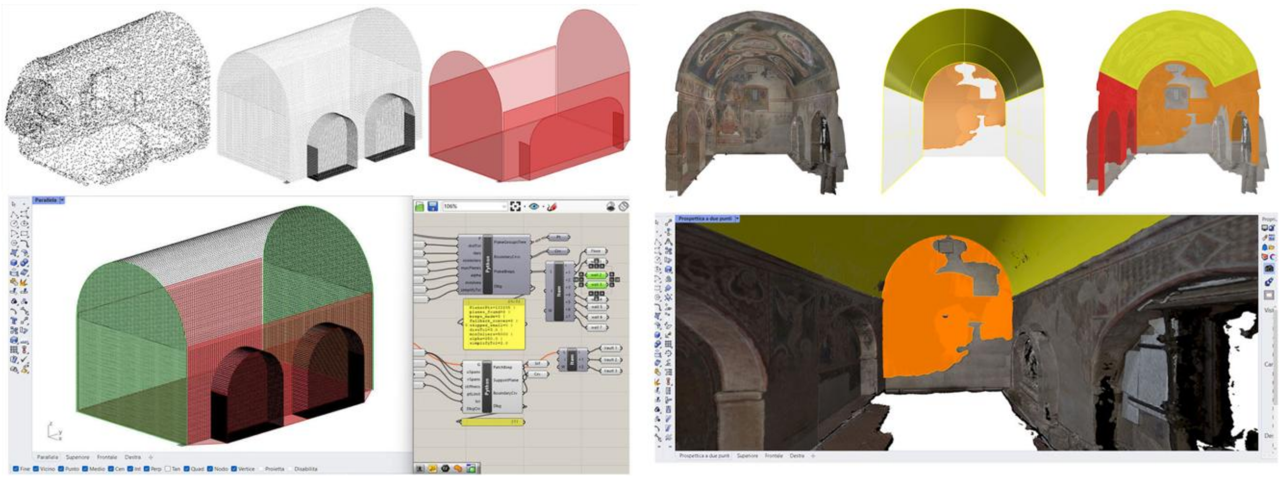

Figure 8. The frescoed crypt in Irsina. On the left: testing of the algorithm for the semi-automatic extraction of planar BRep model from an ideal point cloud; on the right: manual colour-coded mapping of CMR risk scores on BRep aligned with the point cloud. Frescoed walls score = 33 (red/high level), 26 (orange/medium level); vault score = 15 (yellow/medium-low level). Frescoed areas were approximated as planar patches for geometric score mapping of frescoes.

8. Conclusion

This paper presented a decision-oriented framework for integrating conservation assessment within reality-based digital environments. Rather than focusing on the generation of increasingly detailed geometric or semantic models, the proposed approach addresses the complementary and still underexplored problem of formalizing conservation evaluation and maintenance planning into a reproducible and computable process. The main result of the work is the definition of an algorithmic scoring model based on the Conservation Maintenance Record, capable of transforming expert-based qualitative judgments into a synthetic, comparable and spatially explicit indicator. The experiments show that this scoring system can be consistently anchored to different geometric supports, including point clouds, simplified BRep models and HBIM objects, thus confirming the geometry-independent nature of the proposed decision layer. The proposed framework shifts the role of 3D digital models from passive containers of information to active tools for prioritization, planning and diachronic monitoring of conservation actions. In this perspective, different geometric representations are not competing alternatives, but complementary components of a progressive information structuring process supporting a stable and persistent decision model. Future developments will focus on extending the scoring model to additional parameters, improving the automation of data acquisition and testing the approach on larger and more heterogeneous case studies. Nevertheless, the presented results already demonstrate how a lightweight and operational integration of scoring/decision models within Scan-to-nD workflows can significantly enhance the practical impact of digital technologies in preventive conservation and maintenance planning.

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