

HYPERSPECTRAL IMAGING

ANDRÁS JUNG

COSCH Case Study that has employed this technology: Round Robin Test (chapter 8)

Definition

Hyperspectral imaging is the acquisition and processing of images of an object or scene in a hundred or more wavelength bands, typically spanning the visible and near infrared spectrum. The fine spectral resolution enables the identification of features and characterization of materials that would not be possible with systems which have fewer channels of broader responsivity.

Description

Hyperspectral imaging techniques are used in many scientific and industrial applications, both indoor and outdoor. Hyperspectral line-scanners have some limitations when the subject is moving or rapid measurement is needed or long-time illumination is not appropriate. To overcome these limitations a novel technique with increased light efficiency was developed with a non-scanning principle, which is called snapshot hyperspectral imaging or spectral frame camera technique. It enables the acquisition of the entire hyperspectral image during a single integration time (one shot takes about 1 ms). The latest snapshot hyperspectral imaging devices provide a rapid, high-quality and easy-to-use data acquisition for spectral object documentation.

Diffuse reflectance spectroscopy in the visible (VIS) and near-infrared (NIR) regions has been widely used in both the laboratory and *in situ* spectral measurement. Non-imaging spectroradiometers provide the highest available spectral resolution and therefore high information content for estimating material properties with multivariate methods. However, only measurements integrated over a single sampling region, determined by the aperture of the instrument, can be performed, which makes it difficult to analyse spatial variability. In contrast, a

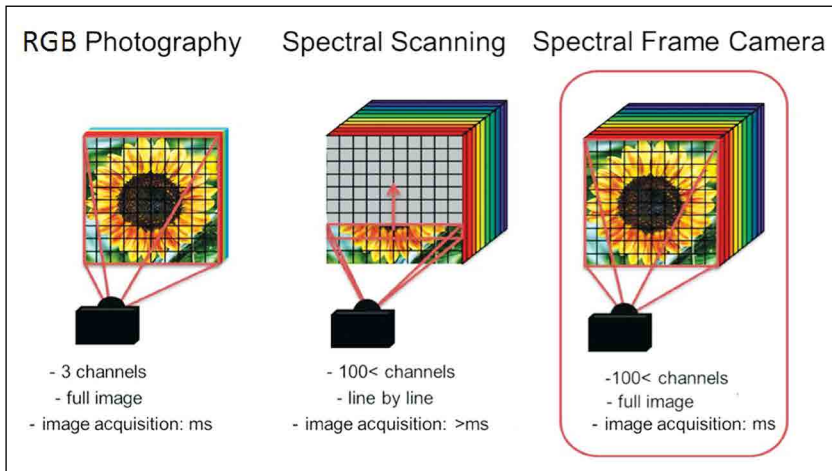


Figure 16.1. Comparison of three imaging approaches. Conventional RGB photography, spectral line-scan, spectral frame (snapshot) capture.
Image © Cubert GmbH, Germany, reproduced by permission.

spectral imaging system captures both the spatial variability and spectral content at each point of the scene.

Hyperspectral imaging has undergone considerable changes regarding data access, usability, and technology. When looking at the four dimensions (spectral, radiometric, temporal, and spatial) of proximal and remote sensing, the temporal resolution is in greatest need of improvement. Regarding usability and flexibility a snapshot (non-scanning) hyperspectral camera behaves like a normal digital camera, while the imaging result is a stack of component images corresponding to the line-scanner's data cube. Hagen et al. (2012) gives a detailed overview on how snapshot systems work and have been developed. Figure 16.1 shows the main differences and similarities between the three types of spectral imaging systems. Snapshot spectral cameras provide high-resolution spectro-temporal data and meet the general demand for high quality and easy to access hyperspectral data.

A snapshot spectral camera is generally designed to benefit from real-time data acquisition. In practice, a silicon CCD sensor with a resolution of 970×970 pixels captures the full frame images with a typical dynamic image resolution of 14 bits. In a normal sunlight situation, the integration time of taking one data cube, with more than 100 spectral channels, is about 1 ms. Such cameras can capture more than fifteen spectral data cubes per second, which enables hyperspectral video recording.

Significant Applications

The COSCH Action initiated a Round-Robin-Test (RRT) in 2013, coordinated by the Spectral Object Documentation working group (<http://cosch.info/wg1>). The aim of the RRT was to compare colour and spectroscopic measurements, by imaging the same four test objects in all participating laboratories. Information on calibration standards and laboratory setups was obtained for the diverse imaging devices. It was the first time that a snapshot hyperspectral camera was involved in a cultural heritage project (Picollo et al. 2016). Jung et al. (2015) used a snapshot hyperspectral camera to detect and analyse soil constituents under laboratory and field conditions to test predictive quantitative models. Whitley (2015) reviewed technological standards and availability for archaeological applications. He emphasized the spectral advantages of snapshot systems compared to traditional cameras.

Literature

- Hagen, N., Kester, R. T., Gao, L., Tkaczyk, T. S. 2012. "Snapshot Advantage: A Review of the Light Collection Improvement for Parallel High-dimensional Measurement Systems." *Optical Engineering* 51: 111702.
- Jung, A., Vohland, M., Thiele-Bruhn, S. 2015. "Use of a Portable Camera for Proximal Soil Sensing with Hyperspectral Image Data." *Remote Sensing* 7.9: 11434–48.
- Piccolo, M., Nascimento, S., Vitorino, T. 2016. "Spectral Object Documentation COSCH Working Group 1 Report on Activities 2012–14." *COSCH e-Bulletin*, 3. cosch.info/bulletin-3-2016.
- Whitley, T. G. 2015. "Unmanned Aerial Vehicles for Documenting and Interpreting Historical Archaeological Sites: Part II – Return of Drones." *Technical Briefs in Historical Archaeology* 9: 41–48.

This page intentionally left blank.