Paintings' investigation by means of tomographic and multispectral imaging

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Multispectral and X-ray imaging techniques are particularly suitable to the investigation of paintings, frescoes and other artistic objects. I describe portable instruments, used for analyses in situ of paintings on wood and canvas.

1 Introduction

The application of multispectral nondestructive techniques - initially developed in the field of materials science - to art and archaeological objects provides the art historian or the archaeologist reliable qualitative and often quantitative information. By this way, it is possible to understand, for instance, the technical and intellectual know-how of the artists or craftsmen of the period under study, and - as for the museum's conservators - to obtain the preliminary often essential information for preservation and restoration of damaged or degraded objects and to assess the authenticity of artefacts and paintings in many cases.
On the other side, availability of a portable apparatus represents a strong constraint for many analyses to be performed *in situ,* since objects of large dimensions or particularly fragile cannot be easily and/or safely transferred to specific laboratories. The infrared and ultraviolet spectrometry is then a suitable technology for this kind of analysis. Moreover, a portable Compton spectrometer has been developed and applied to investigation of paintings, thus complementing usual IR and UV analyses.
In this contribution, a multipurpose multispectral digital system is presented, ranging from infrared radiation to visible light, ultraviolet fluorescence and gamma- and X-ray spectroscopy, in order to perform suitable analyses of paintings on wood or canvas, preliminary to any restoration or cleaning.

2 Experimental apparatus

Our portable instrument for multispectral analysis is based on a high-resolution CCD detector with a large band response, integrated by a number of optical filters in order to select the infrared (IR) and ultraviolet (UV) bands of main interest in applications to the study of the cultural heritage [1]. The experimental system is directly linked to a PC (see Fig.1) where dedicated software is installed. These computer programs, developed by our research group, starting from a collaboration on this matter with the scientific laboratories of the National Gallery in London, where the prototype VIPS image processing system was produced and further improved within the present collaboration, make the control possible on the colour calibration and the relevant acquisition of digital diagnostic images in the different radiation bands.
An advanced optical system, combined with efficient detectors and suitable algorithms of signal processing, based on the grabbing of multiple frames for each single image, in order to average the resulting image pixel by pixel and, therefore, reduce the signal to noise ratio, also by means of regularization procedures [2], allows us to obtain digital images of high quality, with accurate resolution and excellent readability, using cool lighting of low intensity. By this way, the risk of damaging the observed manufact is greatly reduced, even in the case of illuminated codes, parchments, water-colour paintings and drawings, etc.
As for X- and gamma-ray spectroscopy, the possibility to access large samples from one side only makes Compton scattering a powerful method for non-destructive testing in applications aimed to the knowledge and conservation of cultural heritage artifacts, where the characterization of hidden defects at early stages is critical in planning the consequent remedy. The relevant concept is based on the detection of the scattered radiation produced from a collimated beam aimed to the object [3].

Fig. 1 *The ENEA equipe at work in the Amedeo Lia Museum of La Spezia, Italy.*

Fig. 2 *The Raphael's "Madonna del cardellino" of the Uffizi Galleries during the analyses performed with Compton spectrometer in the restoration laboratory of Opificio delle Pietre Dure in Florence.*

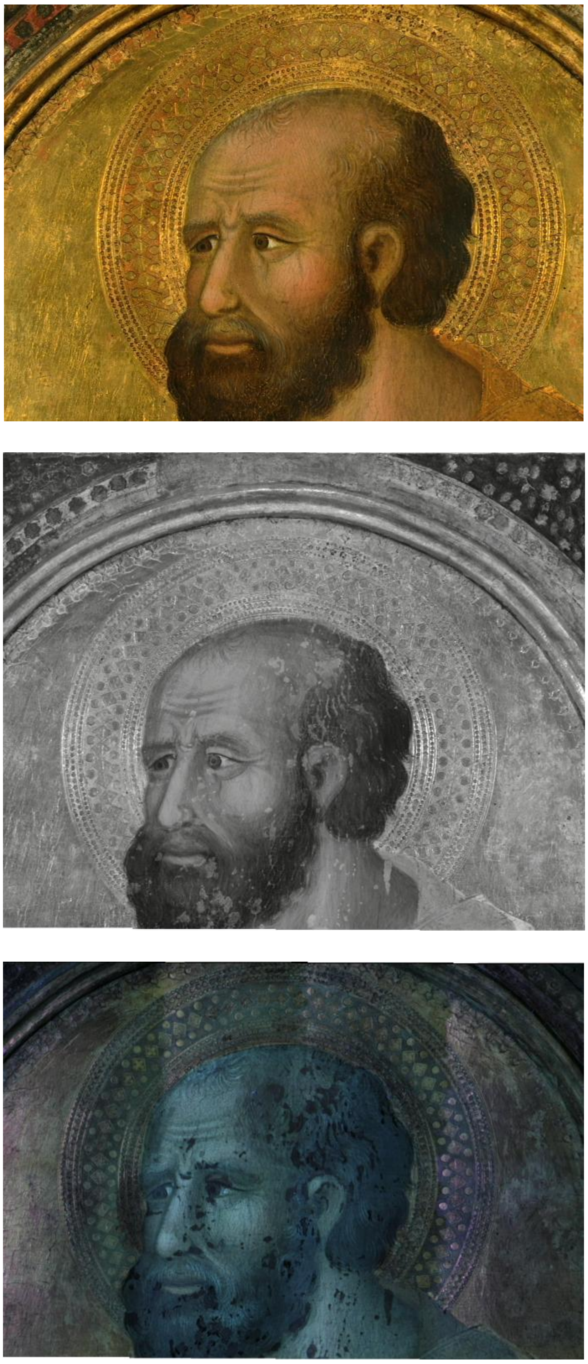

Fig. 3 *"St. John Evangelist" by Pietro Lorenzetti in the Amedeo Lia Museum: Top, detail in the visible light; middle, same detail in IR reflectography; bottom, UV fluorescence.*

The reflected signal provides a measure of the electron density of the material within the tested volume (voxel). Finally, the energy distribution of the scattered photon - which reflects the momentum distribution of the target electrons and hence depends on the atomic number of the atoms – is a further parameter available for material characterization [4]. The ECoSp, Enhanced COmpton SPectrometer, so implemented, is shown at work on Raphael's painting in Fig.2.

3 Results

Figs. 3 and 4 show typical results of multispectral analysis and Compton X-ray spectroscopy, respectively. IR image allows us to make the preparatory drawing evident, underlying the pigment layer – as we can see. UV fluorescence investigation present as dark spots past restorations and repaintings. The density map arising from ECoSp measurements, together with detailed spectra, carry information about the material composition.

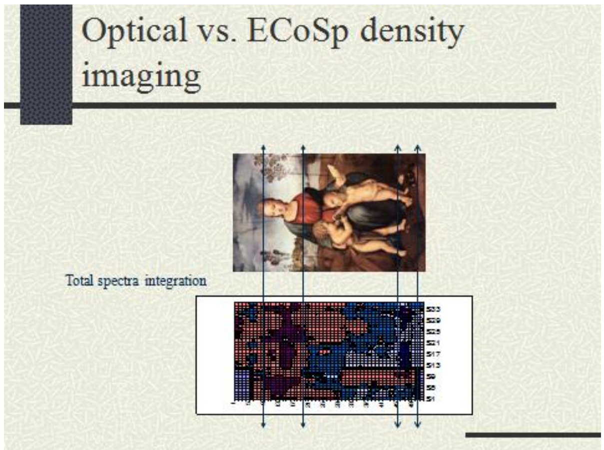

Fig. 4 *Results of X-ray tomography, with the density map shown in correspondence with Raphael's painting.*

References

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