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Mid-wave infrared imaging analysis of XVII century paintings on canvas of the Chigi Palace in Ariccia

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***Abstract* – In this work, mid-wave infrared (MWIR) imaging techniques are applied to the study of three XVII century paintings on canvas preserved at the Chigi Palace in Ariccia. In particular, an integrated approach based on the use of pulsed thermography (PT) and MWIR reflectography (MIRR) is proposed for the analysis of the "Primavera" by Filippo Lauri e Mario Nuzzi, the "Ritratto di Mario Nuzzi che dipinge un vaso di fiori" by Giovanni Maria Morandi and Mario Nuzzi and the "Ebbrezza di Noè" by Andrea Sacchi. It is shown how the combined use of these techniques enables to perform the depth-resolved characterization of the analysed paintings, revealing complementary information on both subsurface graphical features, such as *pentimenti*, and structural elements.**

I. INTRODUCTION

In the study of painted artefacts, precious information for scholars can be obtained by displaying features lying beneath the surface pictorial layers, such as underdrawings and *pentimenti*. Since this kind of information is often not accessible by the naked eye, non-destructive techniques for the inspection of the inner part of artworks are required [1]. For these purposes, optical methods based on the use of infrared (IR) radiation are nowadays considered effective tools for the analysis of subsurface features in Cultural Heritage (CH). Among these methods, infrared reflectography (IRR) is the most adopted technique, mainly employing the near infrared (NIR) range.

In particular, NIR reflectography (NIRR) provides information about the very first layers beneath the painted one [2], thus allowing one to detect underdrawings and subsurface elements by the use of several types of imaging devices [3]–[6]. All these approaches explore the same stratigraphic layer, recording IR images with an increasing level of detail and, consequentially, costs [7].

Nevertheless, most of the interesting underlying elements on an artefact with a stratigraphic structure are often beneath multiple layers of painting and materials. The use of the mid-wave infrared (MWIR) range (3-5 μm) in imaging analyses make it possible to increase the depth of non-destructive investigation and, consequentially, to reach integrative and complementary information with the respect to those achievable with the only NIR techniques, exploiting the increased penetrative power of the MWIR band within the artefact [8].

In recent years, imaging techniques operating in MWIR range have been employed on different kind of painted artefacts, such as wooden/canvas paintings [9] and illuminations [10] by using pulsed thermography (PT) and MWIR reflectography (MIRR), separately.

In particular, PT is based on the detection of the time-dependent distribution on the sample surface of the IR radiation emitted following the heating induced by the absorption of a short light pulse in the visible range (VIS). This technique proved to be able to characterize the main surface and subsurface elements of CH artefacts [11], [12], providing information on both the conservative state and subsurface graphical and pictorial features, such as underdrawings and *pentimenti* [13].

Similar items have been also investigated by using MIRR, which collects the images just after the illumination of the sample by MWIR radiation [13]. This to reduce stray effects on the reflectographic image caused by the MWIR radiation emitted because of the sample heating.

The innovative approach proposed in this work is the combined use of the two mid-wave infrared imaging techniques, usually employed separately, for obtaining stratigraphic and complementary information of the artwork by using the same device and same resolution.

Indeed, the choice of employing the same IR camera for recording both the thermograms and the reflectograms allows to gain images with the same framing and pixel-resolution, giving an immediate and accurate visualisation of the two type of information without the need of rescaling/rotating each image.

Furthermore, the correspondence pixel-by-pixel of the