THERMAL IMAGING FOR THE EXAMINATION AND CONSERVATION OF CONTEMPORARY MURAL PAINTINGS

Marta Melchiorre Di Crescenzo, Dip. di Scienze Ambientali, Informatica e Statistica; Università Ca' Foscari; Via Torino 155/B, 30172 Mestre, Venezia, Italy, +39 041 2346737, marta.melchiorre@unive.it

Elisabetta Zendri[1], Claudia Daffara[2], Raffaella Fontana[2], Silvia Scrascia[1]

[1] Dip. di Scienze Ambientali, Informatica e Statistica; Università Ca' Foscari; Via Torino 155/B, 30172 Mestre, Venezia, Italy

[2] Istituto Nazionale di Ottica (CNR-INO), L.go E. Fermi 6, 50125 Firenze, Italy

This work deals with the use of thermal imaging techniques for the examination of contemporary mural paintings executed from the early 20th century on. These works of art are generally characterized by organic paint layers, based on both traditional media (such as oil, egg tempera…) or synthetic media (acrylic, vinyl, styrene-acrylic copolymers…), which are often affected by the delamination from the inorganic support.

Among the non-destructive testing methods, infrared imaging techniques allow the non-invasive examination of large surfaces *in situ*, as well as the spatial mapping of locally investigated features at suitable resolution. Therefore we suppose that, while exploring contemporary mural paintings, these techniques could be a powerful tool to precisely locate the delaminated paint areas.
We also propose the innovative use of thermal imaging techniques for the evaluation of the adhesion degree between organic paint layers and inorganic support, before and after consolidation treatments.

The operative set-up for the final real artwork investigation resulted from systematic laboratory testing including materials and defects modelling. The thermographic device is a Nikon LAIRD-S270 camera, based on a PtSi detector (475x442 pixels) which acquires thermal images in the spectral range 3-5 µm (MWIR), -20°C÷250°C temperature range at resolution of 0.2°C.

Testing different measurement conditions, we found out that a sample-thermocamera stand-off distance of 600 mm provides an acceptable trade-off between size of smallest resolved features and field of view (FOV= 155x195; sampled pixel at painting surface of less than 500 µm). The surface of investigated object was illuminated orthogonally with different IR sources (tungsten 500W lamp; low voltage halogen lamp), varying either the pulse length or the distance between source and samples. In order to detect delaminations, pulse heating should provide a significant temperature gradient of maximum 7°C. These conditions are absolutely reasonable even while exploring organic paint layers which could be irreversibly damaged by heating.

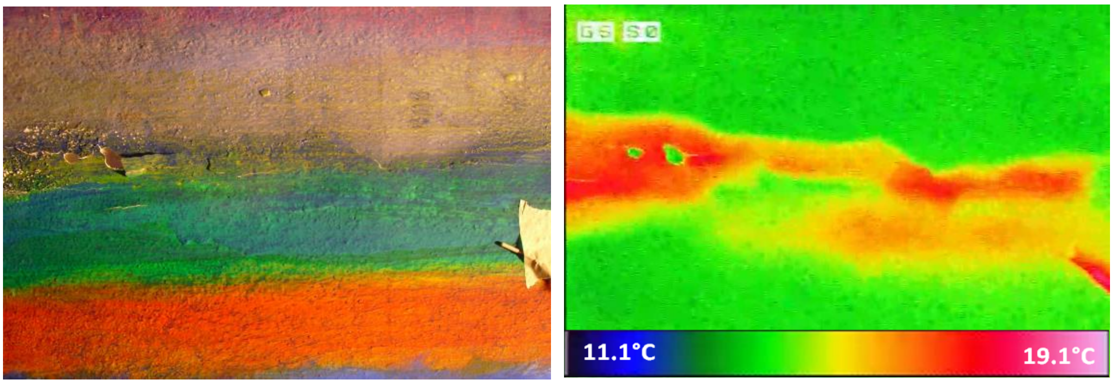
Laboratory tests were systematically done on mock-ups cast on cement lime mortar support with the aim of analyzing thermal responses (decreasing profiles) due to both different defects and different properties of the paint layers (chemical composition and thickness). The surface temperature value is affected by the reflection of thermal waves from subsurface features causing a deviation that allows the detection of the investigation of the delaminated areas.

The first series of investigated samples included: a partially stack paint layer (80±10 μm thick), cast using a commercial emulsion paint formulated with an acrylic copolymer p(*n*BA-MMA) and the Yellow Iron Oxide pigment (PY42); identical sub-superficial defects (1.9 ± 0.7 cm^3) covered by paint layers with the same composition (p(*n*BA-MMA) as binder and PY42 as pigment) but different thicknesses (2a=80±15μm; 2b=182±27 μm; 2c=330±30 μm); different sub-superficial defects (3a=1.0±0.6cm^3; 3b=1.9±0.7 cm^3, 3c=2.9±0.3cm^3; 3d=3.9±0.4 cm^3) covered by paint layers with the same composition (p(*n*BA-MMA); PY42) and thickness (80±10 μm).
The second series of investigated samples was cast using 15 commercial emulsion paints, differing as far as binders (an acrylic copolymer p(*n*BA-MMA); a vinyl copolymer p(VAc-VeoVa); a styrene-acrylic terpolymer p(*n*BMA-styr-2EHA)) and pigments (Titanium White (PW6); Ultramarine Blue (PB29); Phtalocyanine Green (PG7); Quinacridone Red (PV19); Yellow Iron Oxide (PY42)). In order to simulate one of the processes that causes the delamination of the paint layer from the support, these samples were exposed to capillary absorption of water.

Results

Tests carried out before and after consolidation confirmed that pulsed active thermography is effective both for the inspection of sub-surface voids (down to sub-millimetric scale) and for the evaluation of the adhesion degree before and after the treatment.

Moreover, tests confirmed that thermal response depends on paint layer composition (chemical differences, mainly due to pigments nature and their thermal conductivity), paint layer thickness (the thinner is the layer the faster is the heating diffusion rate), defects typology (layering and depth…).
Due to the uniqueness and complexity of a real mural painting, the working parameters and defects modelling depend on the specific case study. Anyway, as confirmed by *in situ* investigation of two mural paintings (a tempera realized by Afro in 1936 and a vinyl mural painted by Tarasewicz in 2004), the flexibility of the technique allows to easily find out the best way to adapt the method to the inspected object.



Tarasewicz's vinyl mural paintings: a raking light image of a partially delaminated area and the corresponding thermal map showing the delamination.

This preliminary work exploits infrared thermal imaging demonstrating that it is a promising non invasive technique for assessing the condition of mural paintings, locating the delaminated areas and monitoring the degree of adhesion between organic paint layers and inorganic support after the consolidation.
Laboratory testing suggests that thermal responses to the pulse stimulation as a function of time can be analyzed in a quantitative way allowing the study of layer thickness. Further work will be carried out in this direction.