# Hyperspectral Unmixing in Provenance Research of the Fine Art

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**Abstract**

In the study of the authenticity of the fine arts, scientific research methods have gained a foothold in recent years alongside traditional connoisseur -based expertise. X-ray and infrared imaging have long been in active use. These have traditionally been used for to search underlying drawings and paintings behind the paint layers. The limitation of both methods is the poor resolution in the spectral domain, where the observed images are result of strongly mixed signals of different substances (paint, canvas, etc).

Hyperspectral imaging brings new possibilities to the fine arts research. Especially, in the short wave infrared (SWIR) range, hyperspectral imaging is able to reveal hidden things that are between or below the paint layers. In the wavelength range of 1000 to 1700 nm, several pigments loose their absorbing properties, making them partially transparent. From the hyperspectral image it is possible to search certain wavebands that separate as much detail as possible. However, this is laborious and the image can still be mixture of several spectra. Spectral unmixing offers us the opportunity to study these mixed pigments on the painting and use them to reveal possible drawings, paintings and signatures under the actual painting. We can let algorithms to do the separation work for us and to reveal the details that interest us.

In this case study, we examine two different fine art paintings using hyperspectral imager (Specim, Imspector N17E) and different unmixing models (linear, bilinear, and nonlinear). The first work is Claude Monet's unsigned painting Haystack in the Evening Sun (Fig 1.) and the second is a work thought to be a portrait painted by Frans Hals (Fig 2.). In Monet's case combination of hyperspectral imaging and unmixing reveals a signature between the paint layers. With this and other found provenance, the work is proved to be authentic. In the case of Hals, 17th century floral painting is revealed below the actual portrait. More detailed pigment research shows the work to be forgery. In this presentation, we compare different unmixing models and qualitatively compare the obtained separation results with each other.

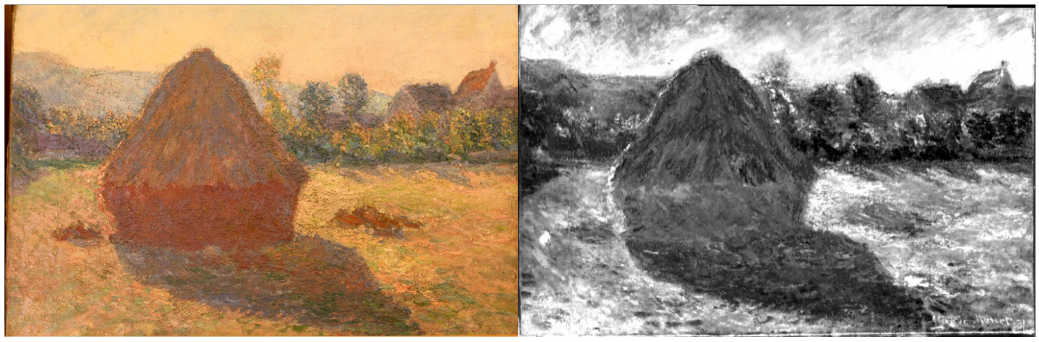

Figure 1: On left: Claude Monet's Haystack in the Evening Sun (Gösta Serlachius Fine Arts Foundation). On right: one abundance map from the linear unmixing method. On the right lower corner there is signature of Monet's and year -91.

Figure 2: On left: Portrait assumed to be painted by Frans Hals (Gösta Serlachius Fine Arts Foundation). On right: one abundance map from the bilinear unmixing method.