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Original article

Integrated reflectography and thermography for wooden paintings diagnostics

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Abstract

The need of inspecting a masterpiece of fine art without affecting it led to develop non destructive methods of investigation. In the field of art conservation, several diagnostic techniques are being widely used to inspect works of art, giving different but complementary results. The present work deals with two of these methods, reflectography and thermography, both techniques examining objects in the infrared spectrum but in different wavelength bands. Their integrated data potentially provide a powerful tool for mapping hidden features and alterations of artworks. This was confirmed during the inspections of a 13th century panel painting under restoration at the *Opificio delle Pietre Dure* laboratories (Florence, Italy). A graphical user interface was also designed to aid operators in the field of conservation dealing with the results of the two IR methods. Many options such as image adjustment, comparison, overlaying and transparency variation, in addition to thermographic elaborations, have been made available to users. Imaging data integration provides a multi-layered and multi-spectral representation of the painting that yields a comprehensive diagnosis confirms the anomalies individuation and reduces the ambiguities of information coming from a single diagnostic method.

Keywords: Panel painting; NDT; Reflectography; Thermography; Integrated approach

1. Introduction

The present research work aims at the integration of two infrared methods for the non invasive inspection of wooden panel paintings: reflectography and thermography. Since these techniques may reveal different characteristics and/or features underlying the painting layer, an analysis and comparison of their results enables a more complete knowledge and diagnosis of the artworks. In order to confirm this, the reflectographic and thermographic inspections were carried out on an ancient wooden painting: the *Virgin with Child* (Fig. 1), a masterpiece of the *Santa Verdiana Museum* in Castelfiorentino (Florence, Italy) that was under restoration at the *Opificio delle Pietre Dure* laboratories (Florence, Italy). Despite the controversy about its attribution, the most assume it was painted by Cimabue in the second half of 13th century. Furthermore, a very young Giotto could be the author of the Child. The wooden support measures 68 cm × 47 cm × 2.7 cm and is made of two pieces of poplar, horizontally joint together. Many interventions altered the original features of the artwork. The paint layer was probably seriously damaged by aggressive cleanings. Several gaps, caused by the structure instability, owing to the microclimate changes, were filled with imitative reintegration. The most significant corresponds to the connection of the two panels. Many details of this critical state of conservation

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Fig. 1. *Virgin with Child,* Cimabue, 13th century, tempera on panel, Santa Verdiana Museum, Castelfiorentino (Florence, Italy).

came out from the integrated infrared inspections as shown below.

2. Experimental section

2.1. Methodologies

Infrared methods offer several advantages in the field of conservation of cultural heritage and are widely used, allowing to perform non invasive inspection of artworks. The whole infrared band can be divided, somewhat arbitrarily, into four subregions: near, middle, far and extreme infrared. For the aim of this work, only the near-infrared (NIR: 0.75–2.5 μm) and the far-infrared (FIR: 7–14 μm) regions are considered, dealing respectively with reflectography and thermography.

Thanks to its capability to go through the different layers of the painting, short infrared radiation can be used to reveal some features and alterations underlying the paint layer which are undetectable to the naked eyes. Moreover, this kind of analysis allows the non destructive identification of pigments having different spectral response in the NIR region [1].

The FIR waves acquired by an IR camera, instead, correspond to the thermal radiation emitted from the surface of the examined object due to its temperature, according to the black body radiation theory. As for wooden panel paintings, the observed temperature differences indicate the presence of heterogeneous materials, subsuperficial or structural defects, such as voids underneath the paint layer that can be located because of the insulating properties of the air they contain. Generally, fine artworks are inspected with active thermographic techniques which require an external stimulus to generate relevant differences of temperature that cannot exist otherwise. Thermography is a very powerful tool in non destructive evaluation in a wide range of applications [2,3].

2.2. Experimental apparatus

Two imaging devices, based on different sensor technology and currently in use in museum laboratories, were employed for the NIR examinations. They are a digital camera, the Sony DSC F828, and the INOA IR Scanner. As for the FIR inspections, the IR Camera ThermaCAM S65, produced by Flir System, was used to get the thermal map of the painting.

The Sony F828 is a compact cyber-shot, provided with a Carl Zeiss zoom lens and an array CCD colour filtered sensor, nominally sensitive in the range 350–1100 nm. In the night-shot modality, the IR blocking filter is removed so that the acquisition in the NIR spectrum is enabled. The visible radiation was excluded thanks to the high-pass Hoya R72 IR filter and a set of long-pass and band-pass filters by the Isuzu Optics Corp. The camera processes 14 bit images which are finally available in portable and in raw proprietary format. The acquired images have a resolution in terms of pixel size on the painting surface which depends on lens configuration, working distance and CCD array characteristics. The experimental set up for the reflectographic inspections of the *Virgin with Child* performed with the IR camera is shown in Fig. 2. As infrared source, two tungsten 600 W lamps were used.

The INOA IR scanner is a modular device based on an optical head and a lighting system which move together on a x-y precision translation stage. The optical head is provided with an achromatic doublet lens (73.5 mm focal length) working in 2f-2f configuration and at 1:1 magnification, and a single element InGaAs photodiode with spectral sensitivity up to 1700 nm range. A cut-off filter excludes the radiations under 900 nm. The lighting system consists of two low-voltage halogen lamps fixed on the opposite sides of the detector, illuminating the painting surface at 45°. The examined surface is scanned with a spatial resolution of 4 pixel/mm in both directions. According to the lens configuration, a sampled pixel on the painting surface has the same size of the detector active area. The signal is processed at 12 bit and final images are available in portable format and in raw data [4,5].

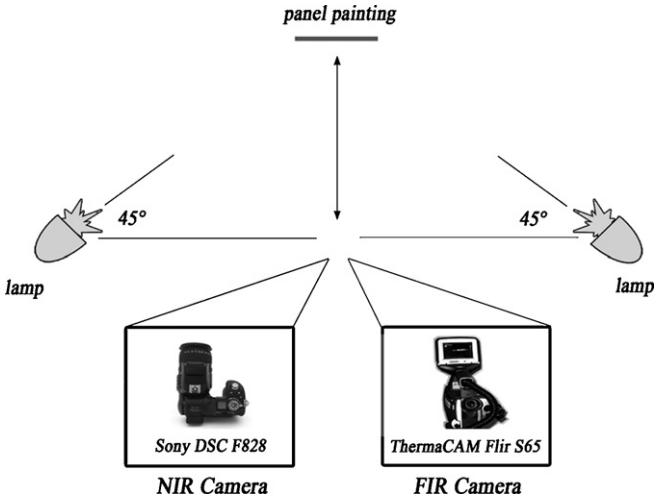

Fig. 2. Experimental set up for the NIR and FIR inspections.