

Hyperspectral Imaging

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CIRCULAR ECONOMY UAS



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Have you ever observed the rainbow on a rainy day? This beautiful phenomenon where raindrops act as millions of small prisms makes an important characteristics of sunlight visible. Sunlight consists of electromagnetic waves with many different wavelengths, some of which in the rainbow we can see as colors.



Content

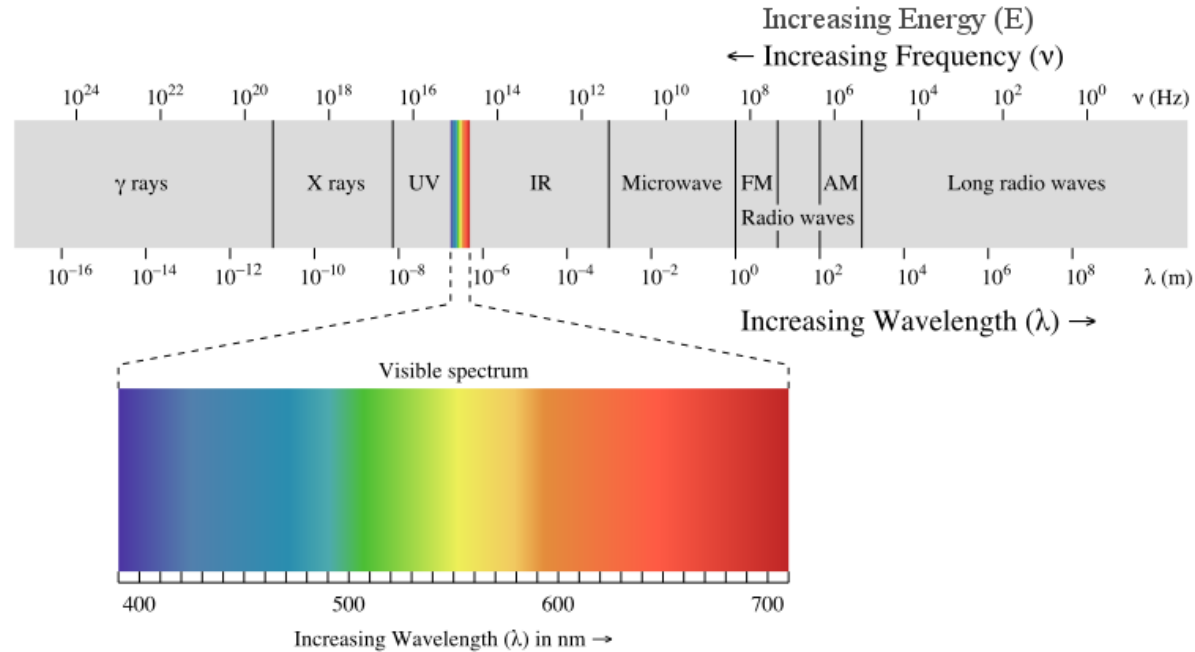
- Spectral Image Basics
- Benefits of Spectral Imaging
- Data Acquisition
- Application Example
- Other Applications
- Video Content





Spectral Image Basics

The Electromagnetic Spectrum



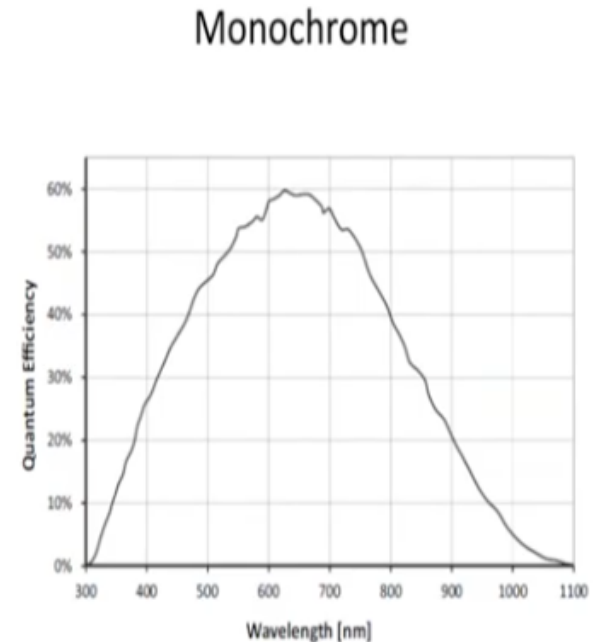
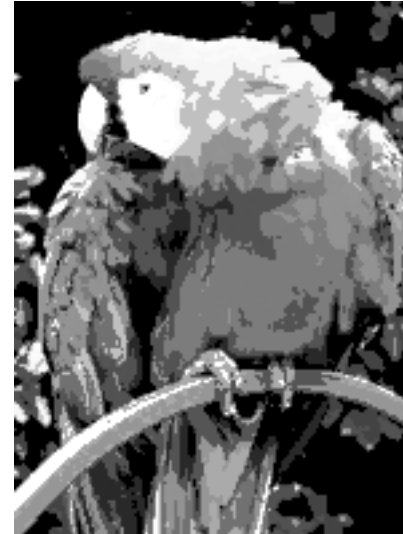
source: http://en.wikipedia.org/wiki/File:EM_spectrum.svg
author: Philip Ronan

We can see only very small part of it with our human eyes. Roughly between 400 and 750 nano meters. On the lower end of the spectrum it extends to ultra violet and on the other end above red it extends to the infra red region of the spectrum



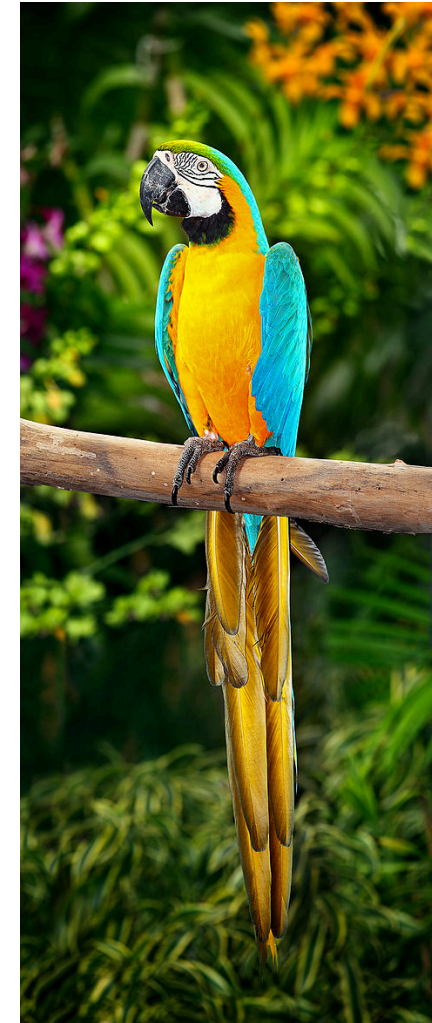
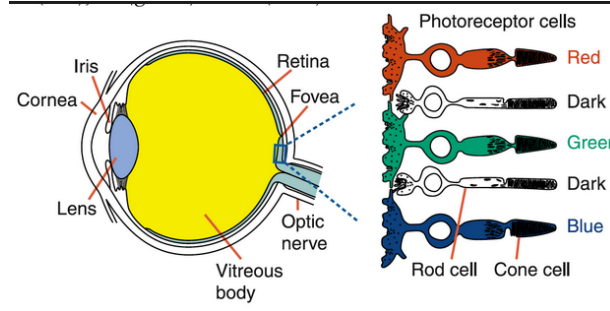
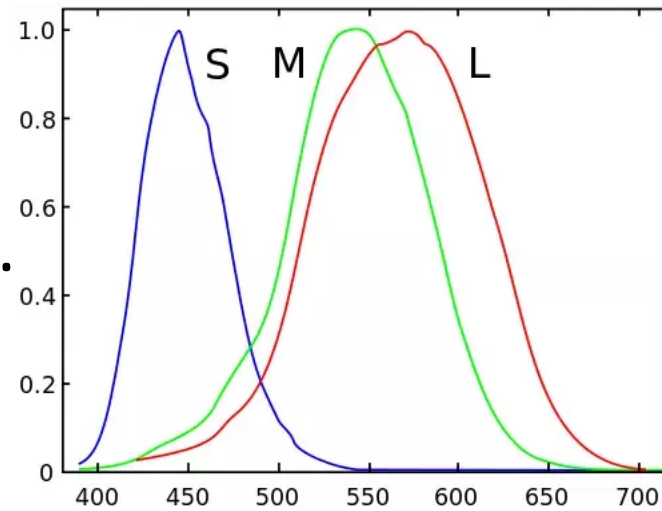
The Visible Spectrum - The World is Grey

- If we have only one receptor in a visible range, we would see the world in different shades of grey.
- We would not see different colour because we would not be able to differentiate different colours.
- This would be a pretty boring world.

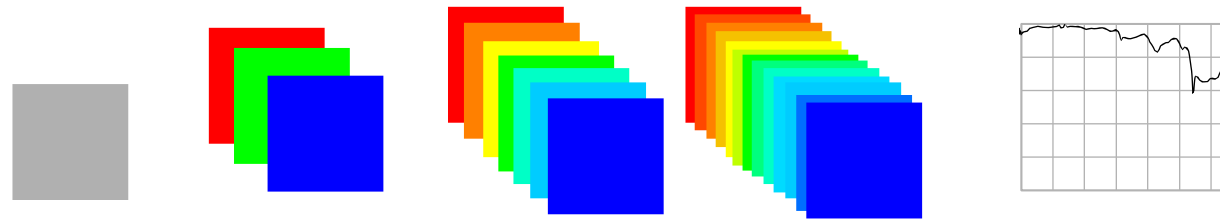


The Visible Spectrum - Human Vision

- Human visual system has three so called cones: a short cone (S), medium cone (M) and long cone (L).
- Because of this three receptors we can see colours. Our brain brings this together.
- Colour imaging sensor works pretty much the same way



Spectral Imaging Basics - Overview



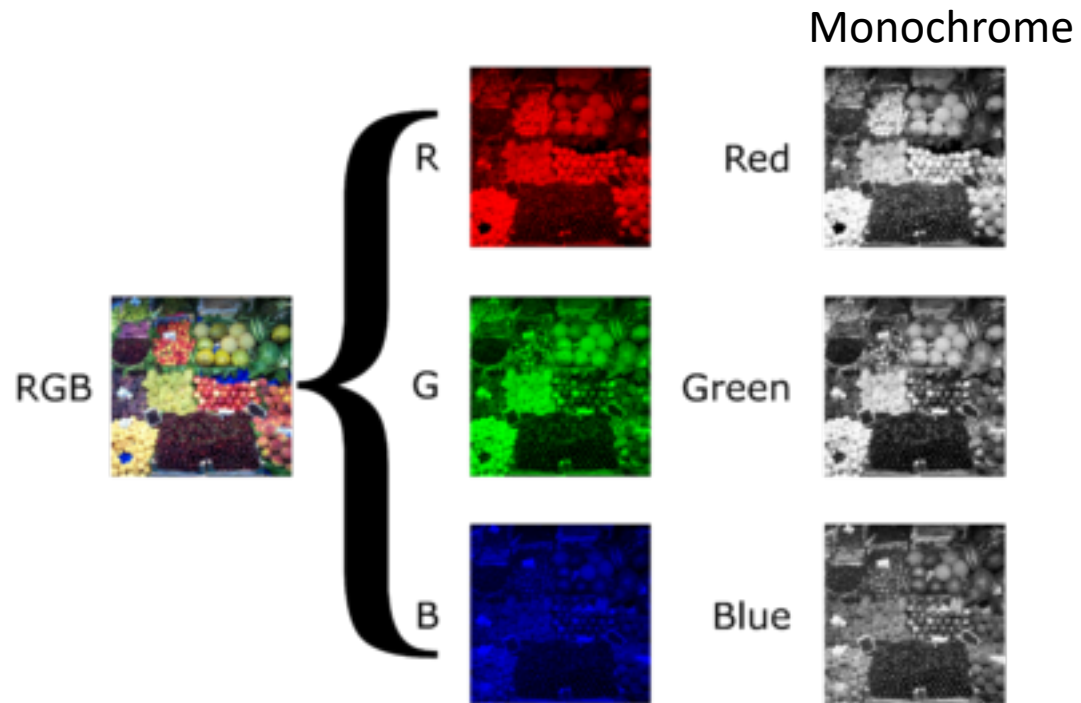
	Monochrome	RGB	Multispectral	Hyperspectral	Spectroscopy
Spatial Information	yes	yes	yes	yes	no
Band Numbers	1	3	2 - 10	>10	continuous
Spectral Information	No	limited	Yes	Yes	Yes





Benefits of Spectral Imaging

Benefits of Spectral Imaging



- More information



Benefits of Spectral Imaging

The more spectral data, the more information

- Differentiation of material
- Identification of material characteristics
 - Determination of water content
- Material composition



Data Acquisition

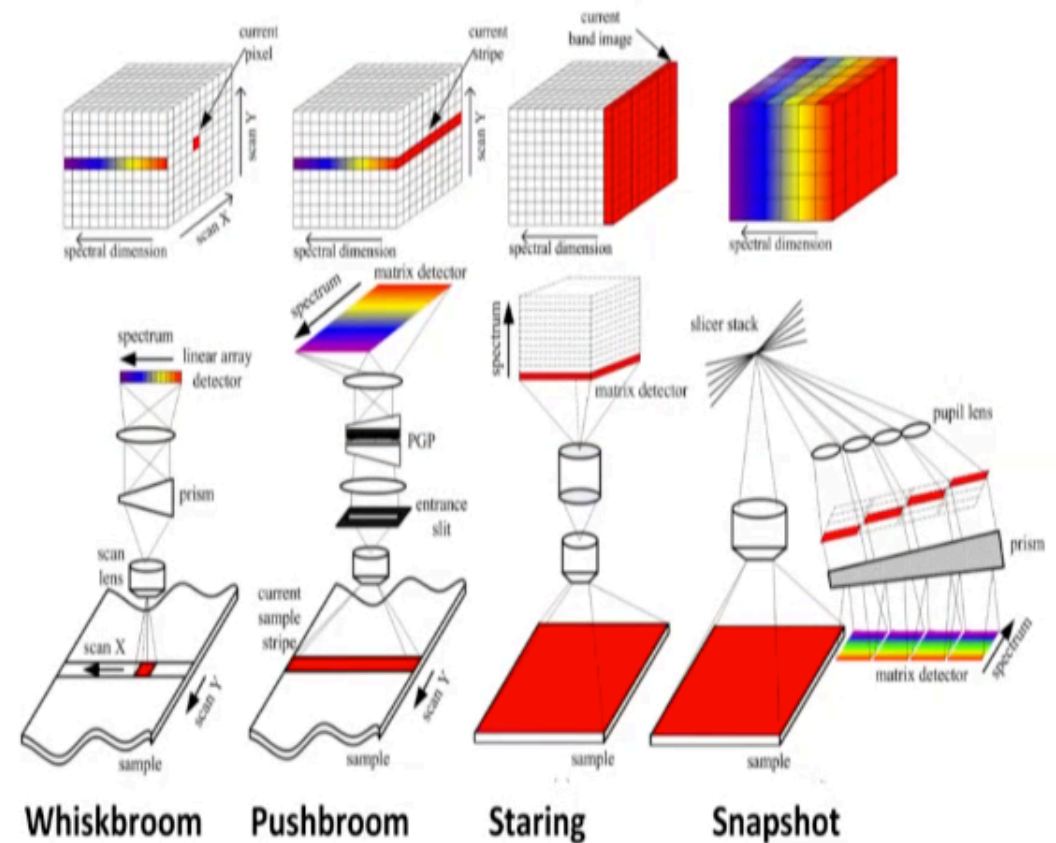
Hyperspectral Imaging Data Acquisition

Whiskbroom: Observe region pixel by pixel like using whiskbroom for cleaning floor and then extracting spectral information to line sensor. Not used much anymore.

Pushbroom: Observe one line at a time. Scan the sample line by line or the sample itself moves under this line. Nyperspectral data cube is build.

Staring: Take sample picture by picture with different filter.

Snapshot: With one shot spatial and spectral information. Requires quit sophisticated arrangement of mirrors and lenses.



Application Example

Application Example - 3 White Powders

Three different powders. Just by looking it is not possible to distinguish any.



Source:

h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
Optotechnik und Bildverarbeitung (OBV)
Christian Günther
Frank Friebl
Prof. Dr. Heckenkamp

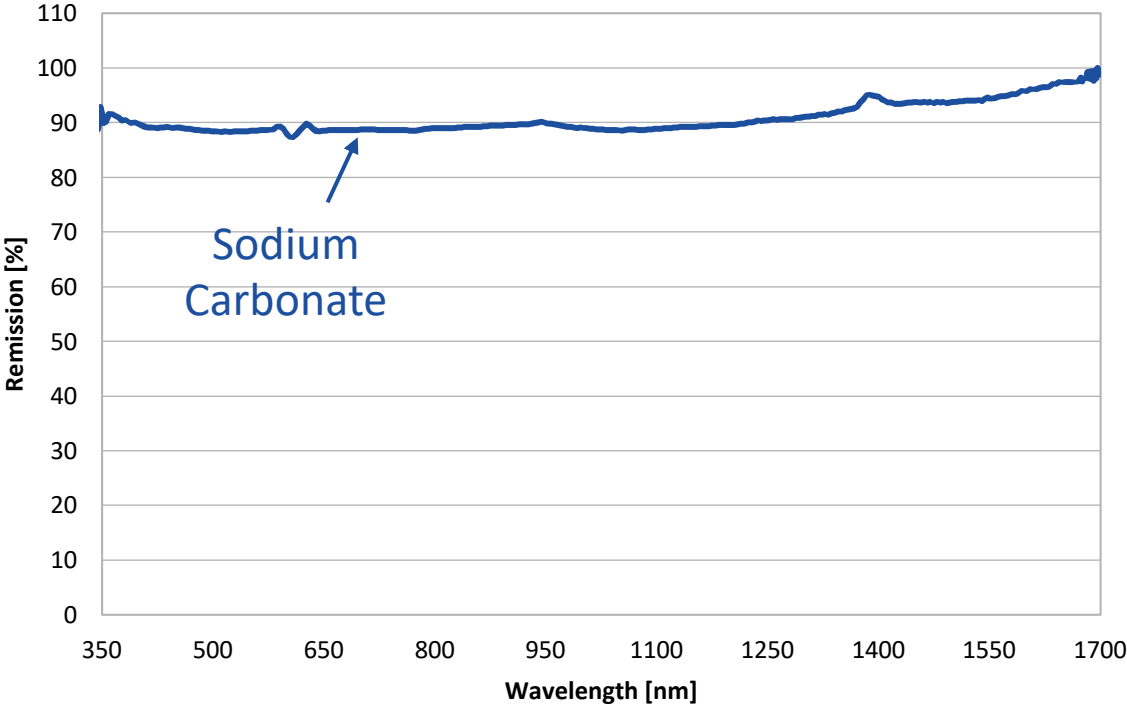


Application Example - 3 White Powders



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Use Spectral Information

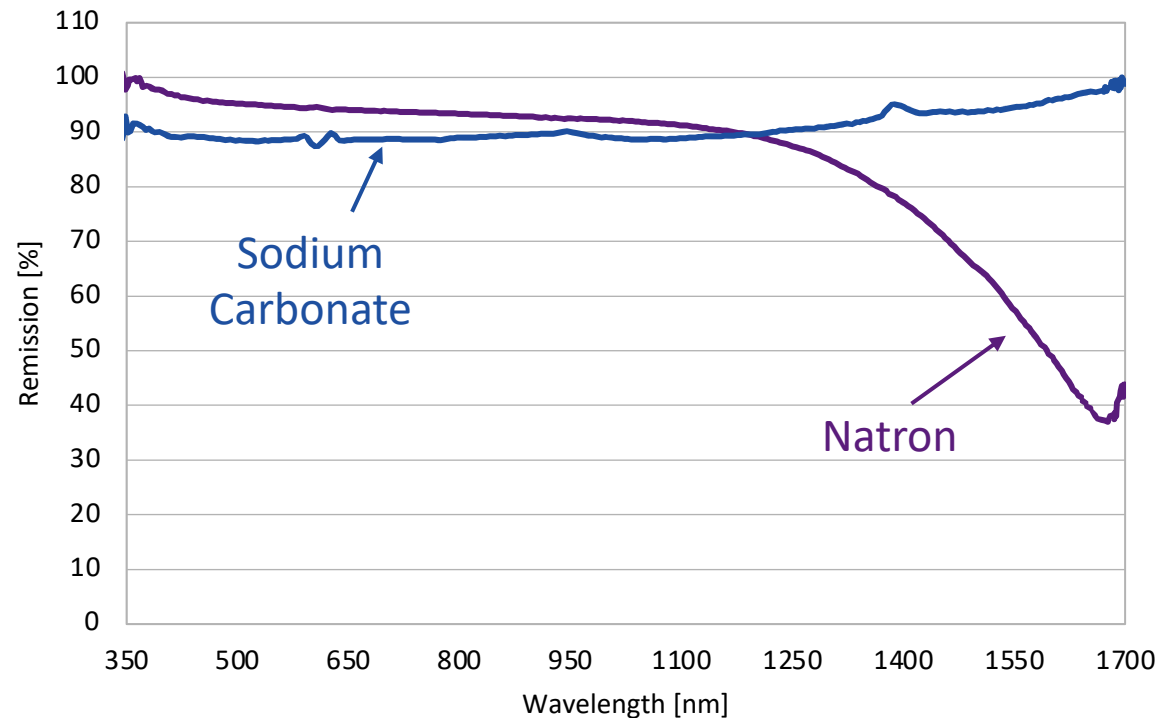


Application Example - 3 White Powders



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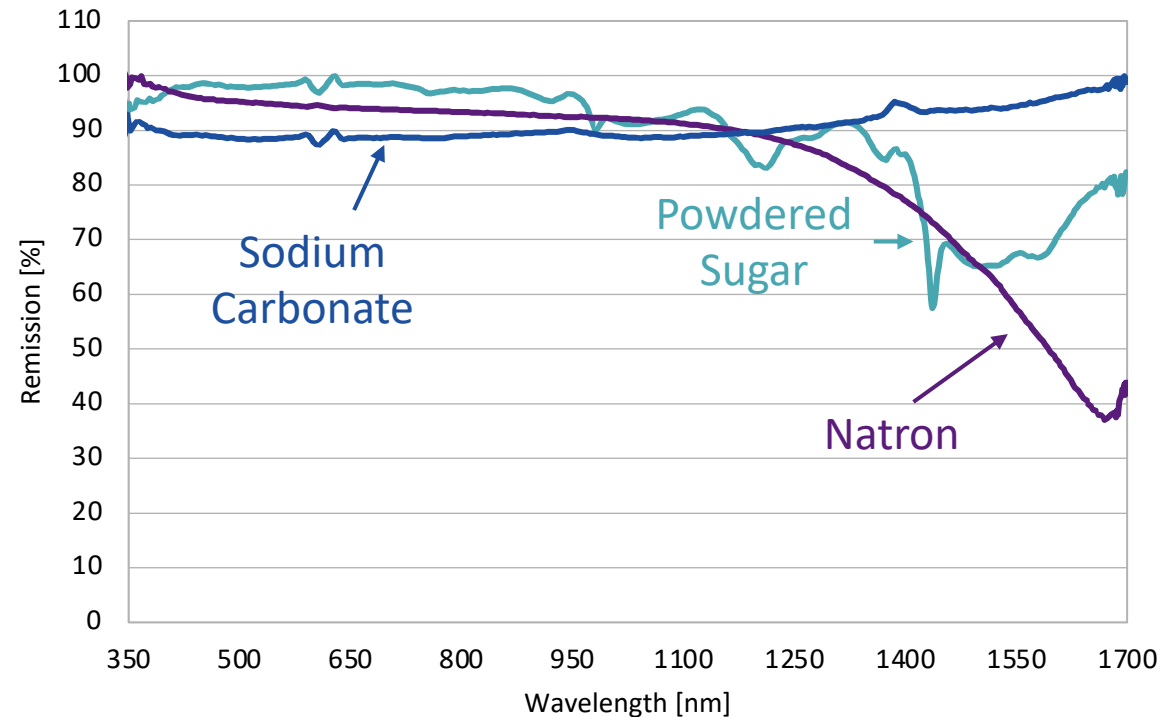


Application Example - 3 White Powders

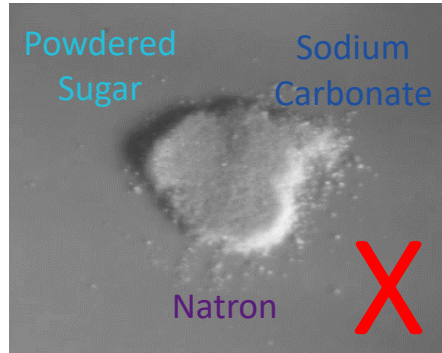


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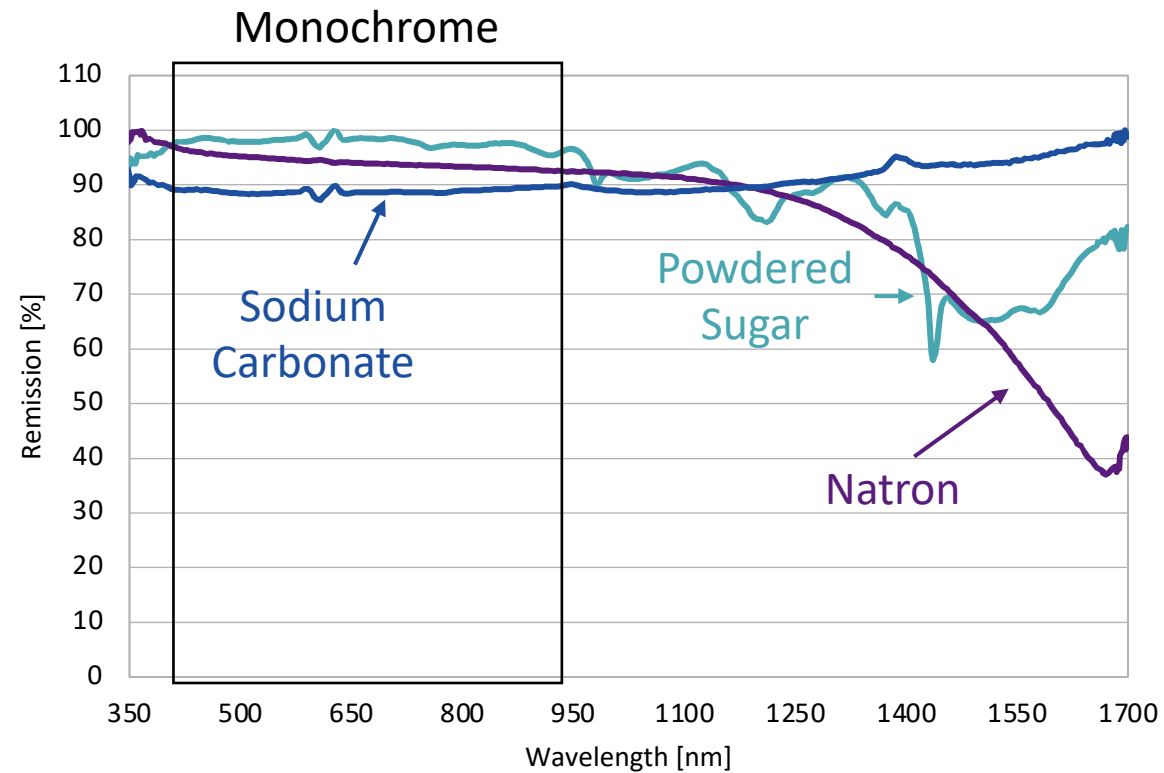
Use Spectral Information



Application Example - 3 White Powders



We have spectral data each of the material recorded.

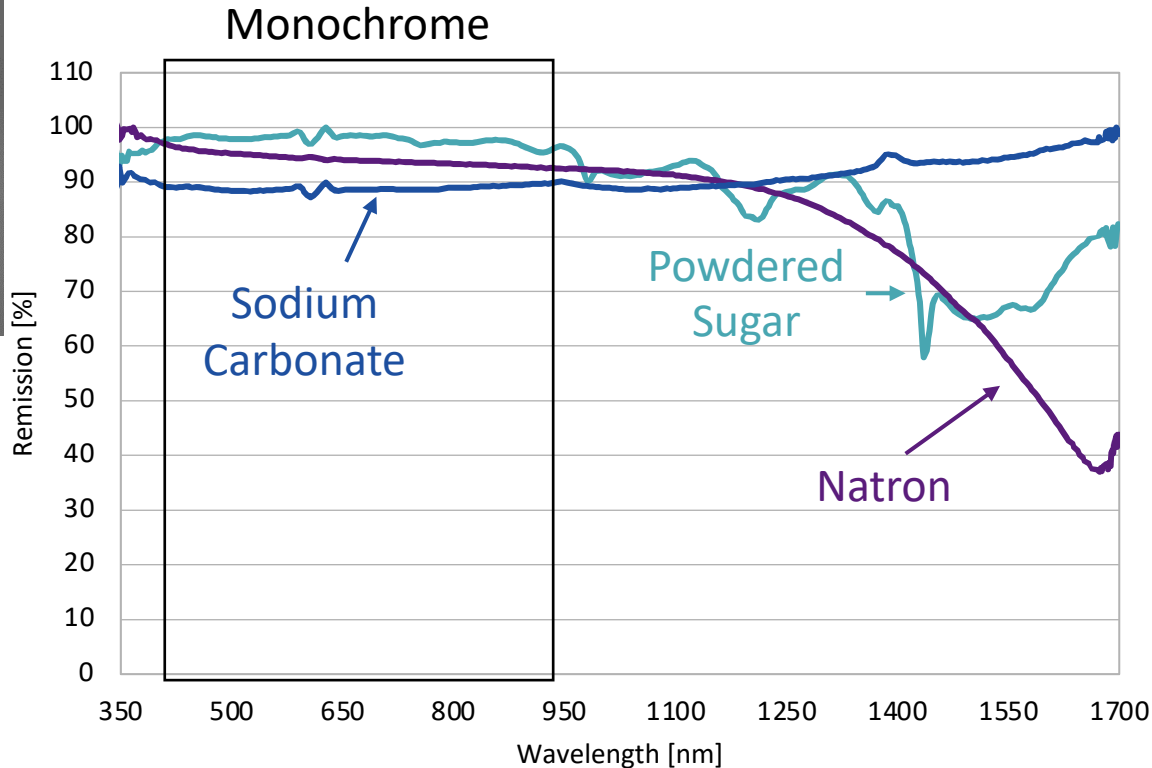
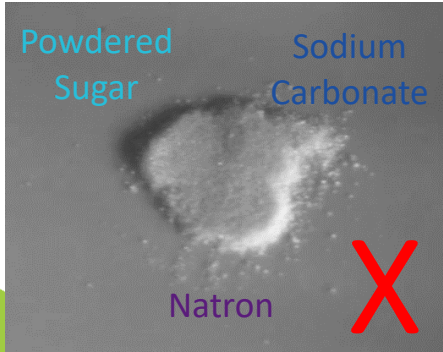


Typically curves are uninteresting in the visible range but come more interesting in IR-range. Sodium carbonate: Spectrum is pretty flat over wide range of wave lengths Natron: Flat in the beginning but drops suddenly after 1000 nm. Sugar: Flat in the beginning but more interesting above 1000 nm.

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Application Example - 3 White Powders

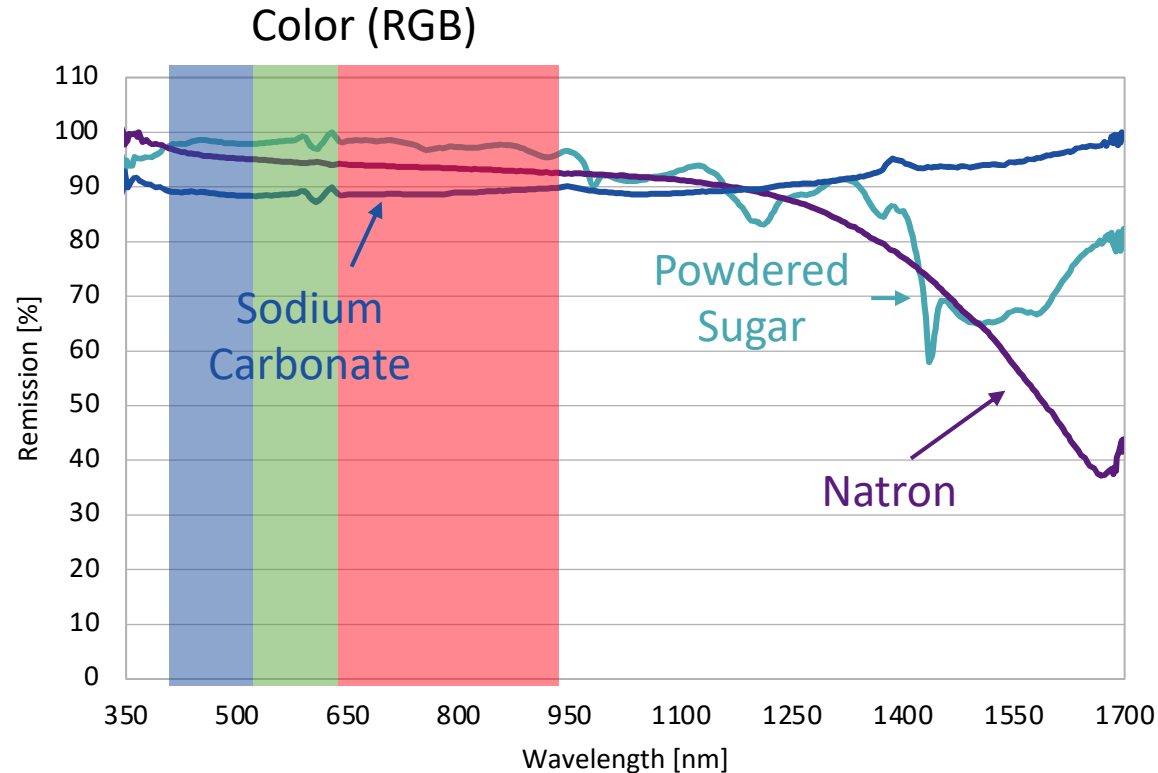
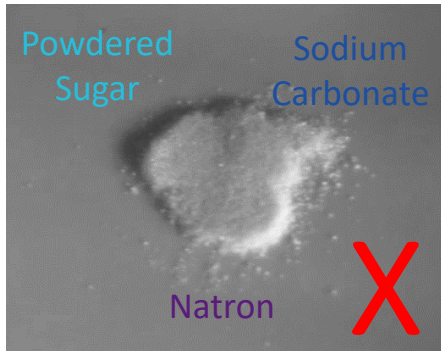


This is an interesting characteristic of many materials. We don't see very interesting spectral curves in the visible range but if we look at the infrared spectral range curves come very interesting and we start to be able to separate materials. This would not be possible if we just look the visible range. If we look at those powders in regular monochrome sensor, as expected we can't differentiate them. All curves are pretty much flat in this region, which means that the sensor is quit saturated.

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Application Example - 3 White Powders

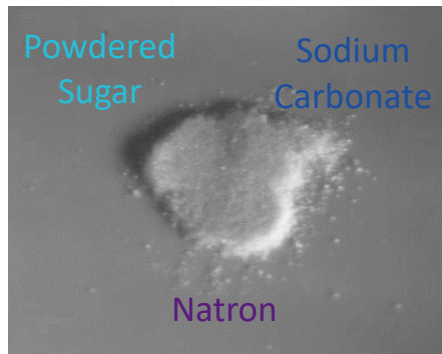


If we take a colour imager and try to differentiate the powders with three RGB-filters, we still not see any distinguish possible.

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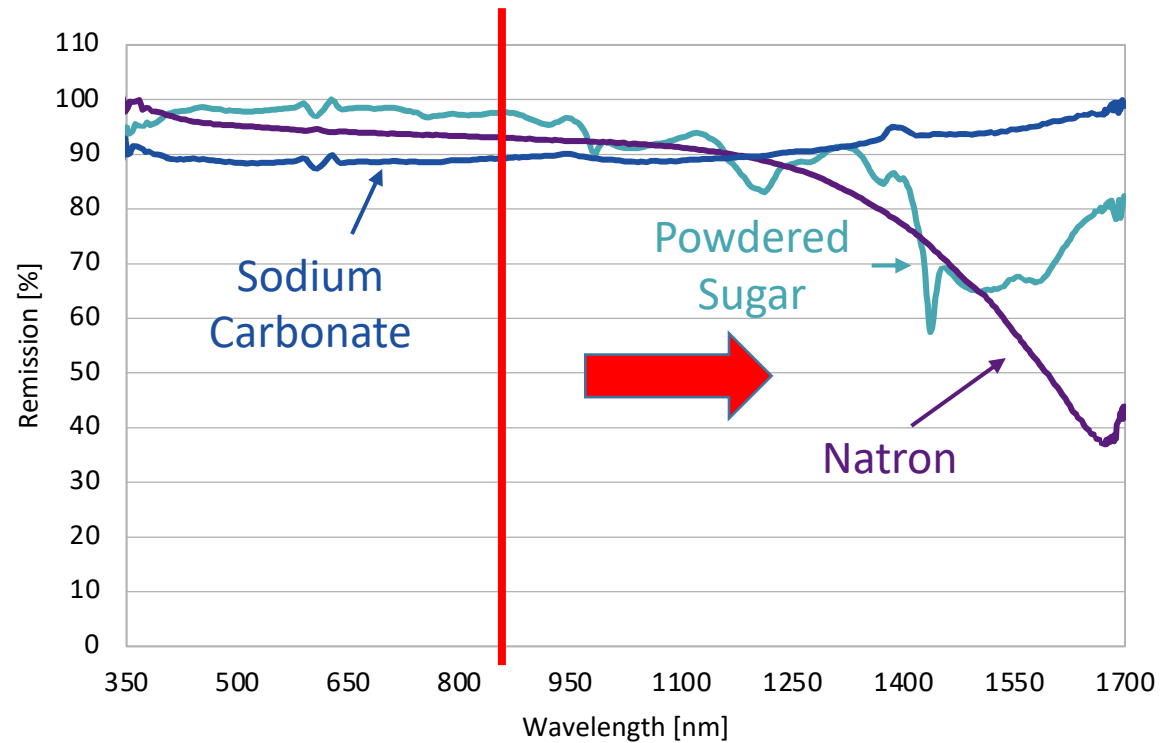


Application Example - 3 White Powders



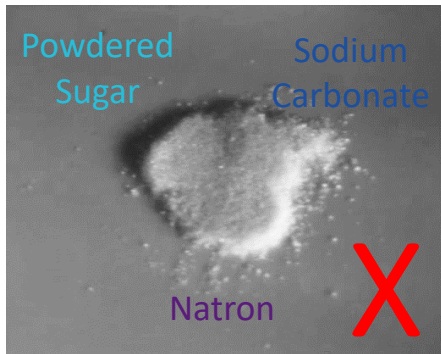
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Consider Infrared



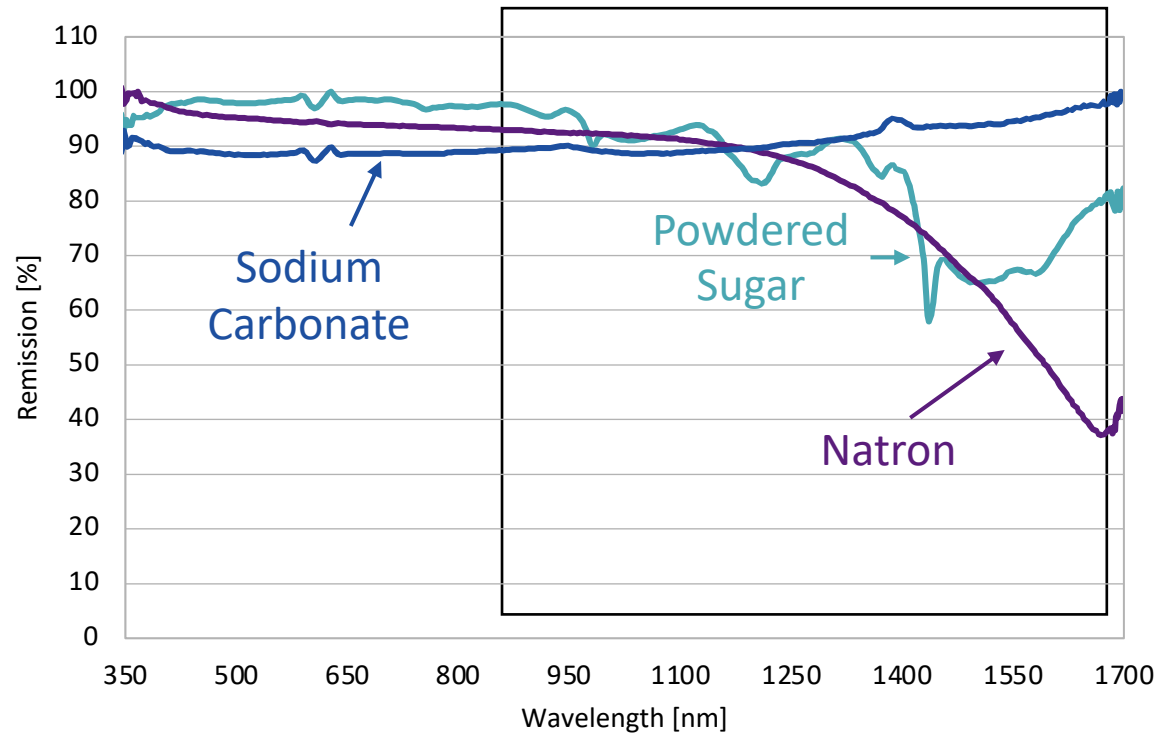
Application Example - 3 White Powders

SWIR



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SWIR



If we take short wave infrared camera SWIR-camera, we hope to be able to distinguish them, but it is not possible.

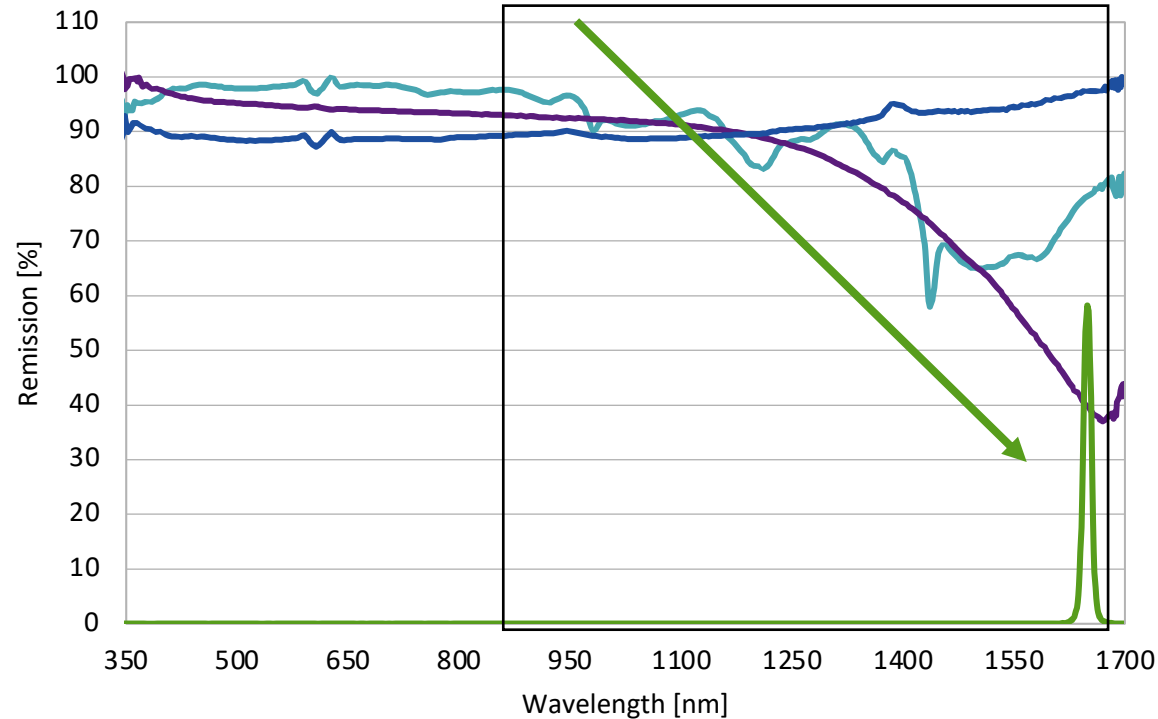
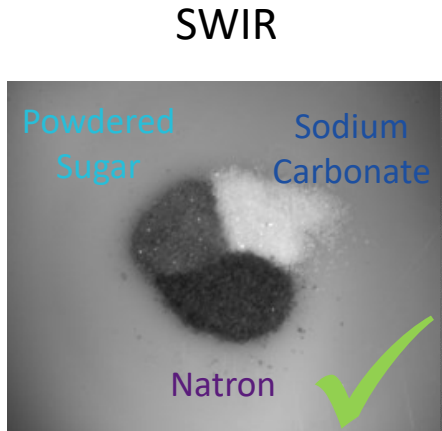
Reason for this is that at the lower part of SWIR all signals are very high. All three substances are able to saturate the signal. What can we do now?



Application Example - 3 White Powders

Choose bandpass filter

SWIR



We take a very narrow bandpass at 1650 nm with width only 35 nm. Suddenly the picture changes

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Application Example - 3 White Powders

SWIR



We are now able to distinguish the three powders quite clearly. Sodium carbonate has still quite a strong signal and is quite saturated. Powder sugar is somewhere between the two other substances, we see as grey. Natron drops a lot and is seen as black. You don't always need to observe the whole spectrum. Sometimes it can be enough if you know exactly what you want to do the substances you want to separate it is possible to use just one filter.

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Sometimes a filter is all it takes

SWIR



You don't always need to observe the whole spectrum. Sometimes it can be enough if you know exactly what you want to do the substances you want to separate it is possible to use just one filter.

Depending on task, one filter can be enough
Can be a small and robust solution for easy integration
A hyperspectral solution reduced to one relevant bandpass

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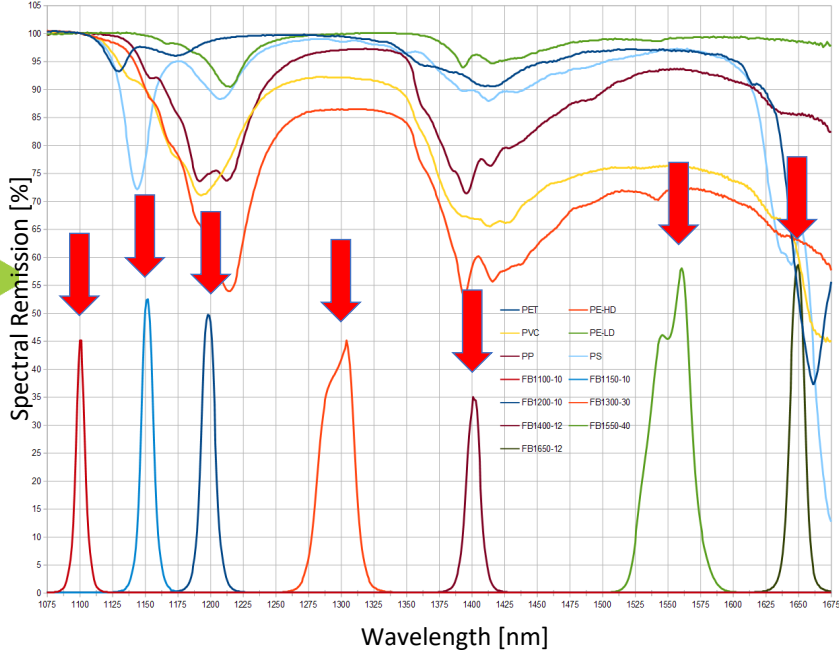


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And sometimes a multi/hyperspectral solution is require

Identification of recyclable plastics



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Separation of Recyclable Plastics



Spectral curves of different plastics. Here it would not possible to use just one filter to differentiate. Curves are too similar. Here we could use for example seven filters and we could be able to distinguish quit many of the plastics. It's always very specific how many filters are needed.



Other applications

Food sorting

- Detection ripeness
- Detection of impurities, foulness



Recycling

- Separation of plastics
- Waste separation
- Separation of building materials



Agriculture/Farming

- Detection of moisture content
- Detection of nutrients



Other applications

Aerial sensing

- Mineralogy
- Reconnaissance
- Space exploration



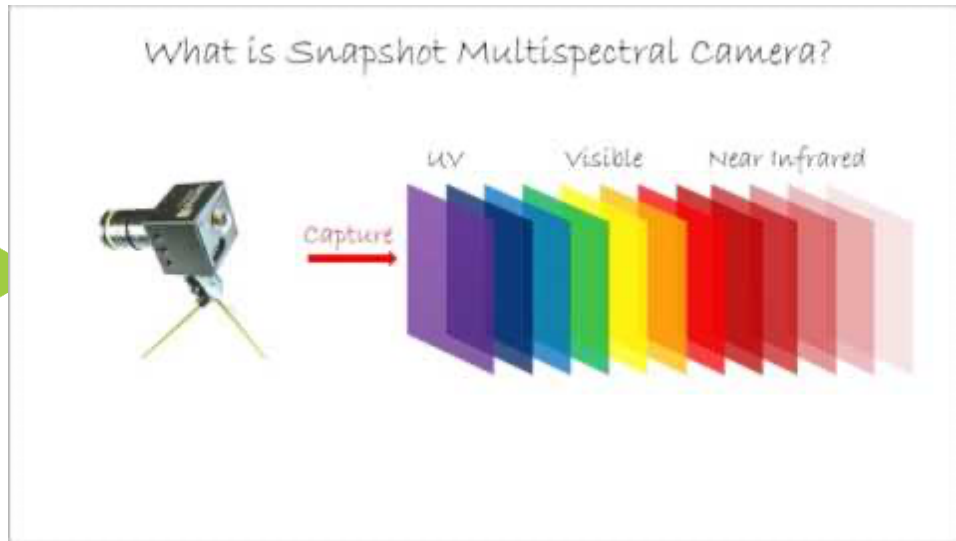
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Video Content

Video content



Multispectral Camera Technology by Spectral Devices Inc.



Multi- and hyper-spectral imaging by Mittuniversitetet



Video Content



Introduction to Hyperspectral Remote Sensing
by NEON Science

- **Hybrid of Spectroscopy and Imaging**
Best of both worlds: detailed information on *chemical identity and spatial location*

- **Also Known As**

- Hyperspectral imaging
- Imaging spectroscopy
- Chemical imaging

- Multispectral imaging



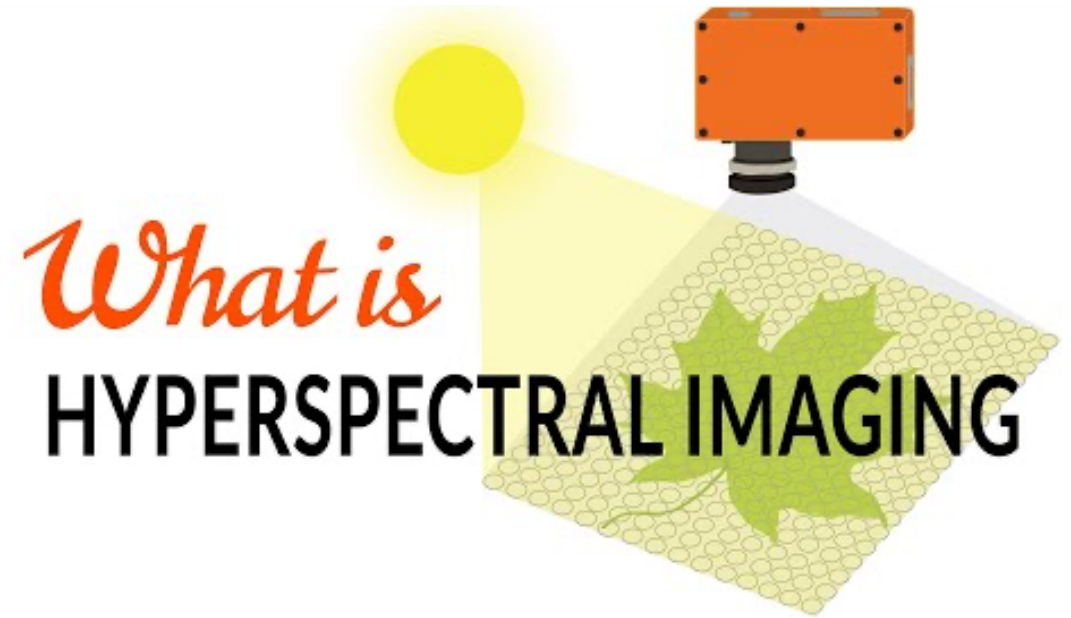
Multispectral and Hyperspectral Imaging for
Plant Science by Analytik Ltd



Video Content



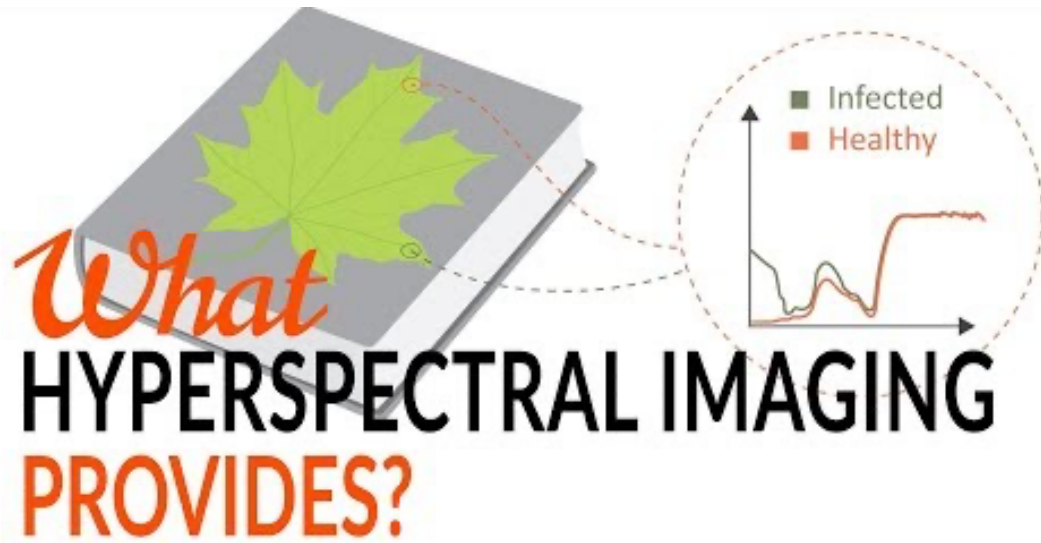
How Specim line scan hyperspectral cameras work



What is hyperspectral imaging - Tutorial



Video Content



What Hyperspectral Imaging provides - Tutorial



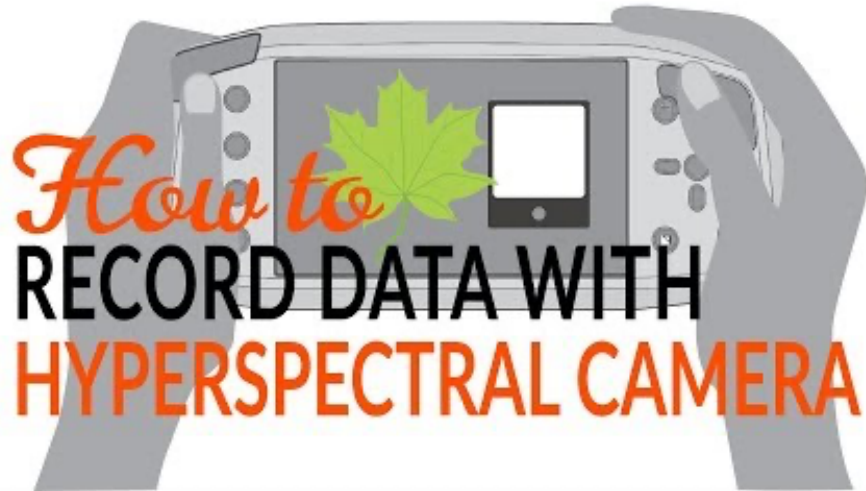
HOW TO KNOW YOUR
WAVELENGTH RANGE?

A thumbnail for a video titled "HOW TO KNOW YOUR WAVELENGTH RANGE?". It features a colorful, abstract geometric design with overlapping triangles in shades of purple, blue, orange, and green.

How to to know the right wavelength range



Video Content



How to record data with hyperspectral camera - Tutorial

A graphic with a colorful geometric background of overlapping triangles in shades of orange, purple, blue, and green. The text 'SPECIM' is in large black bold letters. Below it is a red circle followed by 'LIVESTREAM' in black bold. At the bottom, 'Q&A WITH MATHIEU & JEFF' is written in black bold.

SPECIM
● LIVESTREAM
Q&A WITH
MATHIEU & JEFF

Sorting food with hyperspectral imaging



Video Content

SPECIM

● **LIVESTREAM**

**Q&A WITH
MATHIEU & JEFF**



Sorting plastics with hyperspectral imaging

**HOW TO KNOW YOUR
WAVELENGTH RANGE?**



How to to know the right wavelength range

