Spectral Imaging for Historical and Cultural Preservation

Hyperspectral sensors are now being used to examine Cultural Heritage. From texts, maps, paintings and other art to monuments, buildings, and even excavated archeological sites, the technology is easily deployed.

Imaging in the VNIR and SWIR has a number of important and interesting applications for Cultural Heritage because this type of imaging technology provides a more complete representation of the entire field of view. This is a critical distinction because true *context* is provided on what are typically heterogeneous objects; by comparison, point sensors can only sample discrete locations. Imaging in the VNIR has been used since the mid 1990s for texts and paintings. For texts, the application is typically content; for example, reading palimpsests and faded or damaged texts and maps. For art, the application is typically color and pigment mapping. SWIR imaging offers the possibility of chemical imaging, allowing the conservator to monitor and track chemistry changes over time.

Hyperspectral imagers offer scholars, curators and conservators unique advantages:

- Enhance faded or hidden features-text/signatures
- Detect restorations and repairs via chemical signature
- Monitor and track changes of the object, or repairs and restorations
- Identify local material components for proper repairs
- Assess original coloring and pigmentation

Since little or no preparation of the document or artifact is necessary, this non-destructive spectral technique is invaluable for a wide range of conservation research relating to changes in color, chemical and substrates.

Within the field of view of the Hyperspec® sensor, hyperspectral imaging provides quantitative spectral information for all wavelengths across the complete

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spectral range of the sensor. The VNIR (Visible-Near-Infrared) range is 400-1000nm; the SWIR (Shortwave Infrared) range is 900-2500nm. The key to spectral data is calibration; well-calibrated datasets can be compared and analyzed over time and between multiple users. There is an existing and significant body of spectral analysis, classification and mapping algorithms and software available to work with spectral data. Most of this software has been developed over the last 20 years for satellite remote sensing and is easily available.

The job of the hyperspectral sensor is to collect image data and then assemble this valuable information into a 'datacube,' which represents a data set that includes all of the spatial and spectral information within the field of view. The datacube is used by research teams to more thoroughly evaluate documents and other artifacts that will greatly enhance knowledge of the spectral composition and uniqueness of these samples.

Headwall is the world's leading manufacturer of advanced spectral imaging systems. The **Hyperspec®** family of sensors are valued for key performance characteristics that include:

- Aberration-corrected optics
- Wide field of view
- High spatial and spectral resolution
- Very high signal-to-noise (SNR)
- Low stray light

Typically (but not exclusively), Headwall's hyperspectral sensor will be configured into a Starter Kit™ for historical and cultural preservation work. The Starter Kit™ is a turnkey solution that includes a gantry to which the sensor is attached, a moving stage, proper illumination necessary for the spectral range of interest, and Headwall's advanced and easy-to-use Hyperspec® III software. The kits are available in standard- and large-format configurations, and both VNIR and SWIR sensors can be used as image-data collection needs warrant.

Headwall's Starter Kit™ includes gantry, illumination, and moving stage. It can be used with Hyperspec® sensors

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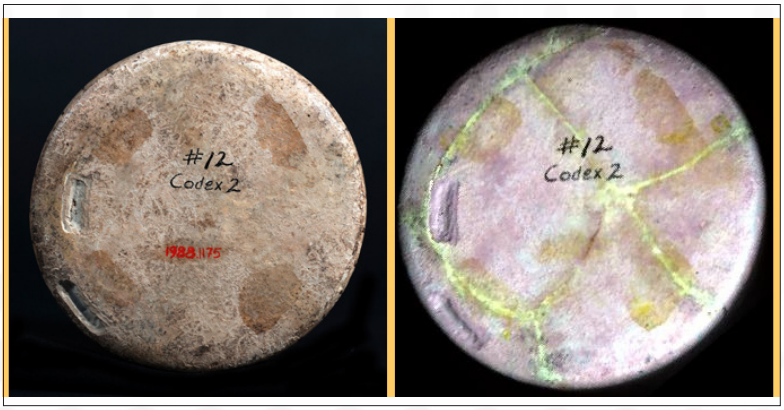
Headwall specializes in hyperspectral imagers that precisely analyze color, spectra and chemical composition. This is particularly useful for the detection and measurement of changes while also examining repairs and restorations. Headwall's Hyperspec® sensors are available for the VIS (380-825nm), VNIR (400-1000nm), Extended VNIR (550-1700nm), NIR (900-1700nm), and SWIR (900-2500nm) ranges. The sensors are used in conjunction with Headwall's advanced and easy to use Hyperspec® III software.

We present some examples of spectral imaging applied to Cultural Heritage.

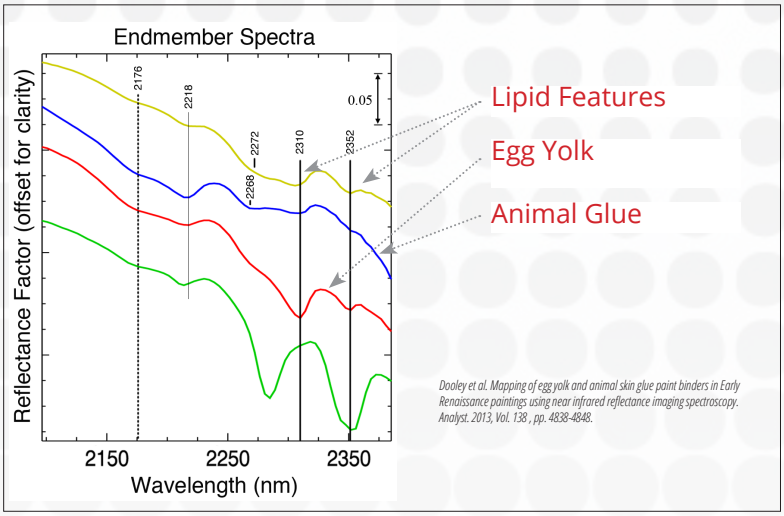
Mayan Vase

Chemical imaging shows that the bottom has significant repairs and that the restoration and original can be separated in SWIR and are chemically different. The restoration has been painted over and is not visible to the eye. Such data can provide information on past repairs that may not be documented.



Pigment and Binder Mapping

SWIR spectral image shows there are two different binders in this painting, animal glue and egg. Knowing the nature of the organic pigments binders is important to understanding the chemistry of changes in the objects as well as doing repairs using matching materials.



Historical Documents

The top image is a print of *The Gallows*, from a set of etchings by French artist Jacques Callot, titled "The Miseries of War." The collection is held by the Johnson Museum at Cornell University. Some very faint markings can be seen in the top image that are nearly invisible to the eye. Upon analyzing the VNIR hyperspectral data using Principal Components Analysis, it was evident in the bottom image that the markings were actually translations of the printed French captions.

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Starter Kits

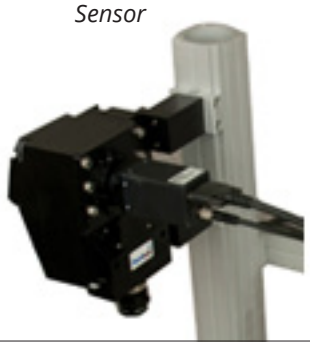
Headwall's starter kits are available in two versions: standard and large-format. The latter is perfect for large and heavy objects, providing a longer travel distance. In each case, the Starter Kits comprise a gantry to which the sensor (sold separately) is attached; a moving stage; noninvasive 'cold' illumination for the spectral range of interest; and full Hyperspec® III software for managing the incoming hyperspectral data into a 'datacube.'

Standard-format Starter Kit™ (VNIR or SWIR)

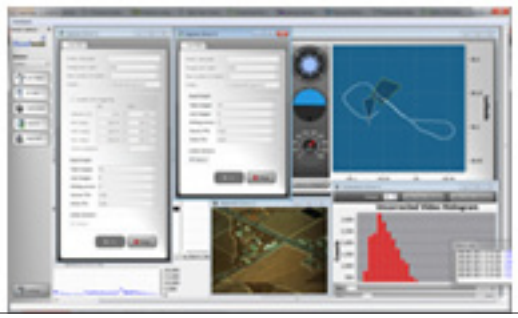
Large-format Starter Kit™ (VNIR & SWIR)

Illumination

Sensor

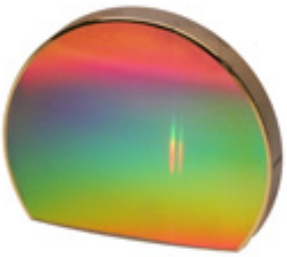


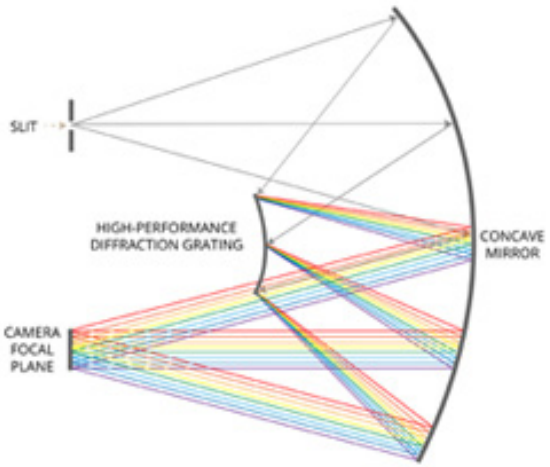
Hyperspec® III Software



Diffractive Optics

Headwall's Hyperspec® family of hyperspectral sensors feature attributes that are critically important to collection-care professionals. The mechanically simple design is based upon the science of *diffractive optics*, comprising gratings and mirrors. Every sensor contains a Headwall-manufactured high-performance diffraction grating, which manages incoming reflected light with exceptional precision. The design provides very high signal-to-noise (SNR), very high spectral and spatial resolution, low stray light, and aberration-corrected imaging.





About Headwall

With production facilities in North America and Europe, Headwall is the world's leading manufacturer of spectral imaging solutions for industry, remote sensing, government, and collection-care applications. Headwall's experience in optics is unsurpassed, leading to solutions that are precise, affordable, application-specific, and repeatable. Headwall is also ISO-9001:2008-certified.

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