

Tri-modal (MA-XRF, Reflectance and Fluorescence Imaging Spectroscopy) investigation of works of art

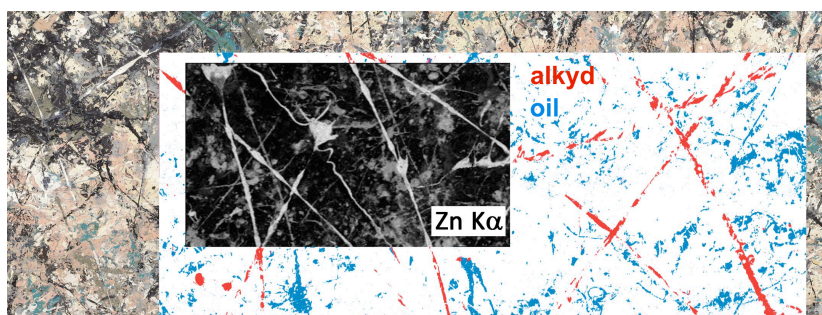
John Delaney⁽¹⁾, Kathryn Dooley⁽¹⁾, Damon Conover^(1,2), Lisha Glinsman⁽¹⁾

(1) National Gallery of Art, 4th and Constitution Avenue NW, Washington, D.C., 20565 USA

(2) The George Washington University, Dept. of Electrical and Computer Engineering, Washington, DC, USA

j-delaney@nga.gov

Combining site-specific results from different analytical methods provides a higher level of confidence in the identification of artist materials present. Analyzing an area using techniques such as x-ray fluorescence imaging (MA-XRF) and reflectance imaging spectroscopy (RIS) is the logical next step, and extends the data collection to two dimensions. Here we describe a novel 2-D, tri-modal scanner along with case studies showing the utility of having such data sets. The scanner system operates by moving the artwork on a two-axis computer-controlled easel across a series of the stationary sensors. This allows for a variety of imaging sensor modules, including prototypes to be used. The easel provides three scan modes: raster, line, and step/stare over a 1.5 m² collection area. Currently three modalities can be collected: x-ray fluorescence, diffuse reflectance (350 to 2500 nm), and light induced molecular fluorescence (400 to 1650 nm). In the raster scan mode, XRF spectra and diffuse reflectance spectra (350-2500 nm, fiber spectrometer) can simultaneously be collected with moderate spatial sampling (0.1 to 1 mm and 1 to 3 mm, respectively). In line scan mode, visible and infrared hyperspectral cameras (400-2500 nm) are used with higher scanning rates (500x faster than MA-XRF) and at higher spatial resolution (0.160 mm). Novel registration software allows fusion of all of these image modalities with the reference color images and x-radiographs. Case studies of artwork in the collection of the National Gallery of Art has shown the added utility of having such registered multimodal data. These include demonstrating the earlier version of Fragonard's "Young Girl Reading" which depicts a woman looking out towards



Detail from Jackson Pollock's Number 1, 1950 (Lavender Mist) showing color, RIS and XRF maps. National Gallery of Art, Washington DC [2].

the viewer, matching one of the sketches in a recently found Fragonard drawing of the Fantasy Figures [1]. The results from MA-XRF and RIS of Pollock's "Lavender Mist" allowed the identification of two Zn- and Ti-based white paints, one an alkyd with rutile titanium white and the other an oil with anatase titanium

white. These paints were used selectively to create the 'pools' and skeins of white paint.

[1] Jackall, Yuriko, John K. Delaney, and Michael Swicklik. *The Burlington Magazine* 157, 1345, 2015: 248–254.

[2] Dooley, Kathryn A., James Coddington, Jay Krueger, Damon M. Conover, Murray Loew and John K. Delaney, *Anal. Methods*, 9, 2017, 28-37.