Shearography and 3D scanning for assessing the strip lining in the case study: *Pericles observes Phidias's artwork on the Parthenon*, by Gaspare Landi

Chiara Saltarelli[1], Vito Pagliarulo[1], Maria Rosaria Vigorito[2], Melania Paturzo[1]

[1] *Institute of Applied Sciences and Intelligent Systems "E. Caianiello" of CNR, via Campi Flegrei 34, Pozzuoli (Na), Italy*
[2] *Department of Umanities, University Suor Orsola Benincasa, via Santa Caterina da Siena 32, Naples, Italy*

Abstract – **Nondestructive techniques for cultural heritage are a valuable tool for assessing restoration activities. This study examines the strip lining method, addressing frame tension issues by attaching canvas strips. The case study focuses on Gaspare Landi's paintings. Pericles *observes Phidias's artwork at the Parthenon*, currently stored in the Museo Real Bosco di Capodimonte. We examined the artwork before and after the strip lining procedure using two non-invasive methods: Structured-Light 3D Scanning and Shearography to report the tension problems. They both assessed the effectiveness of the intervention and collaborated to analyze the outcomes in some areas where uncertainties existed.**

I. INTRODUCTION

The restoration process is consistently supported by a diagnostic campaign, before the restoration and afterwards, to assess the outcomes of certain interventions [1].

In this study, we focus on the strip lining procedure that involves attaching canvas strips to the original one due to issues related to frame tension. This method occurs when the original canvas experiences a loss of tension in the original frame, necessitating the replacement of a new frame. Therefore, it is sufficient to apply strips around the edges of the original canvas, using strips with a fabric texture that closely resembles the original, to extend the canvas and attach the new frame [2].

This study explores the integration of Shearography (SH) and Structured-Light 3D (SL3D) Scanner, both non-invasive imaging techniques, to analyze canvas tension issues in the painting named *Pericles observes Phidias's artwork on the Parthenon* by Gaspare Landi.

SH is an interferometric technique used for structural evaluation and has been applied in art conservation to detect cracks, inhomogeneity, nails, and detachments [3]. In canvas artwork, shearography provides insights on not only color cracks or cuts but also tension issues between the canvas and the frame, as will be seen in this instance.

SL3D Scanning collects shape and color data to create digital 3D models, providing valuable information on the painting's surface and geometrical characteristics [4]. In this case, the goal was to achieve a more accurate representation of the shapes in the 3D model to support the shearography images revealing tension loss in the painting.

II. MATERIALS AND METHODS

A. The painting

The case study titled *Pericles observes Phidias's artwork on the Parthenon* (1811-1813) by Gaspare Landi was originally created for the Zodiac Room at Quirinale in Rome, referencing Napoleon's support of the arts and culture. The painting is an oil on canvas (390 x 250 cm) and illustrates Aspasia at the centre, the long-time lover of Pericles, who had influenced many philosophers and artists to come. She appears to act as intermediary, conveying to Pericles the words of Phidias, who is presenting one of his reliefs of the Parthenon [5].

Gaspare Landi is an Italian painter, studied in Emilia Romagna until he obtained funding to pursue studies in Rome, where he focused on portraits and paintings with mythological themes [6]. He had strong connections with many erudite, which provided him with numerous job opportunities and began to advance his career. He was a classicist, selectively emulating the masters of the 16th century, such as the illustration of the expression in Leonardo and Raffaello art pieces and the chiaroscuro from Correggio and the Venetian artists [7].

Nowadays, the painting is not included in the permanent

collection of Museo Real Bosco di Capodimonte, but it belongs to the stores where it is preserved (Fig.1).

Fig. 1. The artwork in the restoration lab, at the Museo Real Bosco di Capodimonte.

However, the painting exhibited last May for a showroom at the Musei Capitolini in Rome. This event highlighted the possibility of an occasional restoration for an artwork typically kept in storage. The painting was restored prior to its arrival in Rome, which consisted in consolidation and cleaning processes, then it returned to Naples where a strip lining process, and a frame replacement took place. A 30 cm thick canvas strip was cut, with 10 cm adhered to the original canvas for adhesion and 20 cm extending for anchoring. Beva 371 thermoplastic synthetic adhesive was chosen for its excellent adhesive properties, including reversibility and flexibility. The adhesive was applied evenly using silicone spatulas, minimizing excess. After allowing 2 hours for drying, a Melinex sheet was inserted between the layers before ironing, which was performed at a maximum temperature of 70°C to protect the paint film. This process ensured a strong bond while maintaining the integrity of the artwork (Fig.2).

Fig. 2. Strip lining operation on the painting and

application of the adhesive.

B. SH technique

Shearography [8,9] utilizes full-field speckle interferometry to analyze displacement gradients via speckle patterns formed from light scattered by an object. This technique employs Michelson interferometry [10] and a coherent laser for illumination, allowing for the observation of static or dynamic displacement due to external factors. A computer system continuously tracks the original and altered surface positions, creating phase maps that detail out-of-plane displacement variation. Art evaluations require subtle stimulus that effectively induce motion; imperfections and dimensional changes affect storage artwork [11].

The experimental setup is based on the ISI-SYS SE5 system with a 5.1 MP CMOS camera and red laser diode array (class 1). Two halogen floodlights (2x1000W) obtain thermal loading. The thrill arises from thermal stimulation at a safe distance to prevent damage, yet sufficient to induce object movement.

Initial measurement involved veils over the painting's front (Recto) to protect colour during the lining process, so the measurements were taken on the back (Retro) of the artwork. During the subsequent campaign, following the strip lining procedure, the veiling was removed, allowing for registration on the recto. In both cases, the painting was segmented into 12 sections (Fig.3).
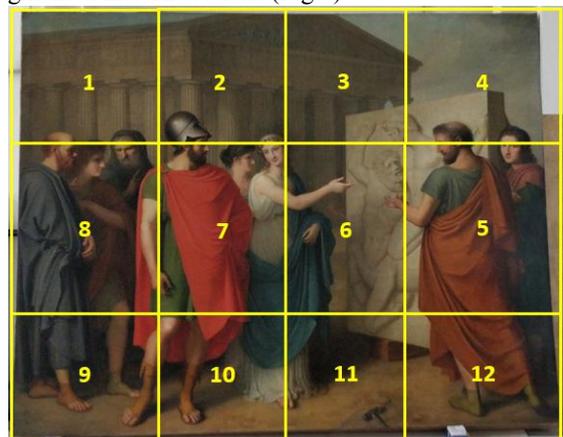

Fig. 3. Picture of the painting featuring a grid and numerical labelling of the examined areas.

C. SL3D scanning method

SL3D Scanner captures an object's 3D shape by projecting light patterns onto its surface and measuring the resulting deformations. The scanning software processes these distorted patterns into 3D coordinates reflecting the surface location. This results in a Point Cloud of coordinates representing the object's shape. Multiple scans

are necessary to accurately capture details like engravings and reliefs. A thorough analysis of the object's shape is conducted, alongside tests to develop a tailored scanning approach based on the specific artwork and available scanning space [12]. We utilized extendable rods and mobile scaffolding to register the entire surface of the Landi painting.

The Eva Artec 3D device is designed for scanning and creating 3D models of medium to large objects. The painting's size limited us to scan just the front section due to movement issues. The registration process was relatively simple and swift, providing ample information on geometry. The scanner utilized provides rapid caption speed (16 FPS), a 3D resolution of 0.2 mm, and high-quality texture (1.3 MP) [13]. In this instance, prioritizing accurate geometry over texture quality was essential, as numerous deformities from canvas tension can be observed in the 3D model, rather than the texture quality.

As stated, the veiling on the recto can be seen in the initial acquisition for the scanning process as well as for the shearography techniques but they do not affect the outcomes.

III. RESULTS

The results demonstrate a stunning effect on the before and after the strip lining procedure, especially the tension points on the angles. The results of the upper angles will be displayed first, including both the left and right (Fig.4).
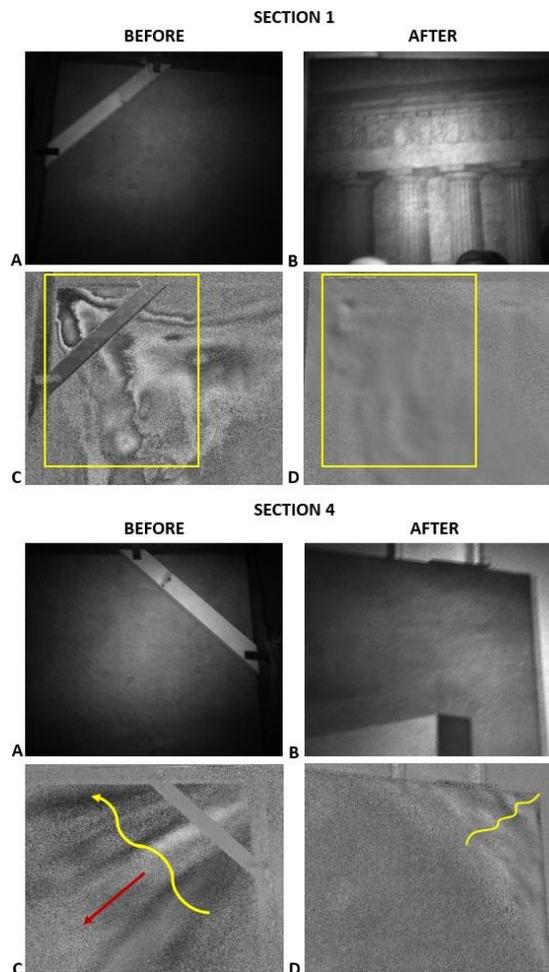

Fig. 4. This scheme displays the enhancements of section 1-4, the images A-B serve as references, whereas C-D represent the shearography images.

As shown in Fig.4, section 1 has nearly completely recovered, and the tension is uniform in most of this area. Certain deformities we observe are those of the canvas itself. In section 4, image C, there was a wave-like movement of the canvas indicating that it was quite loose at the frame, which is less evident in the subsequent image. Instead, the movement has shifted so it indicates that the primary tension has been resolved, yet in certain areas, different minor tensions have emerged. It will be fascinating to observe what impacts the canvas will face in the future.

The resolution of the primary tension loss is quite evident in the 3D model as well. As demonstrated in Fig.5, the 3D model of section 4 provides a clear indication of the improvements achieved through the restoration process of the strip lining method. Although, the change in tension at the corner cannot be observed because of mesh issues in the 3D model reconstruction process.
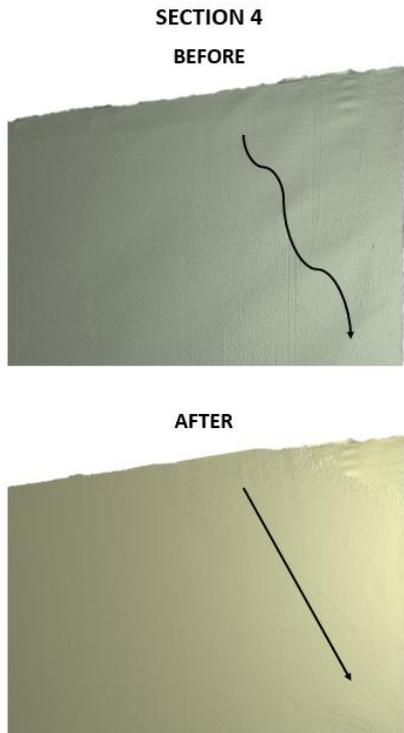
49

SECTION 4

BEFORE

AFTER

Fig. 5.The 3D models are captured beforehand and afterward to illustrate a comparison.

As stated, texture was not a focus therefore the 3D models are shown without texture. Generally, when utilizing 3D models in shearography for evaluating structural issues, we find that representations of the 3D models devoid of texture information extremely beneficial. Although the conditions of the canvas are somewhat discernible to the naked eye, this specific artwork makes it challenging to evaluate deformities because of the size. Indeed, it is easier to see the state of the canvas without texture that could disrupt the canvas.

Subsequently, the outcomes of the lower angles will be presented, covering both the left and right (Fig.6).
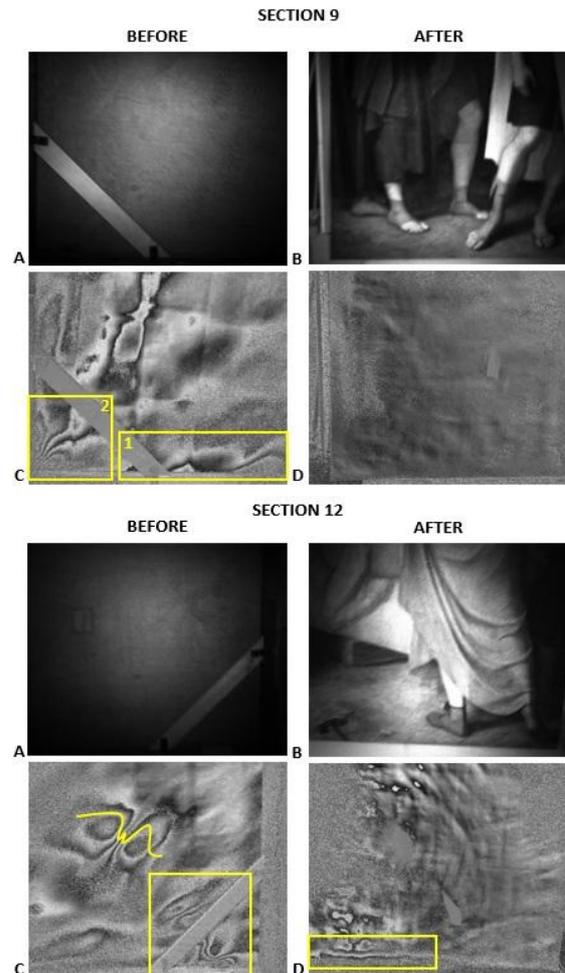

Fig. 6. Scheme of the enhancements in section 9-12, the images A-B serve as references, whereas C-D represent the shearography images.

In Fig.6, section 9, the shearography indicates that the strip lining has been effective. Similar to section 1, the tension loss in the corner and along the frame has been recovered, although there are some irregularities in the canvas itself. Alternatively, in section 12, there remain some anomalies even after the strip lining. Image C shows a point where there was a significant distortion while in image D a slight separation of the canvas from the frame is visible. Even though the situation has greatly improved, certain areas require further examination after a duration of time.

The 3D confirmed certain aspects of the shearography results, although the advantages of the operation are much clearer in the 3D models. As shown in Fig.7, the 3D models taken afterward are straight and with minor deformities. Except in section 12, where it is clear that the new condition has been altered: from a considerable bulge in the canvas to a somewhat sinuous trend.
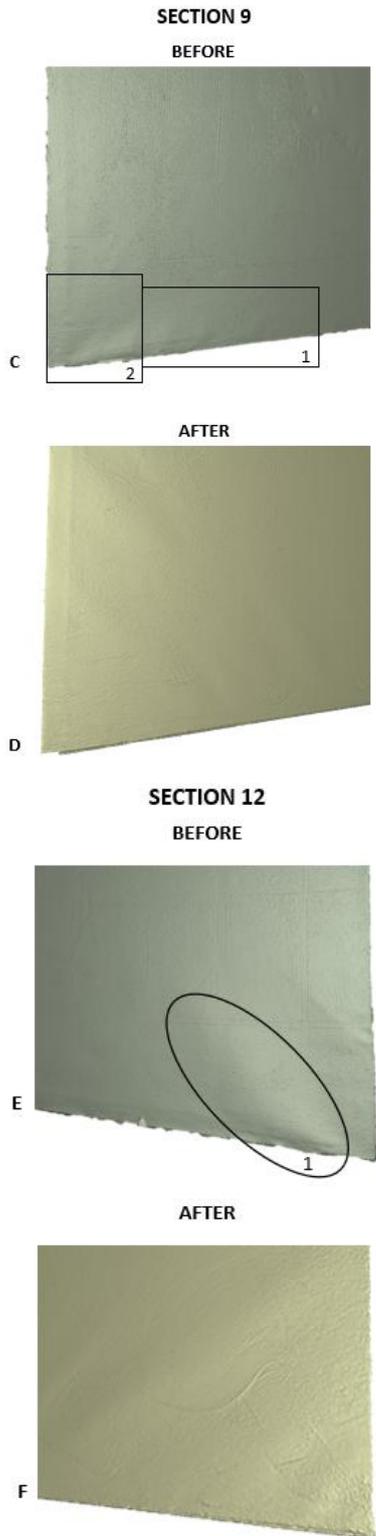
SECTION 9

BEFORE

AFTER

SECTION 12

BEFORE

AFTER

Fig. 7. This scheme displays the comparison beforehand and afterward of the 3D models of section 9-12.

IV. CONCLUSIONS

This article wants to provide a deeper examination of the lining methods in restoration procedures. Shearography and 3D Scanning have been quite useful for overseeing the process before and after.

We can assert not just that the strip lining was effective, but we can also offer the initial monitoring of the new canvas tension. In the future, if this artwork will be removed from storage and exanimated or monitored again, we can gain a better insight into its deterioration, particularly concerning the loss of tension.

REFERENCES

[1] M. Castillejo, editor. Lasers in the Conservation of Artworks. Leiden: CRC Press; 2008.

[2] La Foderatura. Metodologia e Tecnica. Nardini Editore. Available online: https://www.nardinieditore.it/prodotto/la-foderatura/ (accessed on 05/05/2025)

[3] D. Francis, R.P. Tatam and R.M. Groves. "Shearography technology and applications: a review" Meas. Sci. Technol. 21 102001 (2010) DOI 10.1088/0957-0233/21/10/10200.

[4] N. Jončić, J. Zachar, 3D Scanning, in 3D Digital Recording of Archaeological, Architectural and Artistic Heritage, 23-32 (2017).

[5] https://www.artearti.net/mostre/fidia-maestro-dei-maestri (accessed on 02/05/2025)

[6] G. Fiori, "Vicende biografiche ed artistiche di Gaspare Landi" in Bollettino storico piacentino LXXII, Piacenza 1977, p. 25-86.

[7] https://www.treccani.it/enciclopedia/gaspare-landi_(Dizionario-Biografico)/ (accessed on 02/05/2025).

[8] W. Steinchen, L. Yang, Digital shearography. Bellingham: SPIE Press; 2001.

[9] V. Pagliarulo et al. "Non-destructive evaluation of impact damage on carbon fiber laminates: Comparison between ESPI and Shearography" AIP Conf. Proc. 1740, 040002 (2016) https://doi.org/10.1063/1.4952661.

[10] C. Saltarelli, M. Rippa, V. Pagliarulo, T. Cacace, M. Paturzo "Multimodal Imaging for Wooden Panel Painting Analysis: Consegna della regola Francescana by Colantonio, a Case Study" Heritage 8 (4), 118 (2025).

[11] V. Tornari, A symmetry concept and significance of fringe patterns as a direct diagnostic tool in artwork.

Official Journal of the JHL 2689-9620 (2022).

[12] E. Maravelakis, A. Konstantaras, A. Kritsotaki, D. Angelakis, M. Xinogalos, Analysing User needs for a Unified 3D Metadata Recording and Exploitation of Cultural Heritage Monuments System, Advances in Visual Computing, Lecture Notes in Computer Science, Volume 8034, 2013:138-147.

[13] C. Saltarelli, M. Rippa, V. Pagliarulo, M.R. Vigorito, M. Paturzo "The Heritage Building Information Modelling System for non-destructive optical techniques: The case study of the restoration of a Marble sculpture on the façade of the Gesù Nuovo Church in Naples" Akta IMECO 2025, 42, 1–8.