

## MULTISPECTRAL IMAGE ANALYSIS

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### ABSTRACT:

Multispectral image analysis is a technique based on some simple principles. It is sure that different materials absorb the light in different way. It is possible to measure the amount of light absorbed and reflected and to establish precise spectra of absorbance or of reflection for substances that compose art objects. It is also possible to record these spectra not for visible waves, but also for UV and IR waves. The benefit of those capabilities consists in possibility of understanding the way that materials behave beyond visible range. Approaching this idea from a different angle we can consider that electromagnetic waves from UV range to NIR range, including of course visible spectra, go through materials in different ways. If we can develop a specific algorithm to associate certain materials to certain range of former mentioned spectra we can obtain interesting information about multilayer structures.

**KEYWORDS:** Multispectral imaging, Artwork materials, UV-VIS-NIR digital camera

### 1. INTRODUCTION

During the last decades non- invasive photospectroscopic techniques are extensively applied for the analytical investigation and diagnosis of historical and artistic artworks. The most known of those techniques provide accurate and important information for the constituent materials of artworks, by acquiring spectral data from a single spatial point. However the heterogeneous nature of such objects and the presence of non-easily distinguishable old restorations, may limit significantly the reliability and the interpretation of such visually driven probe analysis.

Given such limitation the multi-spectral camera, for imaging in the visible and infrared, has found extensive applications in the characterization and mapping of artworks and archaeological objects. The multi-spectral imaging technique allows the user to selectively view the individual layers of a painting, yielding information about its history, composition, structure as well as its preservation state. Alternatively, in the archaeological field, the multi- spectral imaging serves as a unique tool for the evaluation of the laser cleaning effectiveness and therefore highlights its potential for on line assessment of the laser cleaning

process. The multi spectral imaging combines several techniques in one system, enabling the simultaneous recording of both spatial and wavelength information from a surface. In the imaging part of this technique an image with very high spatial resolution can be acquired. From the spectroscopic point of view, in every individual pixel of the image, a reflectance spectrum can be calculated. This enables the selective imaging of the sample in any chosen spectral region, which can be referenced as imaging modes. As a result caused by the different penetration depth of each wavelength, information from different structure layers can be revealed. The imaging modes are: visible reflection, infrared reflection (2 bands), false-color infrared imaging, visible fluorescence and ultraviolet reflection. These last three modes are particularly suited to distinguish between pigments which look similar in visible.

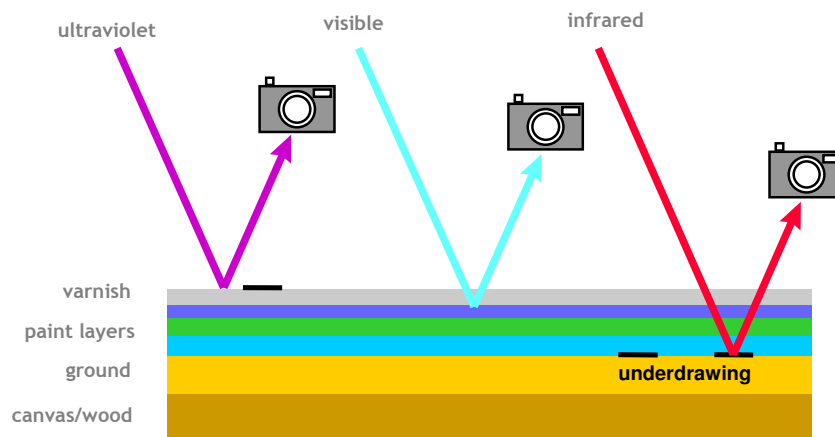
### 2. MULTIMODE STRUCTURE

The fields of art in which the multi-spectral imaging has been applied successfully are:

1. paintings (easel, panel, wall),
2. stony objects (sculptures, monuments)
3. furniture's,

4. textiles and

5. paper or parchments.



**Fig. 1. Selective penetration depth depending on the light wavelength**

The software for the multi-spectral imaging system, written from a restorer's point of view, is easily operated without the need for specific scientific or technical knowledge. Automatic adjustment of the filters and sensitivity levels upon mode-switching ensures optimal utilization of the imaging capabilities. The digital file format in which images can easily be saved is an essential characteristic of the multi-spectral imaging system enabling easy documentation and editing during and after the image has been acquired. Images can be stored digitally in standard formats, enabling further processing in common image processing software. For example: several small images can be combined to produce a single large image of uniform contrast and brightness. The practical application of the ARTIST system is best explained on the basis of the several imaging modes:

**Visible reflection mode (400-700 nm):**

This mode offers a faithful representation of your color image. Images can be easily stored and digitally manipulated. Various objectives can be used, enabling both macroscopic and microscopic imaging.

Color analysis provides the possibility to distinguish colors and quantify the difference. Areas with certain distinct color characteristics can be mapped with a conspicuous color to enhance their appearance. The size of the mapped area is calculated with respect to the screen

image area. A possible use for the mapping function is to visualize brushstrokes.

A practical use for the color analysis is the verification whether (recently) applied retouches blend nicely into the surroundings or the investigation of possible color changes over certain periods of time due to ageing.

**Visible fluorescence mode (400-700 nm):**

This mode captures the visible fluorescence of the surface layers when illuminated with ultraviolet radiation (a Hg lamp, 365nm, 10nm bandwidth). In practice this mode is an excellent aid in examining the condition of the varnish layer and the location of retouches. Also, fungi located on the surface which are normally hard to detect become clearly visible.

**Ultraviolet mode (320-400 nm)**

This mode visualizes the ultraviolet radiation reflecting from the surface when illuminated with an UV lamp. Surface details, roughness and layer thickness can be enhanced. Furthermore, surface layers with different ultraviolet absorbing characteristics can be distinguished.

**Infrared mode 1 (700-950 nm):**

Usually, when going further in the infrared, paint layers become increasingly transparent, and the underlying layers (underdrawings) are visible. Dividing the IR region into three separate bands, the

mode giving the best contrast and resolution can be chosen in every circumstance.

Infrared mode 1 gives nice contrast results when viewing paintings with relatively thin layers of overpaint. The image result of this mode is comparable to an IR-photograph.

**Infrared mode 2 (950-1150 nm):**

In infrared mode 2, normal cases of underdrawing can be visualised with great detail, showing an excellent resolution.

### 3. PRACTICAL APPROACH

Every working mode helps the specialist to discover or to understand better some degradation related to certain layers. Images are also used to justify a precise intervention. They testify that no damage is produced by restorer or by any other person who is responsible for that object conservation



**Fig. 2. Basic working principle consists in comparing sets of images taken in different wavelength modes between them or with real object**

In the framework collaboration with Museum of Braila a number of interesting details were relieved at different artifacts which were kept in museum deposits.

In the case of the icon representing probably Saint Andrew the moment when multispectral images were recorded corresponds to an intermediate restoration procedure. Being on restoration studio table the icon revealed, due

to the multispectral imaging analysis some valuable information regarding cleaning procedure and also offered some new ideas about the future approach of whole restoration process. Due to this analysis it was also possible to identify original inscriptions located under a recent paint layer. Successive multilayer analysis permitted distinct identification of varnish and other layer alterations.



**Fig. 3. IR image (left) offers a better image of the ground layer compared to visible colour image.**



**Fig. 4. UV mode provides useful information about 3D surface of the icon.**

A remarkable icon, with great historical and cultural value is the icon of Mother of God with Child Jesus, located at the entrance of the Great Church of *Dintr-un Lemn* Monastery. This icon of a rare beauty combines in a fantastic way the stylized lines

of Byzantine style with a warm human expression generated by the figures of the two sacred figures



**Fig. 5. “Dintr-un Lemn” monastery – XVIII century icon**

**Fig. 6. IR image shows vertical brush strokes at the beginning of the work on character figure.**



**Fig. 7. UV image shows horizontal brush strokes at the surface of the figure and also the small black dots indicate the presence of the original varnish.**



Due to the multispectral imaging the restorer was able to record images illustrating his restoration procedures and he was also able to identify hidden overpaints on the surface of the original paint layer.

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