

Non-linear image processing for hyperspectral images



Hilda Deborah

Colourlab

Department of Computer Science

Norwegian University of Science and Technology - NTNU

What is a hyperspectral image?

- ✓ Spatial coordinates
- ✓ Spectral dimension
- ✓ Correlated wavelengths

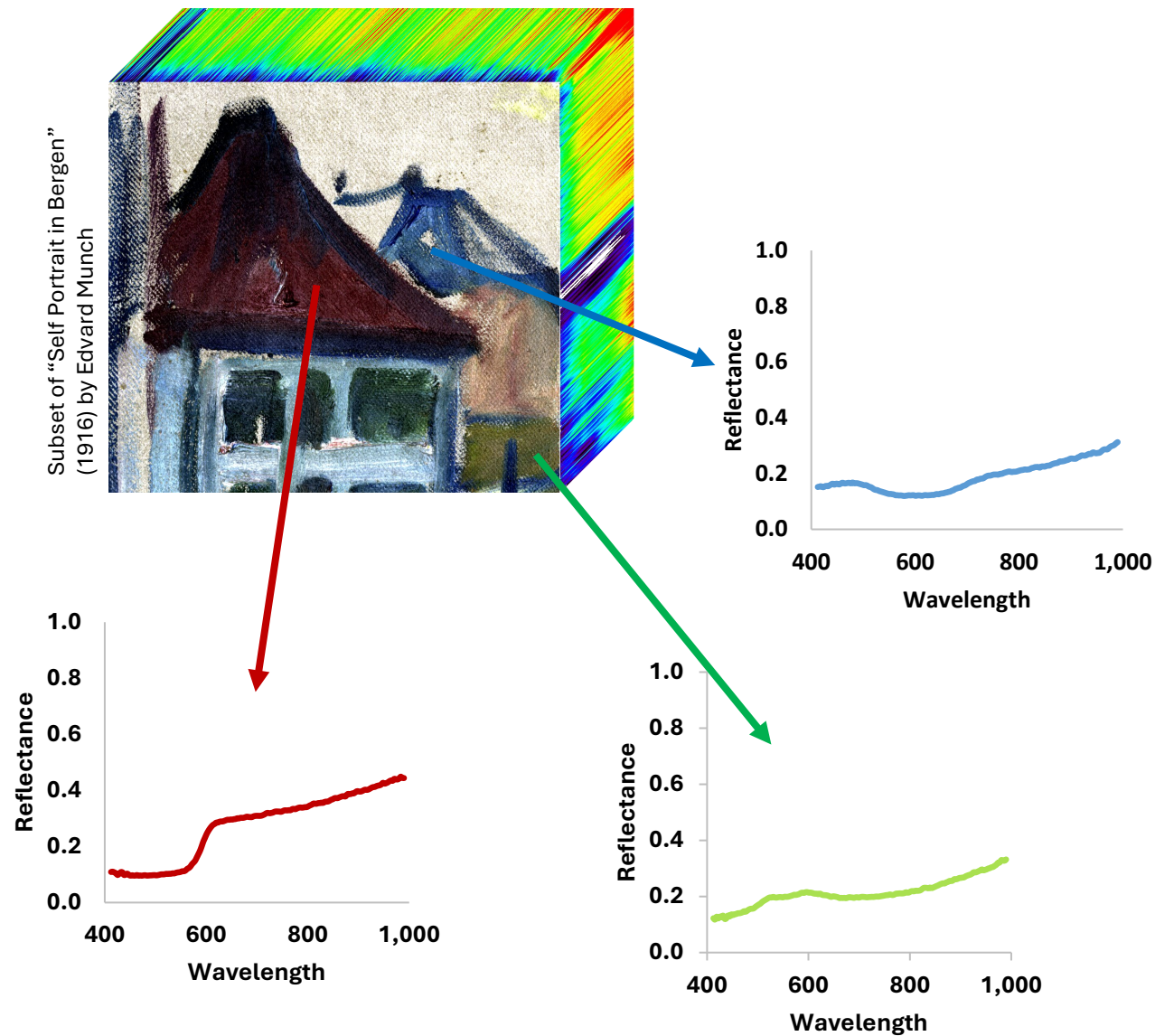
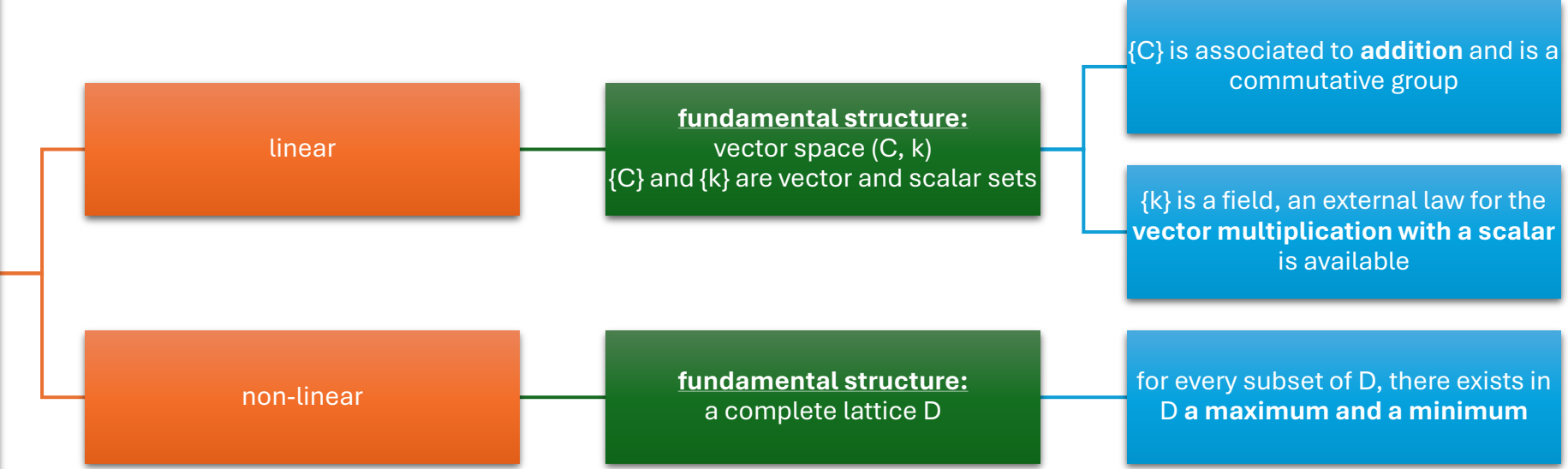


image processing

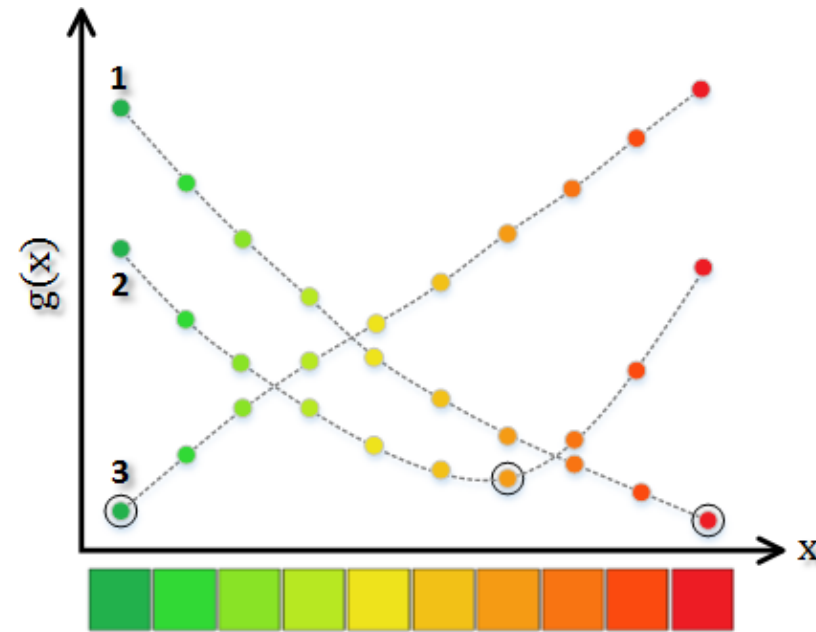
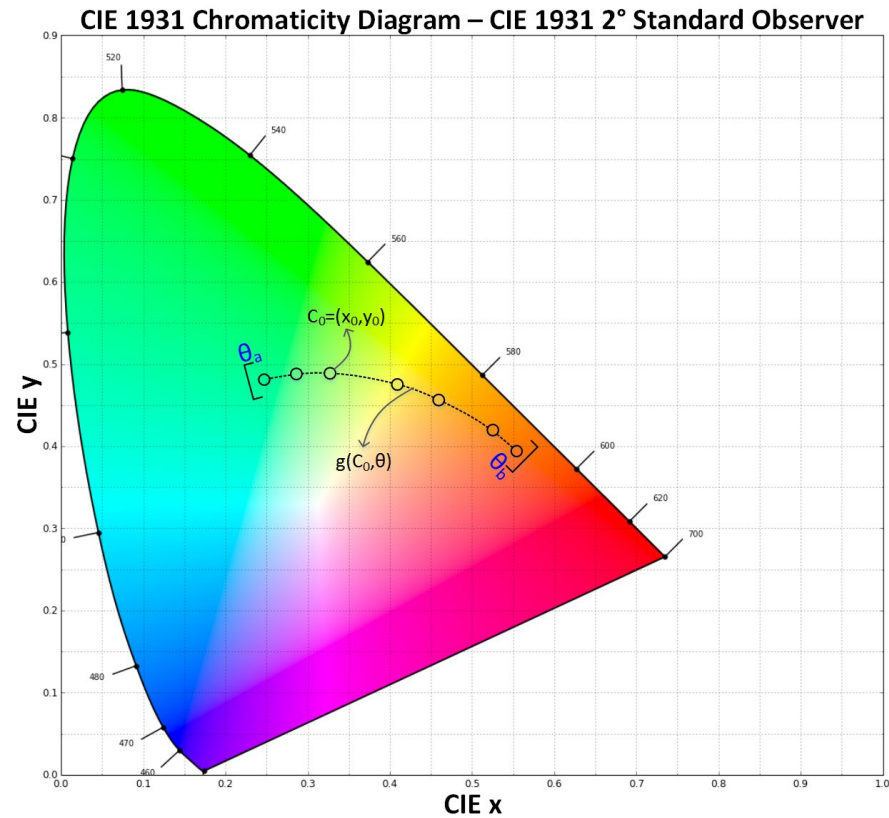


What does it mean to perform an addition of spectra and multiplying a spectrum with a scalar?

Obvious problem: Max of reflectance is 1

But we can work with min and max, or the ordering of spectra
The **scalar domain** is naturally equipped with the notion of order
No uniform ways/ consensus in the **multivariate domain**

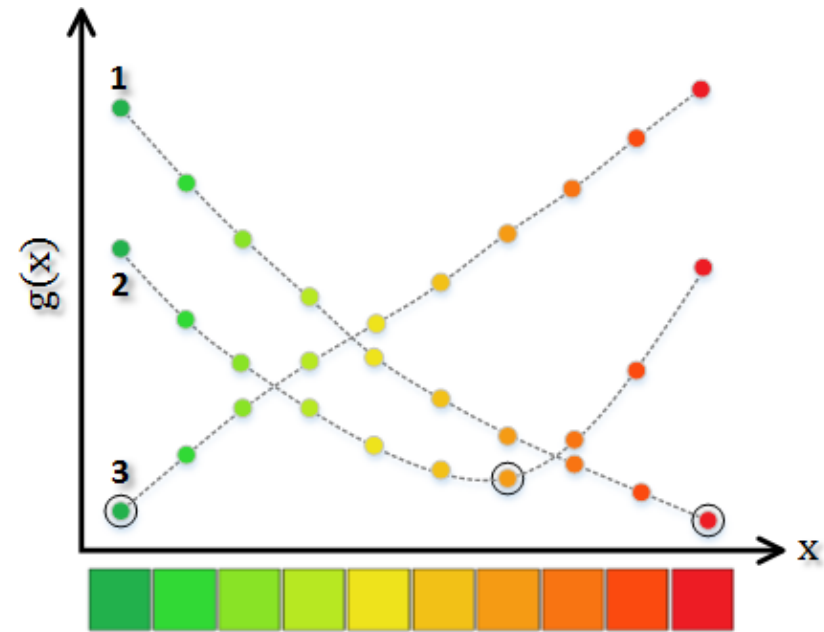
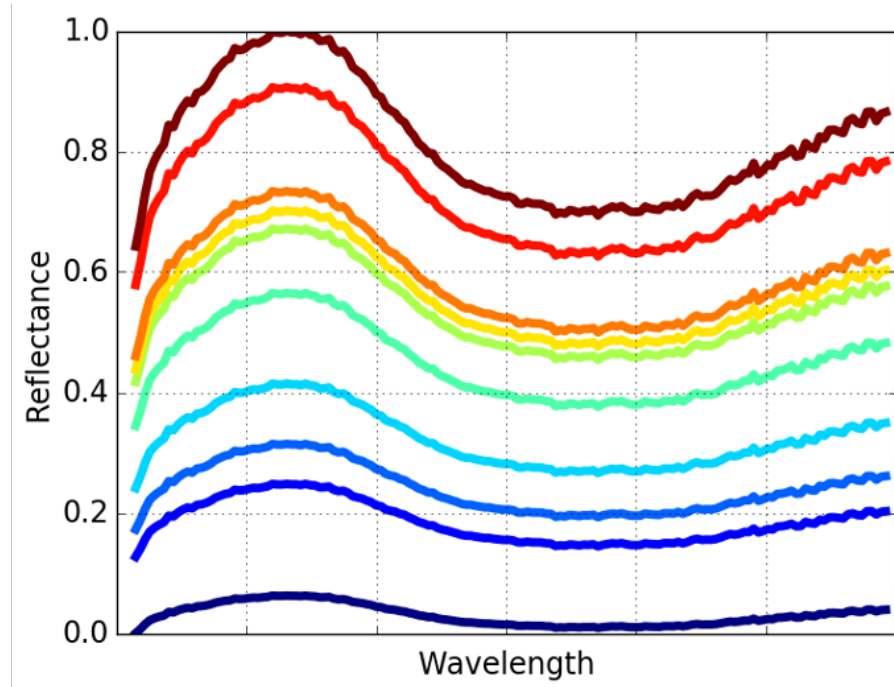
Ordering relation in the color domain



A suitable ordering relation must maintain the existing order of a given color set.

Ordering relation

in the spectral domain

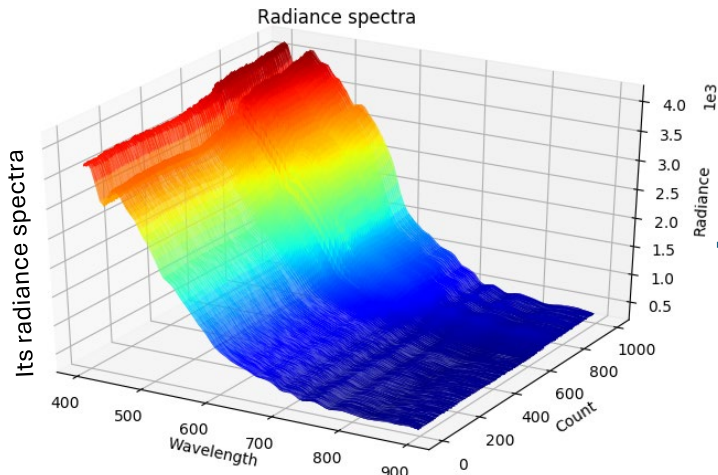


In the same way, existing order in the spectral domain, such as gradual changes in intensity, must be maintained.

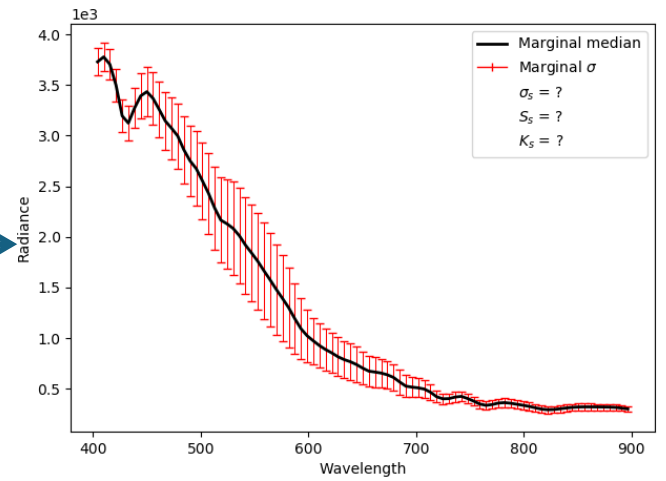
How to order spectra

- Marginal approach (each channel treated separately)
- Conditional approach (sequential ordering) on the image channels
- Prioritization function on the wavelengths
- Distance-based functions
- Supervised ordering approaches

The notion of order in statistics for a spectral set

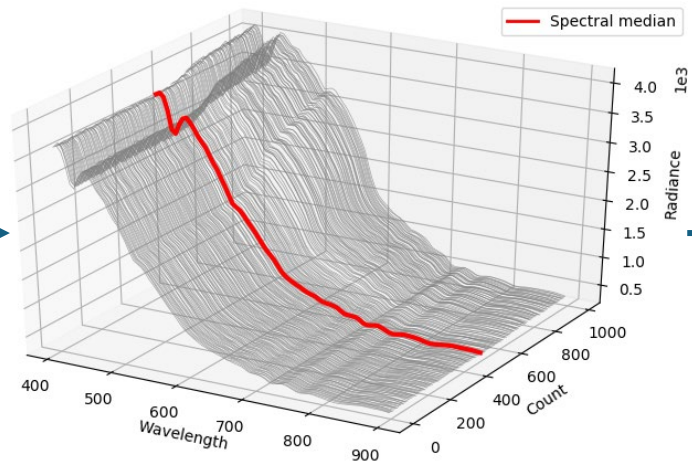


marginal approach

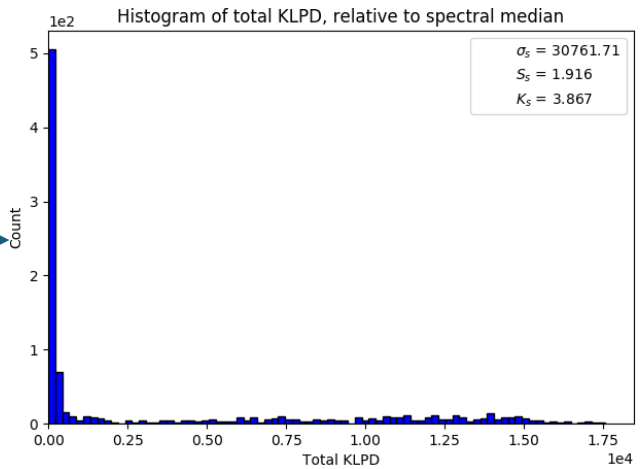


marginal moments

Full-band approach



Count

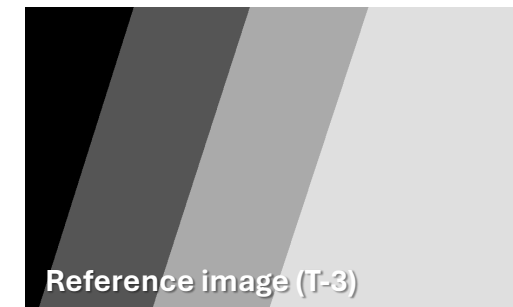
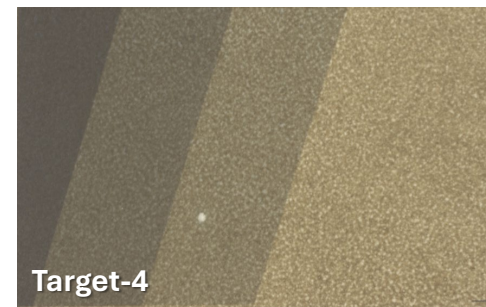
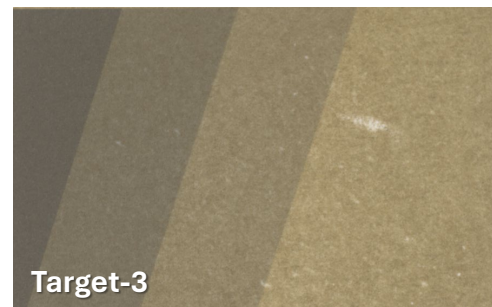
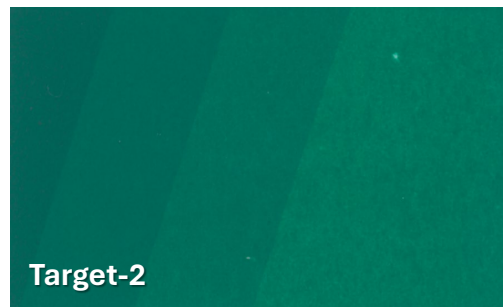
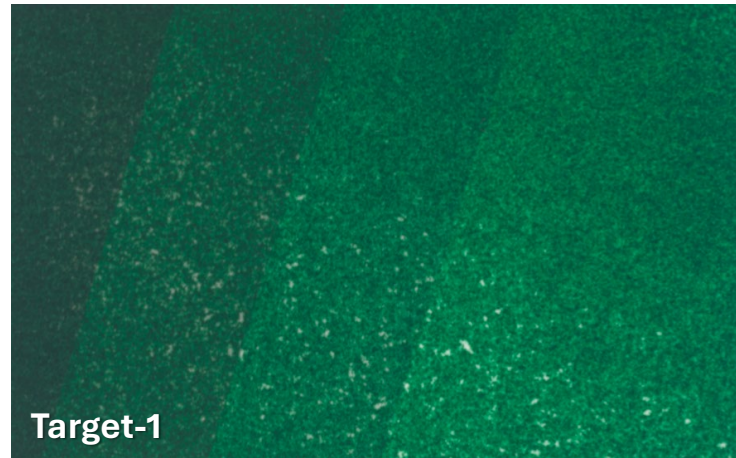


Global spectral moments

Median of the spectral set

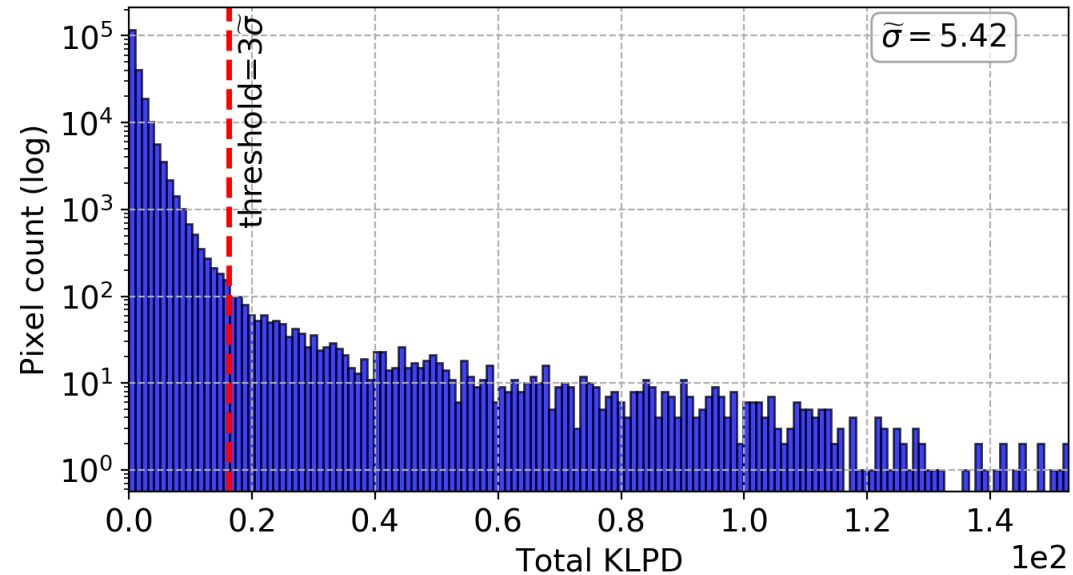
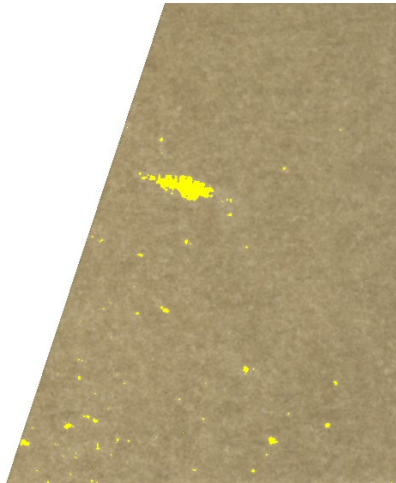
Application

Detection of anomalies in screen printed pigment charts



Application

Detection of anomalies in screen printed pigment charts

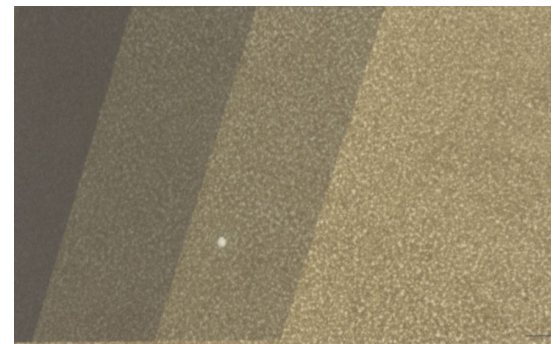
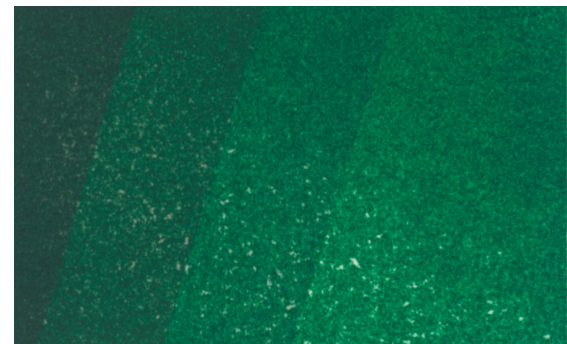
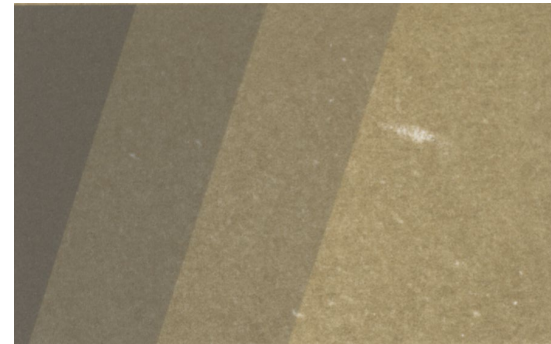
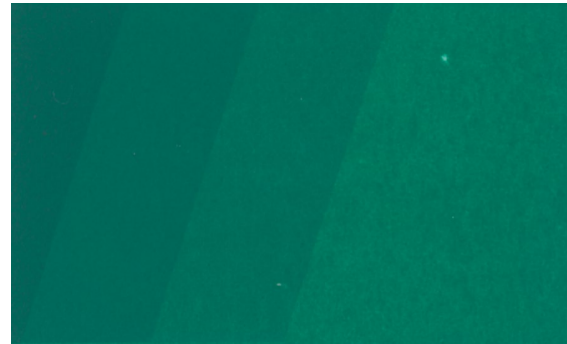


Assuming a normal distribution for individual patch, the empirical rule will be used

- 99.7% of population lie within 3σ
- Anomalies = outliers, use thresholding $\geq 3\sigma$

Application

Detection of anomalies in screen printed pigment charts



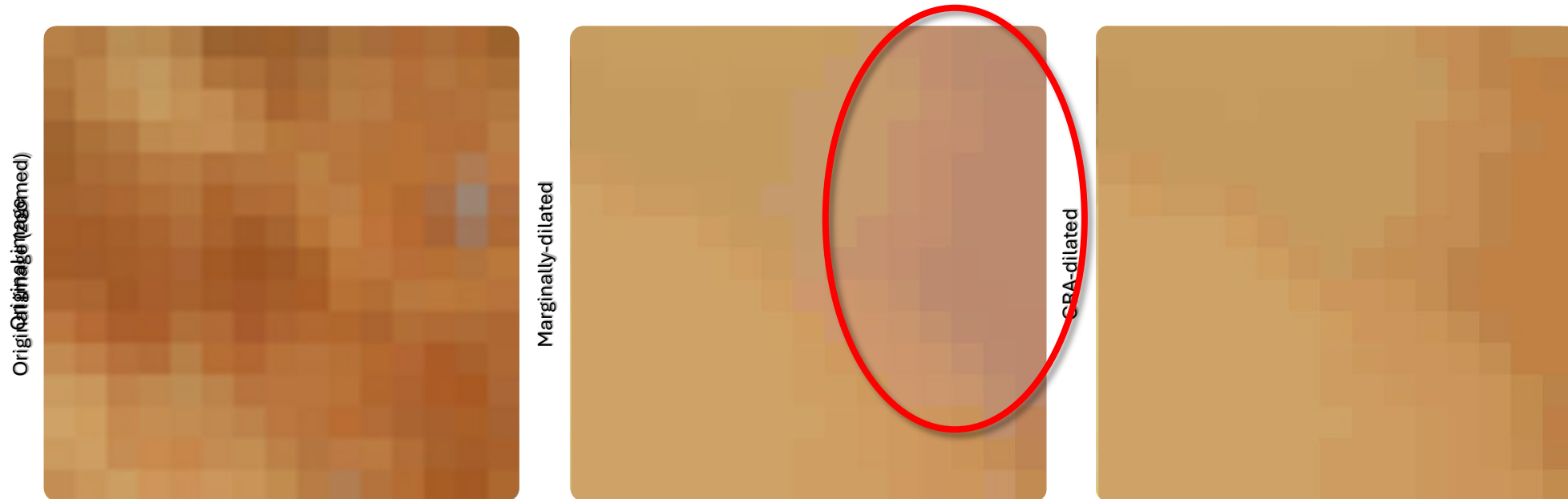
The impact of ordering relations to spectral median filters



Expected: Smoothing of homogeneous regions, preserved edges

Actual results: Varied from **grainy artifacts** to **blurred edges**

The impact of ordering relations to spectral morphological dilation

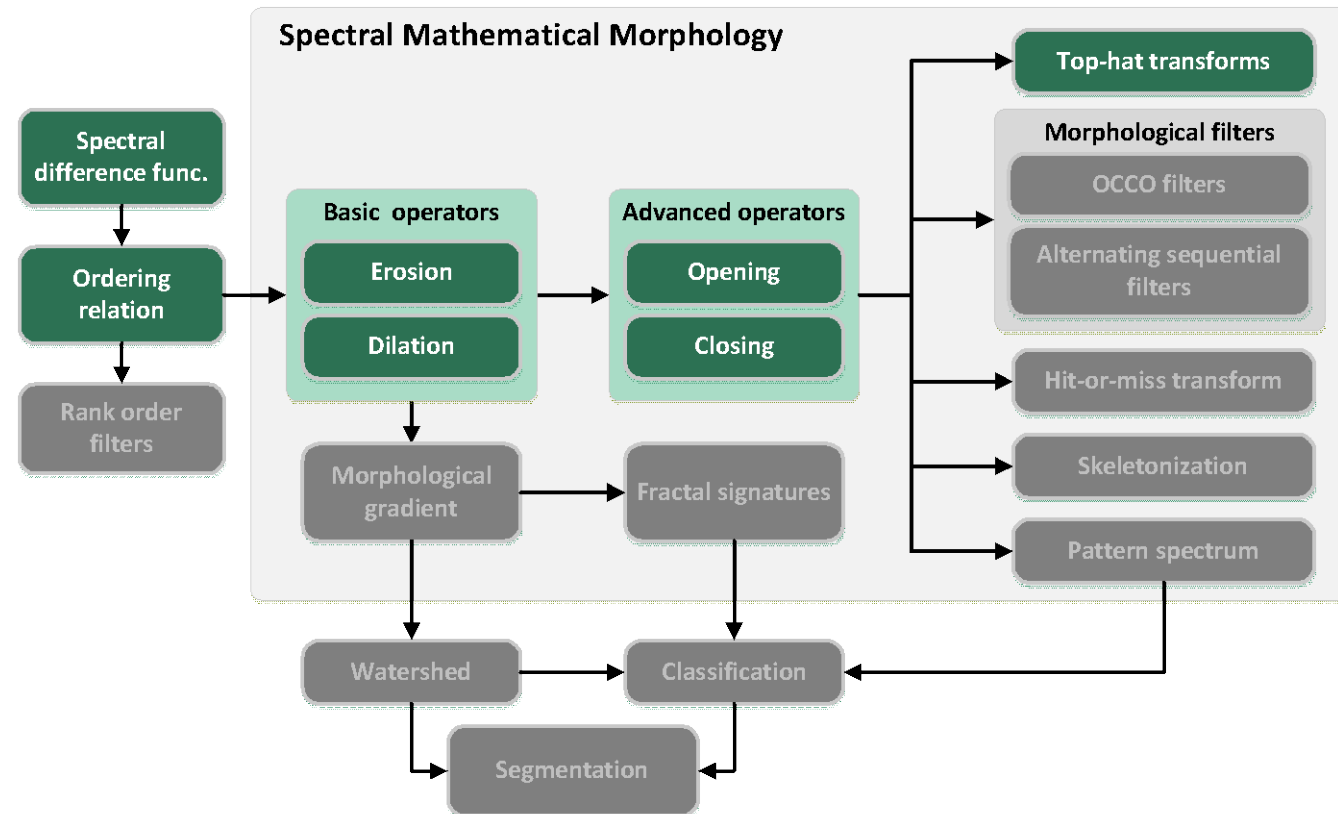


Marginal ordering relation produces **false colors**

This is a significant error in scenarios, e.g., pigment/colorant identification

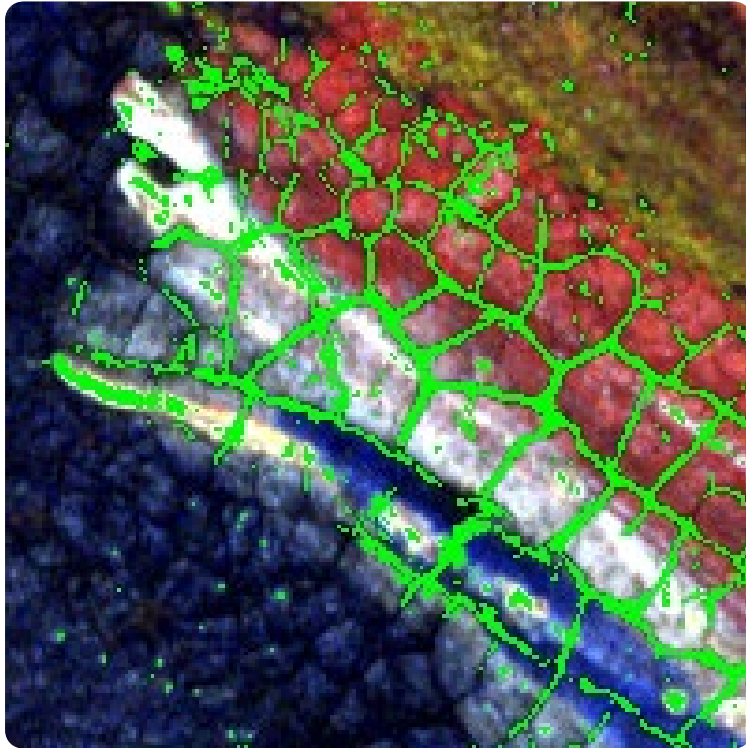
Application

Crack detection for paintings



Application

Crack detection for paintings



Subsets of The Scream (1893, Edvard Munch)

