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# BULLETIN

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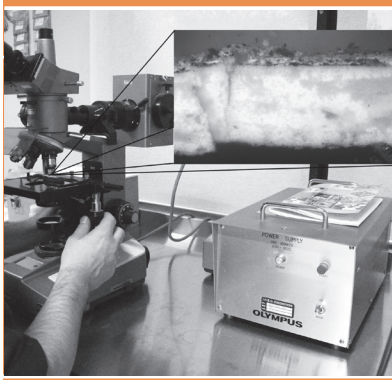
Analyses

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# PANORAMIC MULTISPECTRAL IMAGING: TRAINING AND CASE STUDIES

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## Introduction

This paper reports on a 5-day training program on Technical Photography methods for 2D and 3D Art Documentation that took place in Andria, Italy, in late March 2014. The art works examined during the training are discussed in order to highlight the advantages and limitations of a low-cost system for panoramic multispectral imaging. All the images shown in this paper were taken during the training program.
Dr. Cosentino runs the blog "Cultural Heritage Science Open Source" (chsopensource.org) with the mission to disseminate low-cost solutions for technical, scientific documentation and examination of Art for public and private professionals in the art conservation field. Budget equipment means that the methods can be put into widespread use among professionals and have a real impact on art conservation practices. He also provides a hands-on training program for those who want to practice with the methods illustrated in the blog. The authors want to report on this experience as an example of how it is easy and fast to learn and perform high-resolution multispectral imaging art documentation with low-cost technology.

The students were three young cultural heritage scientists, two of them just got a PhD on analytical methods for art diagnostics (in neutron imaging and Raman spectroscopy, respectively). The other is doing mortar analysis through optical microscopy, x-ray diffraction, and x-ray fluorescence for an archaeometry research group at University of Bari, Italy. They are stating up an art diagnostics company, Terrarossa Studio. Even if their background is on analytical tools and their start-up will provide mostly analytical examinations, they thought it would be useful to encompass multispectral imaging (MSI) and technical photographic methods in their portfolio.
An intensive 5-days (8 hours/day) training-program was agreed upon and the students expressed the need to complete the training in their location. This is actually convenient since it opens possibility to examine local art and architecture. Indeed, the three scientists were proactive to find and select a number of interesting case studies for this training. The first day was spent in the studio to get the students acquainted with the equipment and the general workflow. The second day the equipment was used for an on-site examination at a local restorer. The third and the fourth days the students were ready to perform the examinations on their own with little supervision on art works conserved in Andria's cathedral. The fifth day was dedicated to the 3D photo modeling of the famous Castel del Monte. Erected in the year1240 it is considered to be the most fascinating castle built by the Holy Roman Emperor Frederick II of Hohenstaufen. The training program also included a set of RTI spheres, a mini "pigment checker", a selection of gum Arabic laid pigments to be used as references for multispectral imaging as freebies. Specifically, the topics covered in the training were:
Digital Imaging for Art Documentation
The Nikon D800 modified for full-spectrum (ultraviolet, visible and infrared photography). Photographic equipment for art documentation and editing of raw images in Adobe Camera Raw (Filters, reversible tripod, remote shutter, remote speedlights, camera calibration, ControlMyNikon, mirror up mode).
MSI, Multispectral Imaging
Multispectral Imaging techniques and relative hardware and software tools.
VIS, visible; RAK, raking light; UVF, ultraviolet fluorescence; UVR, ultraviolet reflected; IR, Infrared; IRT, infrared transmitted; IRF, infrared fluorescence; IRFC, infrared false color; IRR, infrared reflectography
Panoramic and High Resolution Imaging
Hardware and software tools for high resolution art documentation by Panoramic imaging. Gigapan Panoramic head, Gigapan server, PTGUI Stitching software, Arduino.
RTI, Reflectance Transformation Imaging
Hardware, Macro Photography for RTI, RTI Builder and viewer.
3D Photomodeling
Free Software and workflow

## Equipment

The training is provided with equipment contained in one luggage (20Kg) and in a hand held (10Kg) suitcase. It is important to have lightweight equipment so that the training can be performed in any location by traveling with economic flights.
The equipment is composed of the panoramic multispectral imaging system [1] covering 4 spectral bands: Ultraviolet, UV (360–400 nm); Visible, VIS (400–780 nm); Infrared, IR (780–1100 nm) and Infrared Reflectography, IRR (1000–1700 nm), (Fig. 1).The acronyms for the specific MSI images highlight first the spectral band followed by R (Reflected), F (Fluorescence), FC (False Color) and TR (Transmitted). So the 8 imaging methods are called VIS (Visible), IR (Infrared), UVF (UV Fluorescence), UVF254 (UVC light source), UVR (UV Reflected), IRFC (Infrared False Color), IRF (IR Fluorescence), IRR (Infrared Reflectography) and IRTR (Infrared Transmitted). It must be noted that there is no standardized way

to perform MSI imaging. The numbers and ranges of spectral bands, as well as the nomenclature, detectors, filters and light sources varies. The set of equipment is completed by a panoramic head [2] and general photographic tools, such as a tripod, remote shutter and speedlights.

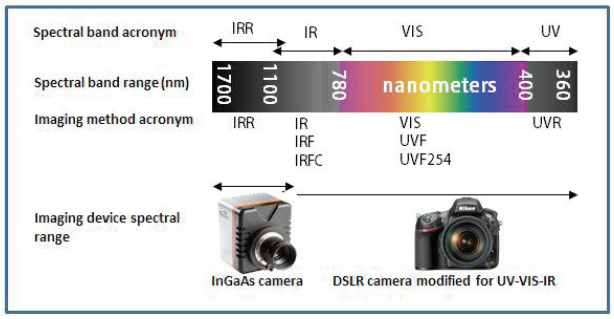


*Fig. 1: MSI scheme: spectral bands, imaging methods and imaging devices.*

## Multispectral imaging

MSI is widely used and is an established method for art examination. Touching briefly on the technique, UVF is used to map the retouches that appear black under UV light [3, 4]. IR, IRTR and IRR aim at the visualization of the underdrawings and pentimenti [5]. Finally, all the methods together can be used for the tentative identification of pigments [6]. Figure 2 shows an example of complete MSI documentation of a painting, which was completed during the first day. The second day a 20th century canvas representing Jesus Christ during his passion, belonging to Andria diocese was documented. The canvas had no preparation layer under the painting and it had not been relined: these two conditions are very favourable to the investigation through infrared imaging in transmission (IRTR). From the comparison between the visible, infrared and infrared transmitted images it is evident that the preparatory sketch, merely deducible from the infrared image, is completely readable in the infrared transmitted one, figure 3.

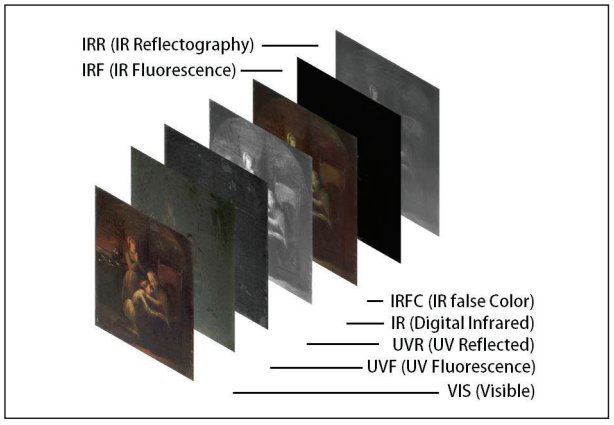


*Fig. 2: Multispectral imaging. The Crusader's farewell, Private collector.*

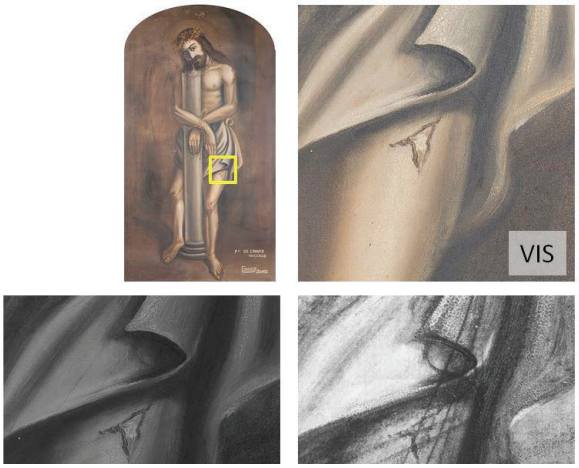


*Fig.3: Infrared imaging in transmission allows better detection of the underdrawing with the right conditions present.*

## Panoramic Multispectral Imaging

One single shot, even from a large format camera, often does not provide enough resolution. It could be fine for a small portrait, but it would not accommodate a large painting, a mural, or when a detailed image is required, as is the case for printing or for analysis of the brushwork. High-resolution multispectral imaging can be performed with the panoramic method, which is economical, fast and mobile [1]. It is composed of consumer level tools for panoramic photography and it consists of taking a series of photos of a scene with a precise rotating head and then using panoramic software to stitch the images. The center and borders of the object must be kept within the near and far limits of the depth of field. The panoramic method is particularly useful for IRR imaging [2] because the pixel count of the detectors (InGaAs and Vidicon tube) is considerably smaller than that of a digital camera and it is always necessary to acquire multiple images to achieve an acceptable resolution by stitching. All the panoramic images shown in this paper were taken with a 200 mm lens and the Nikon D800 camera (36 MP). We first show an example of the method applied for a large painting on canvas documented during the second day. This is an example of large-size painting where the Panoramic MSI is necessary to document with sufficient resolution. In this case, a series of 56 images in the VIS and IR, figure [4], was taken. The painting depicts the Virgin Mary surrounded by Jesuit saints and it belongs to the diocese of Andria. It is currently under restoration in a conservation studio, and this is where the painting was photographed. The research interest of this work lies in the fact that a similar work by a famous local painter conserved in Bisceglie, seems to show analogous shapes in the position of the Virgin and some Saints. The goal of the examination was to retrieve information that could point toward a signs of the same artist. The IR panoramic image was used to search for a signature, but it was not found. The IR image can also

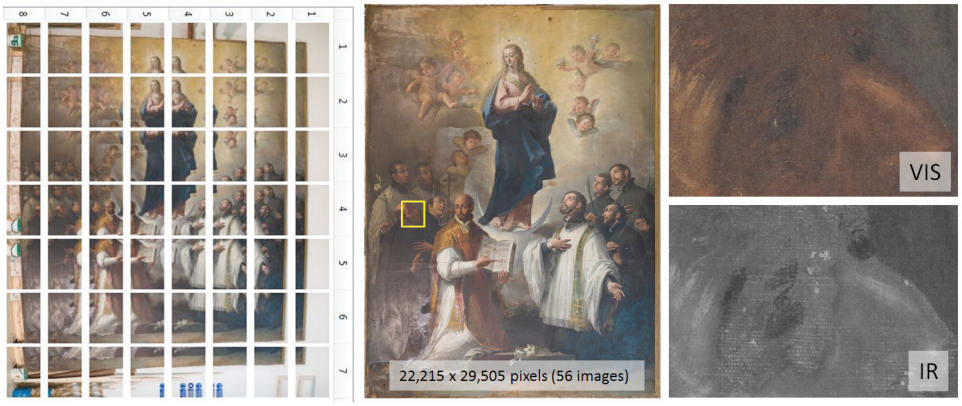


*Fig.4: The images (VIS and IR) are composed of 56 photographs for a final size of 22,215 x 29,505 pixels. The resolution is satisfactory; as the weave is clearly defined in the IR image detail.*

be used to compare the preparatory sketch of some figures with those of the other painting, in order to understand if the same cartoon was used.

The third day, a tempera on panel painting conserved at the Andria cathedral was examined. It dates back to the 15th century and represents the Virgin Mary surrounded by angels. Together with the twin panel representing Christ in the same scheme, they constituted the doors of a closet. Both panels are strongly altered, above all the gilding is almost completely scratched out. A documentation of higher resolution than the previous painting was performed because the goal was to detect the underdrawing, traces of which were eventually seen in the angels, as well as in the dress of the Madonna where the lines indicate the folds, (fig. 5)

The canvas representing the sacrifice of Isaac was documented on the second day. It is kept in a conservation studio in Andria, where it is under restoration and has been partially cleaned. It presents a thick layer of dust and dirt, which, together with a strong alteration of the varnish, completely obliterates the figures. The infrared documentation was performed in order to provide the restorer with an image of the figures under the dirt, since the painted layer becomes more transparent in the IR, figure [6]. Infrared imaging in transmission (IRTR) was also performed on this canvas. The contour of Abraham's arm is much more evident in the IRTR (Fig. 7).

The panoramic method was developed to achieve high-resolution

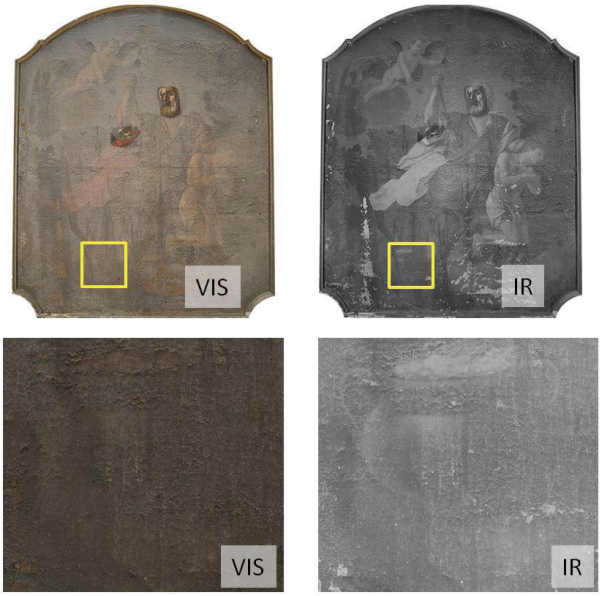


*Fig. 6: The images (VIS and IR) are composed of 77 photographs for a final size of 35,037 x 37,414 pixels. The infrared image makes a vase distinguishable under the dirt.*

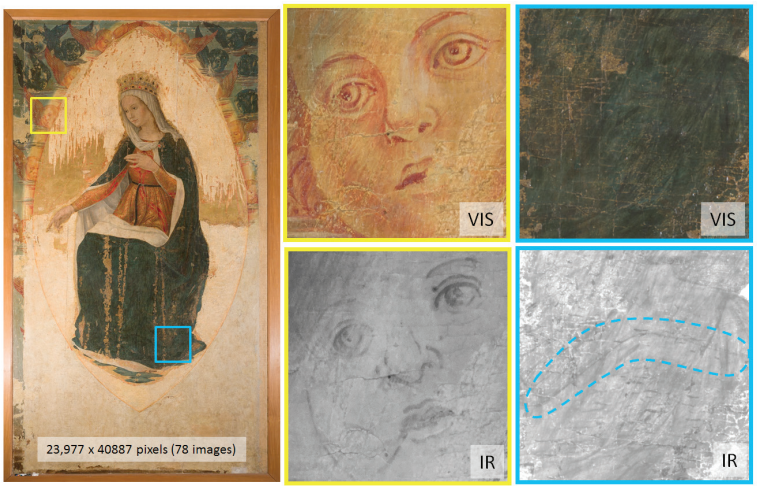


*Fig 5: The images (VIS and IR) are composed of 78 photographs for a final size of 23,977 x 40,887 pixels. Underdrawing is visible in the angels and in the Madonna's dress.*

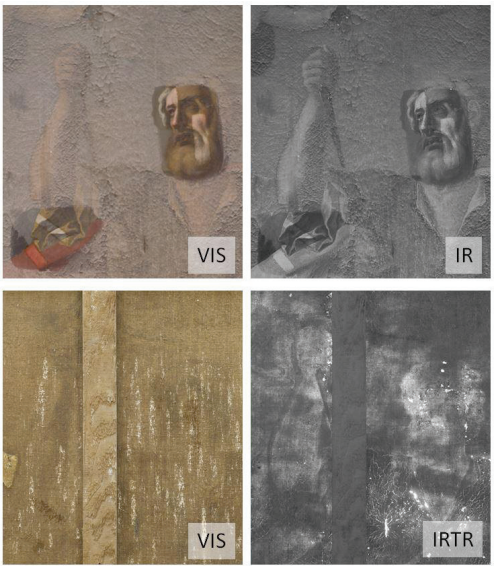


*Fig. 7: The infrared transmitted (IRTR) image makes the contour of the Abraham's arm much more evident.*


*Fig. 8: Visible and infrared high-resolution photographs of a detail of the Saint Joseph mural painting.*

imaging but it also becomes convenient for the documentation of paintings hung high on a wall or similarly at a distance. This is actually the case for many paintings conserved in churches. Often, bringing down the paintings is too much trouble and therefore a panoramic system is useful to achieve a reasonably satisfactory documentation. Even if the condition of the lighting and the angle of the painting from the ground are not ideal, reliable information can still be retrieved.

The third day a mural painting in the Andria Cathedral representing Saint Joseph with the Infant Jesus was documented. The painting is high on the wall at about 6m from the ground. The composition is unusual and above Saint Joseph's head there are stains that are shaped like a crown of stars. These observations suggest the hypothesis that the Virgin Mary was originally represented in the painting in the place of Saint Joseph. The panoramic multispectral imaging examination, even if carried out in non-ideal conditions of light and positioning, were able to highlight some interesting details. On Saint Joseph, the infrared image revealed the scapular of Our Lady of Mount Carmel, figure [8], which means that the Virgin must have been included in the original representation. Other features of the Virgin, however, were not found under St. Joseph. One hypothesis could be that the painting represented the Holy Family and the Madonna's features were completely scratched out. The raking light image shows some lines carved in the plaster on the left of the head of Saint Joseph.

Another painting, which hangs on the wall in the Andria cathedral, was documented(Fig.9). The canvas depicts the Virgin Mary with the Infant Jesus surrounded by Saint Sebastian and Saint Richard, the patron saint of Andria. Between the two Saints, a group of souls in the hell are represented. One of them, accompanied by an angel, seems to detach and head towards the sky. In this area, infrared imaging was successful to reveal additional information. The central group was not part of the original composition, but was added afterwards.

*Fig. 9: The Andria Cathedral. Painting documented from the ground.*

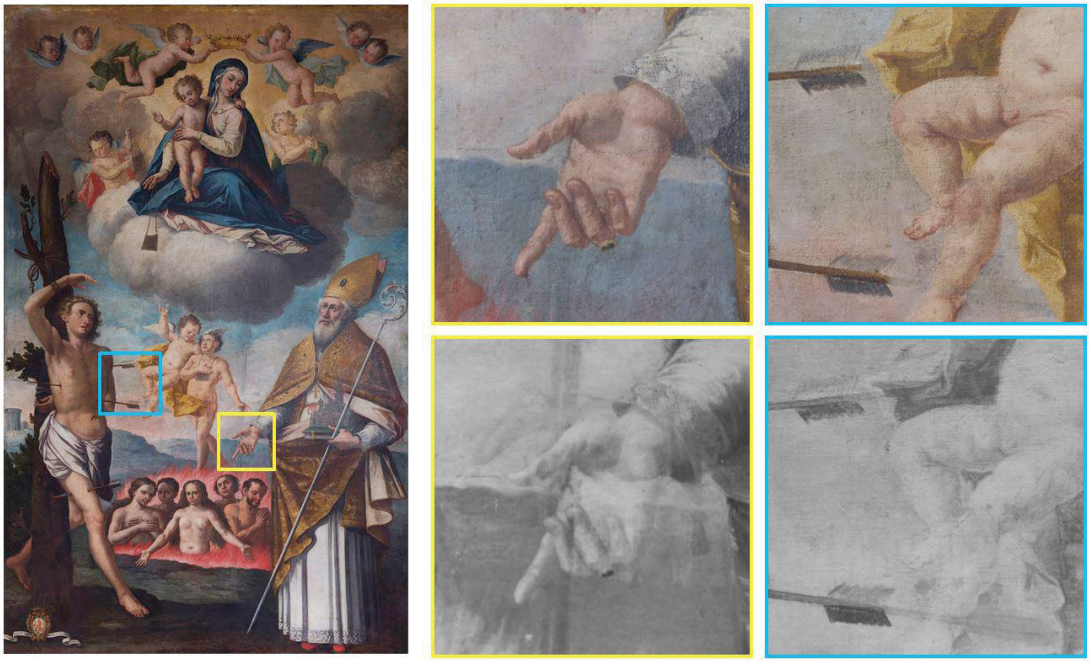

*Fig. 10: The images (VIS and IR) are composed of 40 photographs for a final size of 14,322 x 23000 pixels. The infrared images reveal a number of concealed retouches.*

In fact, both of the figures of the Saints were changed to leave enough space for the group; in particular, Saint Richard's features were moved: his pastoral staff was moved from his right hand to his left. Concerning Saint Sebastian, the arrows running through his body were shortened to provide space for the other figures (Fig. 10).

## Conclusions

This paper has presented some case studies where the application of panoramic multispectral imaging was used to resolve specific tasks. In particular, the method proved successful for the visible and infrared imaging of art works hung on high walls, even in lighting conditions that were not ideal.
The system and the workflow can be easily approached by non-professional photographers, as the training case has demonstrated. Furthermore, the equipment is relatively low-cost and consequently it is more accessible to be implemented by a large number of professionals who deal with art documentation.
(Photos: A. Cosentino)
(Traduction: A. Cosentino)

Dr. Antonino Cosentino is a Physicist specialized in Cultural Heritage Science. He's working out of a start-up private practice based in his hometown in Sicily. He provides technical examinations for art objects as well as training and consulting. His clients are museums, institutions, private collectors, and conservators. He promotes innovative and low-cost solutions for technical and scientific documentation and examination of Art and he disseminates his findings on the "Cultural Heritage Science Open Source" blog, chsopensource.org.
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