Application Note

# Exploring Underpaintings with VIS/NIR Spectral Camera

## Infrared Reflectance for Cultural Heritage

Using reflected infrared (IRR) light has been an important tool for examining paintings and other culturally important artifacts for many decades. One of the main benefits of IR reflectance is that it is nondestructive, and capable of being used on delicate objects without the need to remove part of the object. In some cases, paintings can remain in their frames and even in their spot on the wall and still be thoroughly imaged with IR reflectance. Another benefit is that IR light is less energetic than other parts of the electromagnetic spectrum like ultraviolet light or x-rays.

A particularly useful application of IR reflectance is discovering any underpaintings or underdrawings that exist beneath the final finished painting[1-2]. IR light has longer wavelengths thus it is scattered less and can penetrate the outermost layer of paint. Additionally, light in the infrared region is sensitive to the chemical composition and thus can assist in pigment identification[3-4].

The well-known IRR (Infrared Reflectance) method results in a total reflectance image using the 900-1700 nm range. Having only one image in grey scale, however, does not allow any meaningful correction to emphasize the underpainting or separate it from the outer image because both the outer layer and the underlayer absorb and scatter the infrared light.

## RevealScan-M™ example application

The RevealScan-M is a streamlined imagining system capable of capturing both visible and IR images. An example painting shown in Figure 1 demonstrates the capabilities of the RevealScan-M™. Firstly, the RevealScan uses information from the visible portion of its range to display an accurate color representation of the painting with the same pixel resolution as the infrared images, in this case, the horses grazing in the field.

*Figure 1. "Three Horses" by Pamela A. Betts, oil on canvas, 12" x 15"*

*Figure 2.The same painting as in Figure 1 captured with ambient light conditions with all visible and NIR light integrated. Both the outer paint layer containing the horses and the underpainting of a woman's face as seen in the image.*

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Using the camera's entire range integrated, the RevealScan-M™ can detect an underpainting of a portrait of a woman's face oriented 90 degrees from the surface image, as seen in Figure 2. However, the image from the outer layer of paint, the horses in this case, are still visible alongside the woman's face, thus making it more difficult to obtain a clear image and fully notice all the details of the woman's portrait. In this particular painting, the combination of all IR images, the horses from the foreground vanish, as shown in Figure 3a.

Even though the underpainting is visible in Figure 3a, the face is still obscured by several dark streaks across the cheek and corner of the eye due to the outer paint layer that is also absorbing the infrared light. Common ways of trying to isolate just the underpainting include Principal Component Analysis, which is automatically performed in the RevealScan™ Analysis software on the visible range and the IR range. Figure 3b shows one of the components generated from the Principal Component Analysis of the IR range. While this component doesn't highlight the woman's face, it does enhance the contrast of the dark streaks and can be used to decrease the contrast of the face compared to the background.

With the RevealScan Analysis software, the component image emphasizing the dark streaks was used to remove the dark streaks from the IR image. The result shown in Figure 3c shows the dark streaks removed from the woman's face, making the subject of the underpainting clearer to the viewer. To better visualize subtle differences in the grayscale images, RevealScan-M software can also display any three of the measured or calculated images as a pseudo-RGB image, as is shown on Figure 4. Having several infrared and several visible range images thus have the power to improve, step-by-step, the underlayer image and show it much clearer without the interference of the outer layer image[5].

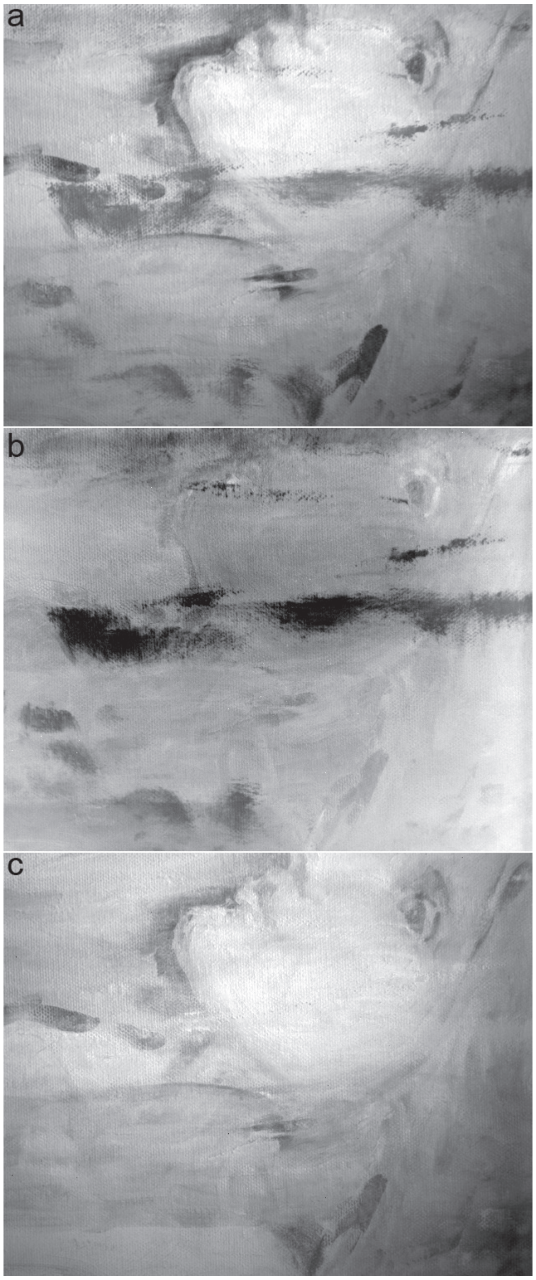


*Figure 3. a.) the underpainting of the same painting in Figure 1 captured with the RevealScan-M, blocking all the visible light. b.) The second component from the Principal Component Analysis of the IR filter images. c.) The resulting image where the image in b is used to remove the dark features obscuring the face in image a*

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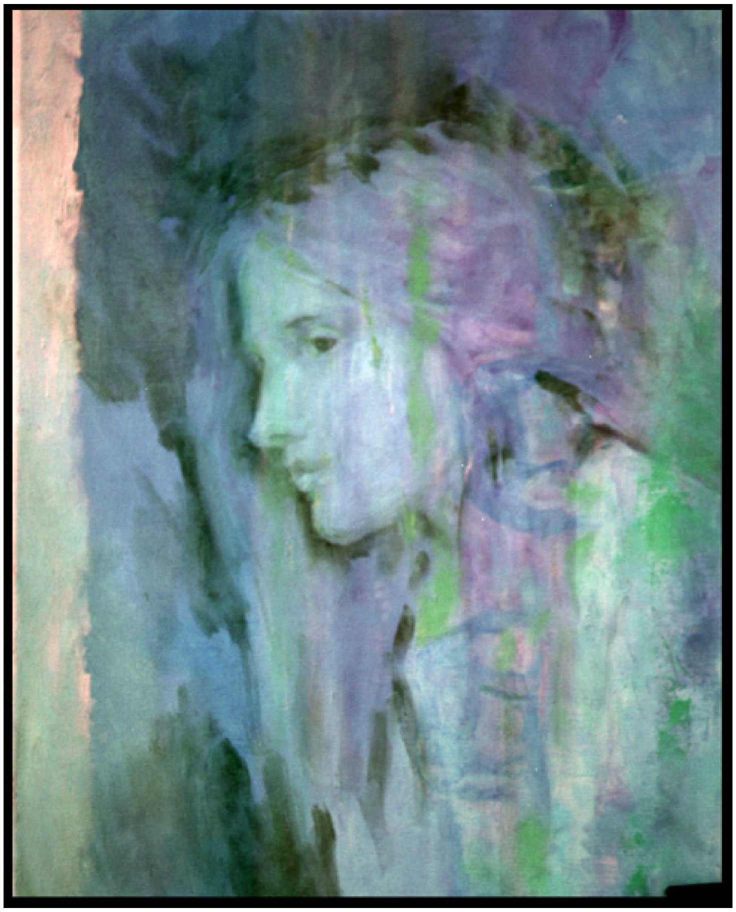

*Figure 4. Pseudo-RGB image generated from the first 3 components of PCA for the IR wavelength range.*

## System Features

- 400-1700 nm wavelength range
- 640x512 pixel spatial resolution
- Dedicated analysis software to improve and enhance collected images

- Optional: select specific wavelength regions of interest
- Optional: independently adjustable dual Halogen and LED visible enhancement light source

## References


1. Burmester, A. and F. Bayerer (1993). "Towards improved infrared reflectograms." Studies in Conservation 38(3): 145-154.
2. Delaney, J. K., et al. (2016). "Visible and infrared imaging spectroscopy of paintings and improved reflectography." Heritage Science 4: 1-10.
3. Baronti, S., et al. (1998). "Multispectral imaging system for the mapping of pigments in works of art by use of principal-component analysis." Applied optics 37(8): 1299-1309.
4. Cosentino, A. (2014). "Identification of pigments by multispectral imaging; a flowchart method." Heritage Science 2(1): 8.
5. Kemeny, G., Stifler, C., Smith S., and Speck, K. (2023). Obscured Content Determination. USPTO No. 63572402