The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLVIII-M-9-2025
30th CIPA Symposium “Heritage Conservation from Bits:
From Digital Documentation to Data-driven Heritage Conservation”, 25–29 August 2025, Seoul, Republic of Korea

Tracking the Material History Through the Analysis of Past and Present Alterations and Restorations. Application to Doors and Walls of the Museum Najerillense (La Rioja, Spain)

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Keywords: Conservation-restoration, Alteration Monitoring, Historical Graffiti, Weathering of Surfaces.

Abstract

Elements of cultural heritage are living entities with a history that is sometimes marked on its surface by means of different types of alterations (stains, wearing, graffiti, erosion, etc.). The discipline of conservation-restoration aims to preserve the materiality of these elements and presents them to users in a suitable manner; but it is also aware of the historic interest of some of these alterations and, consequently they cannot be just erased without being documented and explained. This is precisely the starting point of the present contribution, where the comparison of decay patterns in different elements of a building —the regional museum of archaeology and ethnography of Najera (La Rioja, Spain)— is explored as a complementary methodology to analyse the material history of the building. As many of these alterations have influence in the three-dimensional geometry of the surfaces and the texture, they can be monitored by means of the products that are generated during the geometric documentation works. The text presents a methodology for the study structured in four stages and draws some conclusions about the potential of this approach.

1. Introduction

In line with all fields related with cultural heritage studies, the discipline of conservation-restoration is experiencing significant changes both regarding the practice and the own consideration of its role in the protection, use and enjoyment of cultural heritage.

Several decades ago, within the framework of historicist aesthetics —where the primary objective concerning monuments was to restore their purportedly pristine appearance— restoration efforts were often designed to remain inconspicuous, focusing primarily on erasing the passage of time. In contrast, contemporary approaches to heritage conservation recognise the various marks on heritage elements not only as evidence of deterioration processes but also as historical testimonies. Consequently, while it is essential to monitor the progression of alterations to ensure the accurate interpretation, utilisation, and preservation of these elements, such marks cannot be simply removed without prior analysis. Actually, understanding the nature of these alterations and their temporal evolution is critical, both for the formulation of effective preventive conservation strategies and as a complementary source of historical knowledge (Lourenço, 2014). Likewise, under certain circumstances, alterations themselves may acquire a significant character, becoming an aesthetic and conceptual component inherent to the heritage asset. This recognition aligns with the notion of stratigraphic value, whereby accumulated material traces are understood as layered records of successive uses and meanings, akin to archaeological strata. Within this framework of re-evaluating the material and historical value of deterioration, the integration of digital restoration techniques and the growing use of artificial intelligence (AI) have introduced new professional profiles into the field of conservation, giving rise to divergent —and even conflicting— approaches regarding intervention criteria and the role of technology in cultural heritage management (Kachkine, 2025).

The idea of this contribution originated from a project initially focused on documenting graffiti associated with the former use of the building that houses the Najerillense Historical and Archaeological Museum, i.e., a regional museum of archaeology and ethnography of Najera (La Rioja, Spain) as a prison during the 19th century (figure 1). These inscriptions, created by the inmates, place this case within the broader category of heritage that embodies marginalised narratives and the material memory of social control and confinement.

Figure 1. Three-dimensional recording (with a fringe-projection scanner) of the graffiti (and the surfaces where they are) on one of the doors of the museum.

Starting from the premise that the conservation state (i.e., the degree of weathering) of engravings exhibits variation, even among comparable elements, due to differing subsequent conditions and vicissitudes, the present study seeks to reframe the inquiry; hence it aims to determine whether the systematic analysis of disparities in alteration patterns can yield valuable insights into the differential historical evolution of individual components of the building.

The approach is in line with the concepts of “biography of things” / “biography of places” (Sørensen & Viejo-Rose, 2015), which can be also sensed in several works on alterations affecting cultural heritage, for example regarding the effect of the weather and climate changes, where the specificities of the cumulative impacts for heritage assets exposed to outside conditions, the —usually slow rate— evolution of the elements placed inside the buildings or the effects due to sudden events have been described (Sesana et al., 2021).

As many of the alterations have influence on the 3D shape and the appearance of the surfaces, geometric documentation techniques and products can provide information about them and, consequently, be part of the methodology to study the history through the analysis and monitoring of the decay patterns that are visible, both due to processes that are still active nowadays and the evidence of causes that no longer exist.

2. Objective

In this text, the attention is set on analysing, in the contexts of a case study, how the specific history of the components of a heritage element (different walls, doors, vaults, etc.) can be tracked with the help of the decay patterns that are visible nowadays and the information about the restorations carried out over time. With this goal in mind, a methodology for the study structured in four stages is proposed. Likewise, some conclusions about the potential of this approach will be drawn.

3. Materials and methods

3.1 Description of the building

The building that houses the regional museum dates back to the end of the eighteenth century and was originally intended to serve as the residence of the abbot of the nearby monastery of Santa María la Real and the pharmacy. That is why it was devised with gardens for cultivation of medicinal plants. During the disentailment period in the nineteenth century —when many religious properties were seized by the state— the rooms were repurposed as a regional prison and the gardens were converted into recreation courtyards. This use continued until 1979. After a period of closure, renovation works adapted the space, and the building reopened as a museum in 2001.

Moreover, the appearance of the block and its surrounding buildings was significantly altered with the demolition of some parts and the erection of new buildings. Of the two original gardens that became the prison courtyards, one of them is now an open square, while the second one was reduced to a small rear alley (figure 2).

Figure 2. Photograph showing the museum (on the right, with a white façade) near the monastery of Santa María la Real. No remains of the former courtyard are currently visible.

From the previous uses, the building conserves some remains of wall paintings related to the old pharmacy and a very expressive collection of graffiti produced by the prison inmates on three doors and the wall of the courtyard (now, a rear alley). In most cases, prisoners etched names, ages, dates of detention, professions, and places of birth, but there are also some interesting drawings. Today, these historical elements coexist with the archaeological and ethnographic collections on display in glass cabinets. Together, they provide an immersive experience for visitors, which has been widely appreciated and positively received. Beyond their visual and interpretative appeal, these inscriptions constitute a valuable layer of intangible heritage, offering direct testimony about the social and historical significance of the site.

3.2 Geometric documentation works

The initial intention was to use a short-range 3D scanner — EinScan PRO HD— for the geometric documentation of the graffiti. As can be seen in the picture (figure 1), the scanner is freely handled at around fifty centimetres from the surface and scans an area of around 20 x 20 cm, by moving the device the surface is progressively swept. The software joins all individual scans to complete the three-dimensional model of the object.

This scanner has two possible configuration modes: the “rapid” one —with a nominal accuracy of around 0.7 mm— is suitable for objects up to 2 meters large. This method was tested firstly, because we wanted to check whether it was versatile and precise enough to record, on one go, the entire door and clearly show the graffiti in the resulting 3D model. Unfortunately, that was not the case. On the one hand, the doors proved to be larger than the recommended objects to scan and that fact produced errors in the 3D models of the elements. In addition, the resolution of the models was insufficient to correctly visualize the engravings.

Consequently, we changed to the “precise” method of data capture, which reaches up to a geometric accuracy of 0.3 mm. With this level of detail, both the graffiti and the roughness of the surfaces are better defined. In turn, the area that is documented in each model needs to be smaller, and that is why the different doors were divided in sections.

The three-dimensional models are the initial results. However, further processed outcomes, such as enhanced relief shading images were generated (figure 3).

Figure 3. Synthetic shaded relief of a section of around 40 x 40 cm of one of the doors with engravings. Some alterations on the wood, such as cracks, holes, missing parts and wearing are also visible.

However, the problem of not having complete representation of the elements remained. For that reason, they were documented by means of convergent photogrammetry (figure 4). Indeed, collections of multiple views for each door were obtained and processed. Besides, some control distances were measured with a tape (for the doors) and total station (in the courtyard) so as to give scale to the models.

Three-dimensional models are interesting for visualization. Moreover, they can be also useful for generating new products such as the orthophotomaps, which were used, for example, as the base of the maps of alterations that were generated subsequently. These outputs enabled the identification and comparison of deterioration trends over time, supporting a diachronic analysis of material decay.

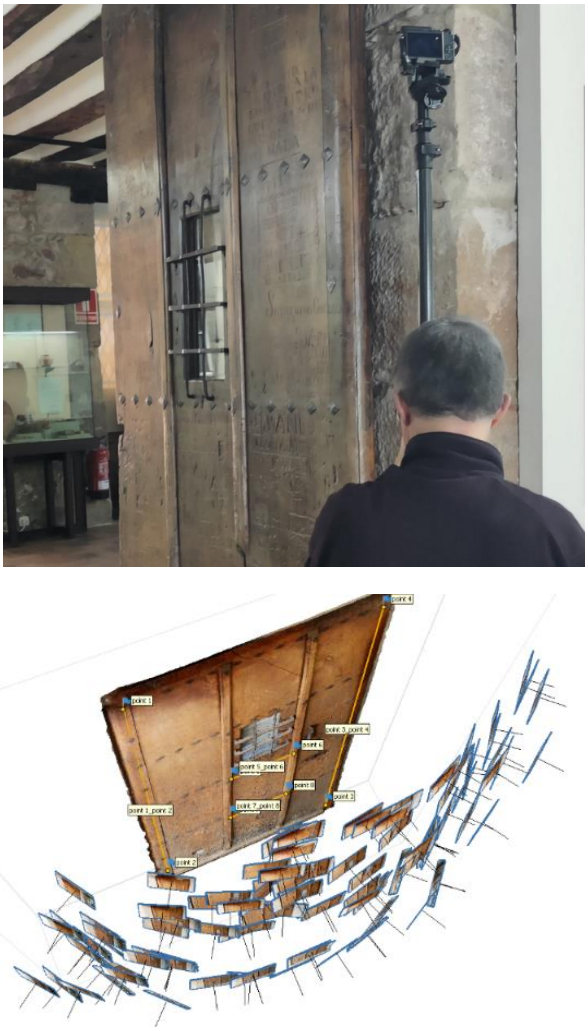

Figure 4. Photographic record and resulting three-dimensional model of one of the doors.

A complementary product was a collection of High Dynamic Range (HDR) images (figure 5). These images were generated for the entire doors and for detailed areas. A fifty-megapixel sensor and series of shots of the same area under different exposure parameters were used.

Figure 5. Generation of High Dynamic Range (HDR) images.

All these results were presented to the Instituto de Estudios Riojanos (IER) (i.e., the funding organization of this study) and to the museum Najerillense. In addition, there is a copy of the final report and to the collection of HDR images freely available in the university repository (Ceniceros et al., 2024). The project also considered the study of the chemical characterization of the stone of the backyard with the aim of trying to identify features that can be related to decay patterns, so the composition may be used to monitor and predict the evolution of the surfaces.

3.3 Proposed workflow

The proposed workflow seeks to bridge material analysis and historical interpretation, offering a structured path for treating surface alterations as chronological markers. The methodology for the use of the alterations on cultural heritage items as historical sources will be outlined and implemented in some elements of the museum, with special attention to two large elm doors (around 3 meters high) that originally had a similar function as doors of the two prison courtyards (and, hence, were covered by similar sets of graffiti), which present nowadays quite different aspects owing to the fact that, while one of them was moved to the inside of the building (thus, protected for external factors such as rainfall, direct sunlight…), the other one eventually got the use as the main entrance of the museum. Since information about the historical placement of these doors exists —and with the help of “earlier or later” relationships among the alterations— it will be possible to link the apparition of the different alterations to successive moments in time.

The workflow presented below is rooted in the framework for the integrated documentation for cultural heritage protection (Kioussi et al., 2013). More specifically, it consists of several stages:

1. Firstly, it is necessary to identify the different types of decay patterns on the surfaces. This was done by means of direct inspection (on-site). Given the coexistence of wooden and stone elements, classification criteria were adapted to ensure compatibility across material typologies, such as ICOMOS (ICOMOS & ISCS, 2008) or the MDCS Damage Atlas (https://mdcs.monumentenkennis.nl/ accessed on June 2025) for stone; as well as the Coremans project for wood (Ceballos, 2017).

2. These catalogues illustrate each alteration with textual definitions and pictures. However, in our case, we have three-dimensional models; hence, we will extend the characterization of the alterations on three-dimensional surfaces and derived products (such as synthetically illuminated orthoimages from elevation models).

3. Thirdly, we need to link each decay pattern with the agents that caused them (IIC-ITCC, 2018); to that end, we can resort to a conceptual model such as the one presented in (Korro *et al*., 2024).

4. Finally, the comparison of agents presenting influence on the elements studied will show the similarities and differences that can help to identify common and distinct parts of the material history over time.

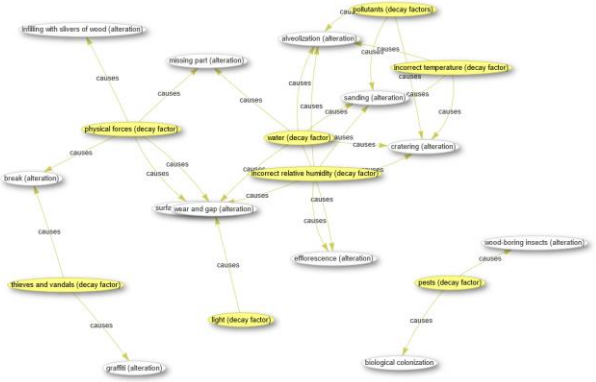

Figure 6. Cause and effect relationships among alterations (in white) and decay factors (in yellow) found in different elements (on wood and stone) of the museum Najerillense.

4. Results

The following results summarise the main patterns of deterioration observed on the two elm doors, based on the 3D models, orthophotos and on-site inspections carried out during the project. The boundaries of the alterations were drawn on a CAD system over the orthophotomaps. The next step will be to pass these geometric entities to a Geographic Information System (GIS) and analyse the overlays.

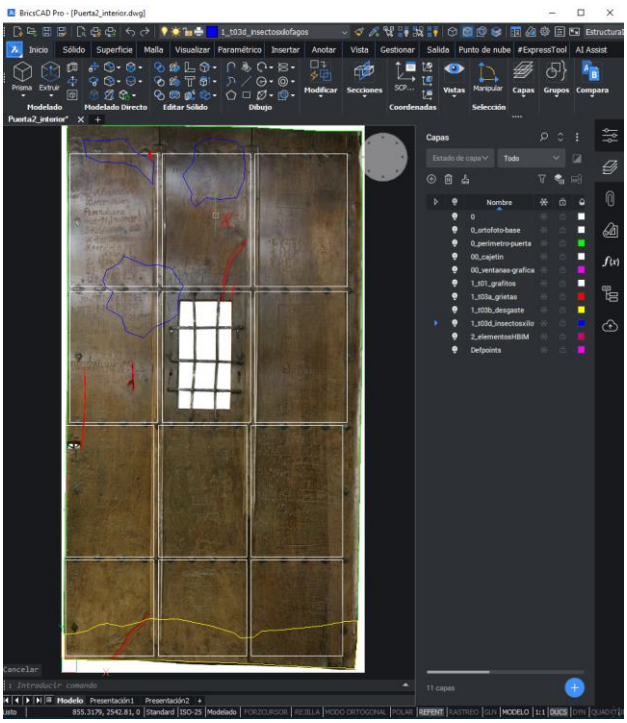

Figure 7. Map of decay patterns represented on the orthoimage of the inside door.

Most of the alterations appear everywhere all over the door, although with some degree of intensity that is variable for one area to another. This fact makes difficult (and, somehow, subjective) the delimitation of the perimeters for the mapping. To address this, the mapping was supported by repeatable criteria based on visual thresholds, complemented by expert judgement from conservators. Some elements —such as the

cracks— can be represented accurately, but many others might require clarifications:

- Graffiti are present all over the surface. Due to the initial classification of the engravings, the door was divided in twelve sections that are represented with white rectangles (figure 7). This subdivision facilitates spatial analysis and allows for cross-referencing engravings with material alterations in each area. The study of the graffiti is in progress, when the database is completed, our intention is to replace these rectangles by more precise identification of each individual text and drawing.

- The wearing at the bottom of the door is a continuous alteration that is more noticeable the further down we see. However, in this preliminary identification, this decay pattern is represented by a closed boundary without any indication about the intensity in each part. Moreover, the decision concerning where to draw the upper limit is also subjective, since there is not a clear moment when the wearing starts or stops to be present. Actually, this subjectivity in the definition of the boundary is one possible area where the analytical study of the surfaces (for instance, through the roughness) may improve the accuracy of the limits and allow better multitemporal comparisons.

- The exit holes of the wood-boring insects are gathered in bunches (blue perimeters in figure 7) but, again, the number of holes that have been considered to create a new bunch or the distance between bunches when it has to be decided whether they should be merged in one or not, were decisions taken by the expertise of the conservator. Again, the automatic identification of holes with the help of computer vision methods is a promising course to follow in order to alleviate the workload necessary to manual selection.

The elm doors were restored in 2017; the inside door does not present any significant active issues, but the main entrance door faces challenges from outdoor exposure, such as direct sunlight, rain, and other weather conditions, which cause wear on the varnish and surface.

The restoration of the doors in 2017 helps to identify which decay factors were present at that moment and which ones are still acting at present. Both by means of the comparison with the documentation of those interventions (for instance, with the photographs taken before and after the restoration) and by identifying the areas that are altered now (but that we know that were not then). Next table shows the types of alterations corresponding to these two doors.

Decay pattern	Outside door		Inside door	
	Restored	Active	Restored	Active
Cracks	X	-	X	-
Missing parts	X	-	X	-
Graffiti	X	-	X	-
Wood wearing	X	X	X	-
Varnish stripped off	X	X	X	-
Holes (insects)	X	?	X	?
Cat door	X	-	-	-

Table 1. Comparison of alterations present in the two elm doors.

As shown in the table, only the outside door presents active weather-related deterioration, while structural and historical alterations such as cracks, graffiti, and losses are common to both doors and appear to be stable. This contrast illustrates the role of environmental exposure in the ongoing transformation of the surface.

Several graffiti contain dates, all of them situated during the 19th century, that is the period when each door closed one of the prison courtyards. This is part of the common history of both elements. As they are also the large cracks and missing parts that are a consequence of the passage of time from the moment that they were not longer used as prison doors (because it is reasonable to believe that during its original use they will be maintained in good conditions).

The holes of xylophages are another shared feature that reflect a similar exposure to this pest in the past. So far, we do not know to which extend there are still insects attacking the wood or if significant differences exist between the evolution of the doors. Nevertheless, thanks to the detailed orthophotos created in the project, each individual exit hole can be mapped, hence, a comparison with a future inspection will be able to provide evidence of the spread of the infestation.

The cat door is a curious addition of the outside door during the 20th century that reflects the use of this element as a door that led onto the street during a time when the cats roamed freely from house-to-house hunting mice. In the restoration carried out in 2017 this hole was plugged.

The two main alteration that are active in the outside door —but they are not, apparently, in the inside one— are related with the climatic factors (since, fortunately, the outside door has been always respected by the inhabitants and has not suffered acts of vandalism). Most noticeable are the wearing of the wooden surface and the discoloration of the varnish, alterations that are more intense at the bottom of the door. Wearing implies material loss; hence, it can be monitored by means of comparisons of three-dimensional models generated in different times; as in this framework of this project a detailed 3D model was generated, it can be used as a reference for future control. Likewise, the products generated (3D models and orthophotos) show the photographic texture of the elements by the time of the recording; therefore, they can be also used for the control of colour changes over time. In future campaigns, this baseline documentation will serve as a reference for assessing the progression of decay and validating the effectiveness of conservation strategies through quantitative comparison.

5. Discussion

The interpretation of surface decay patterns not only contributes to diagnosis and preventive conservation but also opens avenues for historical reading. In this discussion, we assess the methodological implications and future applications of this approach. In our case, the study of the surfaces consisted of a visual inspection and identification of decay patterns. Manually mapping decay patterns on surfaces is often a time-consuming task, therefore, many proposals for automation based on image and scanning techniques, together with software packages have been proposed to speed up the process and increase the reliability (Adamopoulos & Rinaudo, 2021), taking also steps in the automatic detection of changes in multitemporal series of datasets (López-Armenta & Nespeca, 2024).

It must be said that there are some differences when mapping is aimed to represent decay patterns (i.e., to describe mechanisms and to identify the degradation causes) and when the objective is to identify conservation needs and to plan intervention actions (Delgado, 2015), in our case, we are more interested in the former situation.

Decay factors may be of active or not, both are interesting in a multitemporal study of the material history of the heritage elements, therefore it is useful to have methods to identify and analyse them. Some of these methods can be based on the geometry. Nevertheless, there is no single method of geometric documentation that is suitable in all cases. Depending on the nature and size of the alteration, the material and the conservation status of the surfaces, the location (e.g., lighting conditions, accessibility, etc.).

As future steps, it may be interesting to assess to which extent algorithms for analysing the shape of the surfaces in 3D or in the shaded images of the relief can be used to improve the detection and the monitoring of the decay patterns (Fiorini *et al*., 2024).

A positive aspect of the presented approach is that is could be easily implemented in other cases. In fact, information about alterations is being collected systematically in many cultural heritage elements, from simple or customized management tools to fully integrated three-dimensional systems that gathers the geometry, together with the analytical information, reports, annotations, etc. (Stefani et al., 2014). Likewise, resorting to digital twins generated through 3D modelling for the assessment of the conservation status and monitoring the evolution over time are increasingly common too (e.g., Rocca et al., 2023).

For the case of the doors of the museum, it can be mentioned that, in the near future, the building is going to be remodelled, the details of these works are still unknown but more room for the exhibition and facilities is expected. One question that still hangs in the air is whether the outside door will stay in its current placement, or if it would be better to bring it inside and show it side by side with its companion. If this latter happens, only the remains of the distinctive alterations appeared during the period that it served as main entrance would recall us that part of its lifetime. This scenario raises broader questions about the musealisation of use traces and the interpretive strategies that allow heritage elements to retain evidence of their lived past, even when relocated or reframed.

6. Conclusions

Conservation-restoration must be understood as a critical discipline not limited to the recovery the lost appearances or to just stop and reverse the evolution of decaying processes; a work to be done on the elements of heritage without leaving behind any trace of the own intervention. In fact, the knowledge about the object and the surrounding factors that acted on its materiality that is necessary to define and develop the conservation-restoration action must be considered as a source of information for historical studies and museography.

This study was grounded in the central hypothesis that surface alterations may function as documentary evidence of the historical uses and transformations of heritage elements. While the conceptual premise is not entirely novel, there has been a notable lack of systematic methodological frameworks to operationalise it —a gap this study aims to address. Fortunately, for many cultural heritage elements, the datasets and the information regarding decay patterns are already collected and available in databases, therefore it is ready to be used for historical purposes, which opens the possibility of their integration into historical and heritage research agendas that transcend traditional restoration boundaries

Acknowledgements

This paper is an additional outcome of the project “*3D documentation and outreach of the historical graffiti in doors and walls of the Archaeological and Historical Najerillense museum, in Najera*” funded by the Institute of Riojan Studies (IER) of the Government of La Rioja (Spain) in the “*Grants 2023 for studies on cultural topics in the Rioja region*” call.

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