Panel paintings inspection analysis using active thermography in the mid-wave and long-wave Infrared region

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Modern scientific instruments and methods are extensively applied for obtaining information on heritage cultural art objects and paintings, thus providing comprehensive in-depth investigations of various artworks. For the studies on panel paintings and their heterogeneous multi-layer structures (concealed glues, gesso composed of glue and chalk or gypsum, paints and resin varnishes), analytical methods and procedures for their analyses allow one to study each individual layer to inspect the whole painting piece (wood frame, support, preparatory layers, paint and varnish levels) and also to reveal unexpected underlying features (under-drawings, pentimenti, etc.). Analytical procedures are aimed to improve readability of artefacts undetectable by the naked eye. The obtained information may provide deeper insights for understanding the particular context behind the painting under inspection. Indeed, paint media, such as wax, egg tempera, oils, and their combinations, can include materials of different thermo-mechanical properties. External environmental effects (temperature, humidity, condensation-vaporization, air pollution, inappropriate light exposure, presence of bacteria, etc.) may cause mechanical deformations, like expansions and contractions of different zones on the layered structure. These deformations can be amplified by natural aging and may affect mechanical properties of each layer and, eventually, result in detachments, delamination, powdering and development of cracks. A non-invasive investigation of layer-by-layer of a painting may allow one to gain a better insight in defects formation and also to understand the specific modus operandi of the artist. Among numerous non-destructive diagnostics, active infrared (IR) thermography may be mentioned as a well-established technique, which may provide a fast inspection of large surfaces. In our studies, an active pulsed thermography system for the specimen analysis was used. This system offers non-destructive testing solutions for the evaluation of components or assemblies and subsurface defect detection without damaging the materials. The active thermography solution combines mid- and long wavelength infrared TELOPS cameras (MWIR or LWIR) and deferent external excitation sources solutions and user-friendly post-processing software. Optical excitation sources such as flash and halogen lamps or lasers are available along with electromagnetic and mechanical sources (inductive coils, ultrasound generators). A wide range of solutions are available from basic systems to compact integrated systems with a variable level of automatization depending on the customer needs and constraints. Active IR thermography for Heritage Science studies can provide inspection of subsurface layers. Due to the sensitivity of this method to different pictorial materials, it is possible to probe down to the preparatory layer to inspect possible under-drawings, subsurface defects and the presence of nails as well. During active IR thermography application, the surface of the inspected painting panel is heated by an external source in order to produce a dynamic thermal response, which can be detected and recorded with an infrared camera. A mid- or long-wave Infrared (MWIR or LWIR) camera is used to measure a thermal flux emitted by the specimen as a response to the excitation. Temperature estimation is performed on IR radiation emitted from the surface. MWIR or LWIR camera displays and records the corresponding evolution of thermal contrast. However, LWIR measurements are usually less sensitive to ambient illumination, while MWIR band exhibits a lower optical diffraction and background radiation, which results in a sharper imaging with a higher contrast for LWIR camera measurements. Also, using the spectral distribution of the emitted energy, it may be estimated that a blackbody at 293 K emits only 1.1% of its energy in MWIR band, compared to about 42.4% in LWIR band. The results of our study have demonstrated that active thermography in MWIR or LWIR may allow both characterization of internal defects and in situ inspection of paintings for detection of under−drawings, pentimenti and analysis of preparatory layers and canvas, thus providing valuable insights into Artwork history and useful pre-restoration information. Active thermography was demonstrated as being appropriate for characterization of various defects on painting layers and detection of underdrawings, pentimenti and canvas. Such multispectral approach provided simultaneous complementary information on the specimen under inspection.