An Introduction to Hyperspectral Imaging

Bodkin Design & Engineering
77 Oak Street, Suite 201
Newton, MA 02464
(617) 795-1968
info@bodkindesign.com

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WHY DO WE CARE ABOUT SPECTRAL PROPERTIES?

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Because the world is a colorful place!

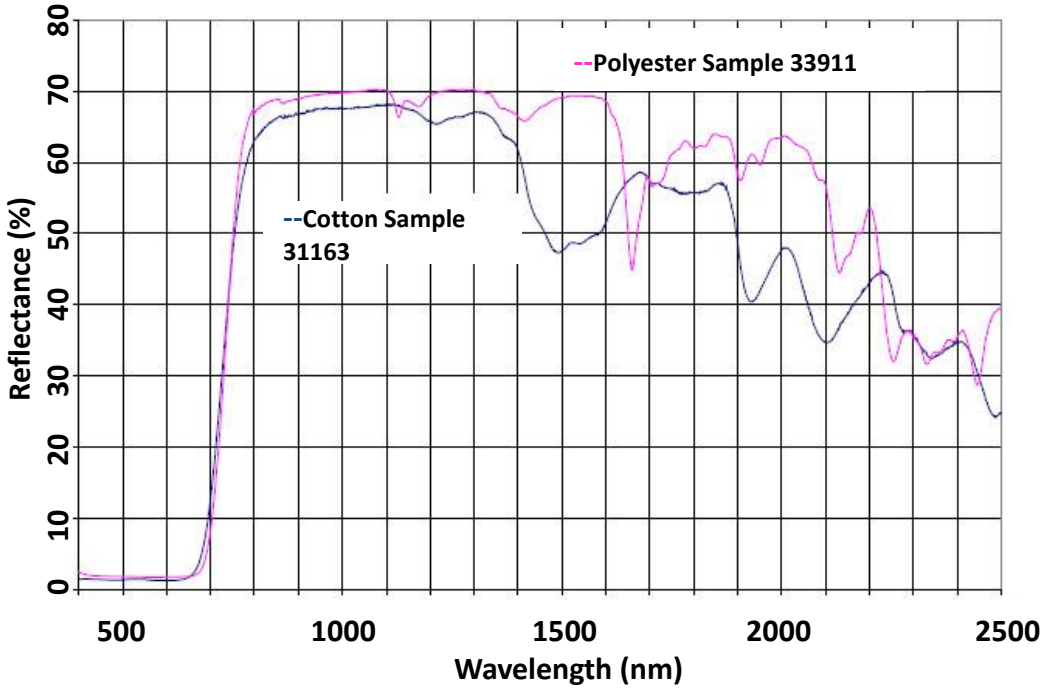
Spectral signatures provide clues to chemical composition of a target or scene (e.g. ‘green’ indicates chlorophyll).

In other words, spectral imaging allows us to learn what something is made of just by looking at it.

What is Spectral Analysis?

Example: Materials Identification

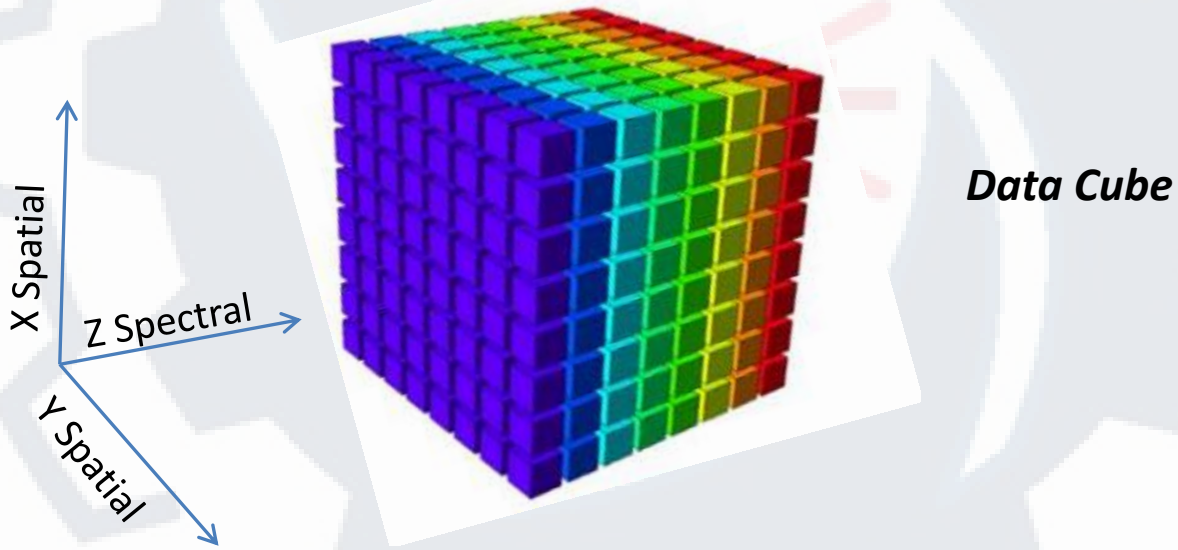
Cotton or polyester?



While the two shirts may look similar to the naked eye, a look at their *spectral signatures* reveals each is made from a different material.

What is a Spectral Image?

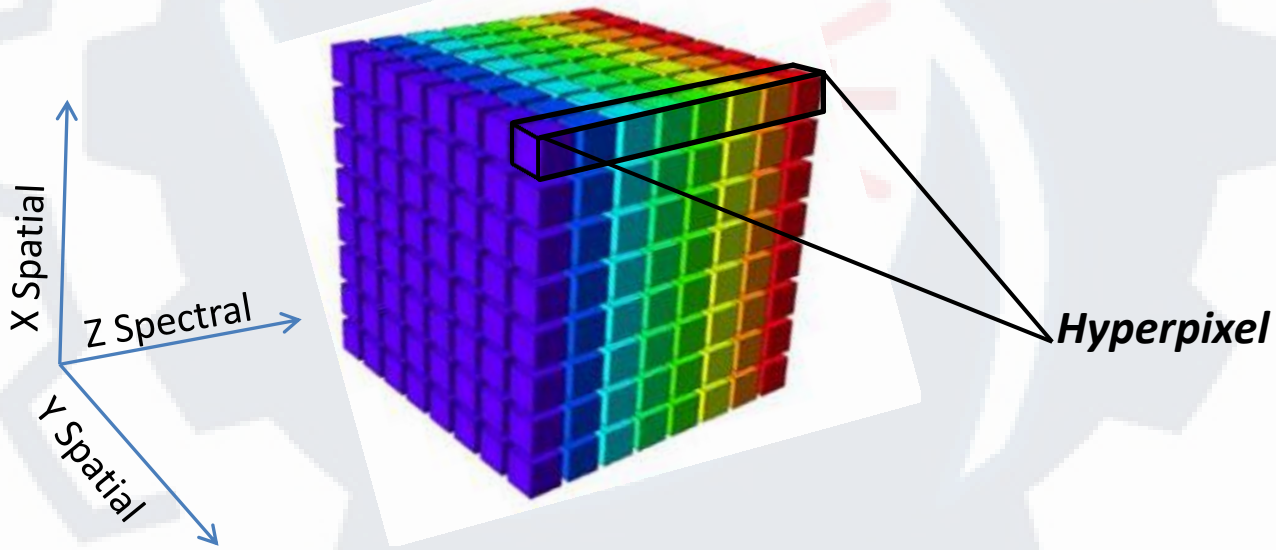
•A spectral image is called a ***Data Cube*** and contains the X & Y position of the scene, as well as the associated spectral data along a virtual Z axis



Data Cube

What is a Spectral Image?

- A spectral image is called a ***Data Cube*** and contains the X & Y position of the scene, as well as the associated spectral data along a virtual Z axis
- Each pixel in a captured scene that contains spectral data is called a ***Hyperpixel***



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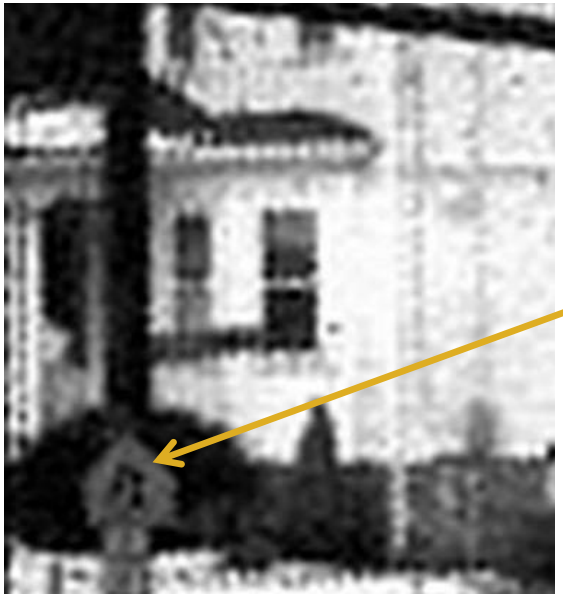
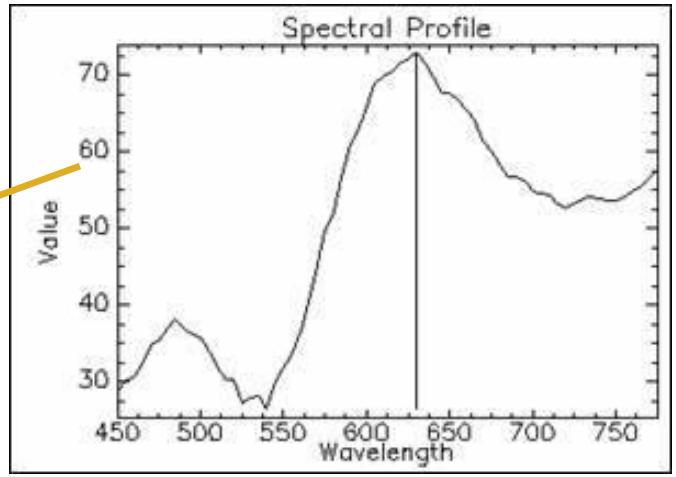
Scene imaged with a visible light camera

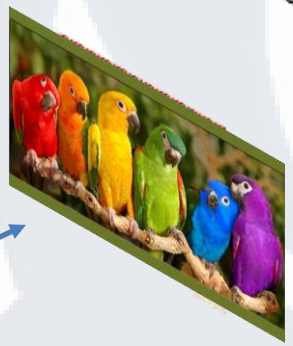
Scene imaged with a 20 wavelength Hyperspectral imager



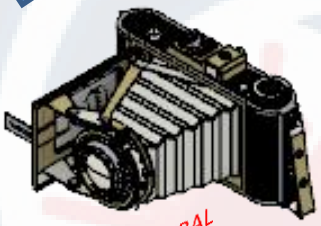
Spectrum of this spot on the image, in this case, the yellow paint used on the sign. The point's position in the image (X, Y) and spectral data (Z) combine to define this Hyperpixel.



How Does Spectral Imaging Work?

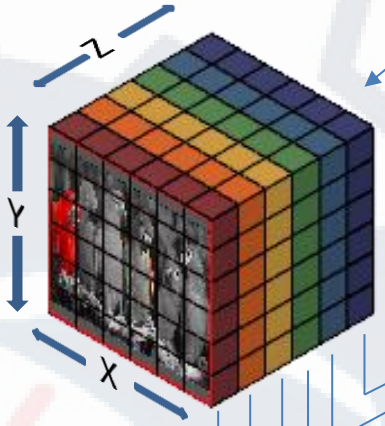


Scene



HYPERSPECTRAL IMAGER

IMAGER OUTPUT



SPECTRAL DATACUBE

COMPONENT OF IMAGE IN GIVEN SPECTRAL BAND

SPECTRAL BANDS

What Kind Of Imaging Systems Are Available?

All Hyperspectral imaging technologies tradeoff between *spatial resolution* (how many Hyperpixels there are), *spectral resolution* (how much spectral detail a Hyperpixel contains), and *speed* of acquisition. Below is a list of technologies and their respective pros and cons.

Hyperspectral Imagers

TECHNOLOGY	PROS/CONS
Slit Scan Spectrometer	
A slit spectrometer is fitted with a 2D focal plane array (FPA). The slit is scanned over the scene and a data-cube is built up over time.	Requires a stationary platform, or active stabilization, and a slow-moving scene. Can build up large data-cubes, but very slow.
HyperPixel Array	
An array of spectrometer slits are laid over 2D scene. Data-cubes are captured instantaneously.	Good for unstable platforms, rapid events. Can collect hyperspectral video. Precise spectral spatial correlation. Limited spatial resolution (trade-off with spectral resolution)
Linear Variable Filter	
A spatially varying bandpass filter is laid over an FPA. Data-cube is built up by scanning over the scene.	Requires a stationary platform, or active stabilization, and a slow-moving scene. spectral and pointing accuracy are linked - leads to spurious signals.
Tunable filter	
An electronically variable bandpass filter is placed in front of a camera. Data-cube is built up by scanning over the wavelengths.	Requires a stationary platform, or active stabilization, and a slow-moving scene. Reduced set of spectral channels can be selected for known targets speeding up acquisition. Suffers from low optical transmission.

What Kind Of Imaging Systems Are Available?

Multi-Spectral imagers are lower-spectral resolution instruments that typically detect under 25 spectral bands. These systems are useful for identifying certain types of targets, such as water or chlorophyll.

Multi-Spectral Imagers

TECHNOLOGY	PROS/CONS
Filter Wheel	
A series of narrow-band filters are rotated in front of a camera. A data-cube is built up over time.	Requires a stable platform, and a slow-moving scene. Best for limited target set.
Filter Array	
An array of narrow-band filters are laid over an FPA. Data-cubes are captured continuously.	Good for unstable platforms, rapid events. Can collect spectral video. Limited spectral coverage (9 to 25 colors)
Multi-band imaging	
Beam splitters and bandpass filters behind a single lens direct the image onto different FPAs.	Good for unstable platforms, rapid events. Limited number of colors. Often combined with IR FPAs
Multi-aperture imaging	
A set of individual cameras with bandpass filters.	Good for unstable platforms, rapid events. Limited number of colors. Often combined with IR FPAs

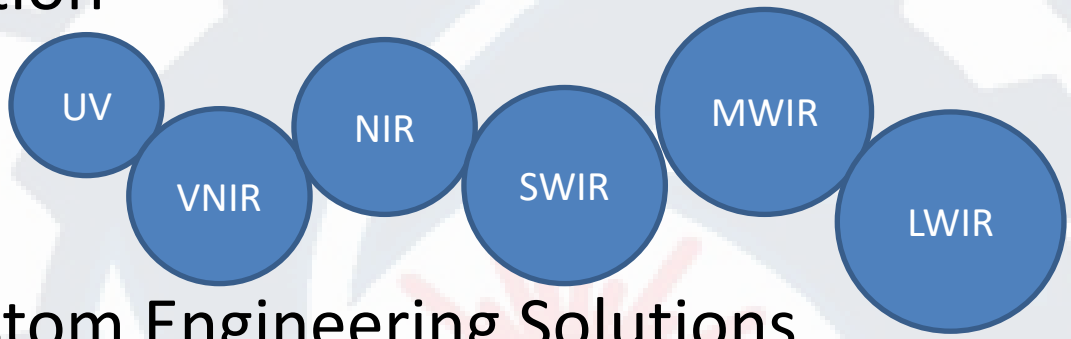
Summary

Required system *speed* is determined by how quickly the target or camera will be moving
Required system *spatial* resolution is determined by how varied the target scene is
Required system *spectral* resolution is determined by the type of analysis that must be made
Special purpose devices can be designed that find the sweet spot between these parameters

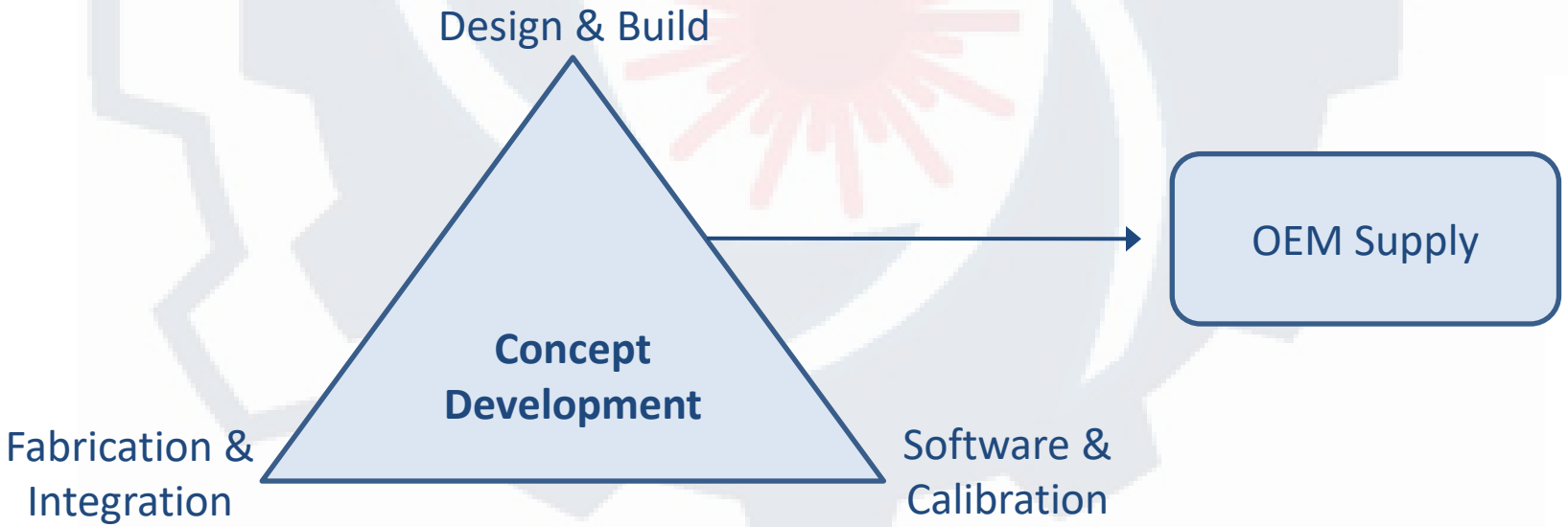
TECHNOLOGY	Speed	Stability	Spatial Resolution	Spectral Resolution
Slit Scan Spectrometer	Slow	Low	Hi	Hi
HyperPixel Array	Fast	Hi	Low	Hi
Linear Variable Filter	Slow	Low	Hi	Moderate
Tunable Filter	Variable	Low	Hi	Moderate
Filter Wheel	Moderate	Low	Hi	Hi
Filter Array	Fast	Hi	Moderate	Low
Multi-band imaging	Fast	Hi	Hi	Low
Multi-aperture imager	Fast	Hi	Hi	Low

Solutions for Every Application

- Spectral imagers for every wavelength and application



- Full Custom Engineering Solutions



We're Here For You.

Make Bodkin Design your ***first*** choice for creative & affordable, full-scale Hyperspectral Imaging system design, implementation, and support.

Email us at
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