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AUTONOME PROVINZ BOZEN SÜDTIROL
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MICROTEC

Hyperspectral technology

H2I Workshop

September, 16th 2021

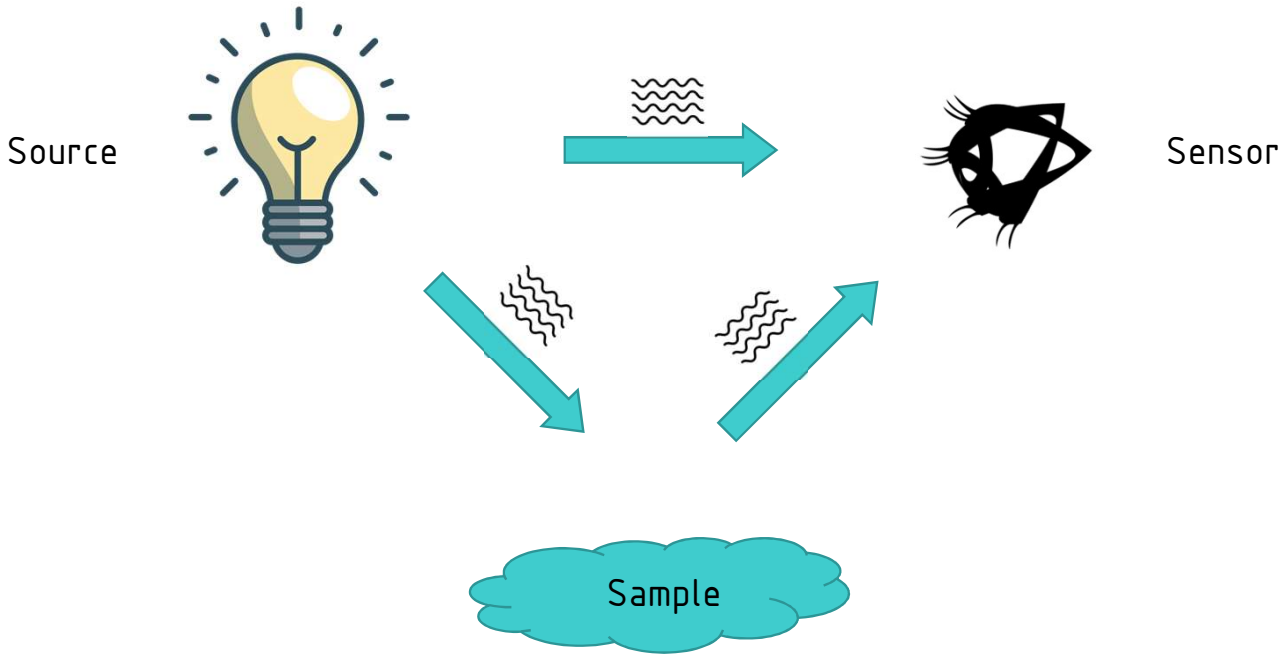
Matteo Caffini, PhD

MICROTEC

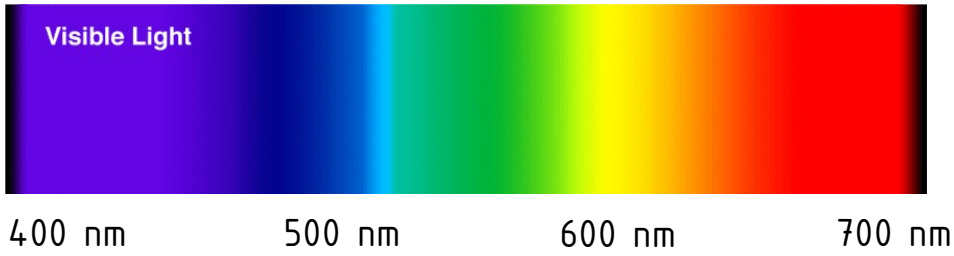
Summary

- Vision
- Hyperspectral hardware
- Hyperspectral software
- Applications & Examples

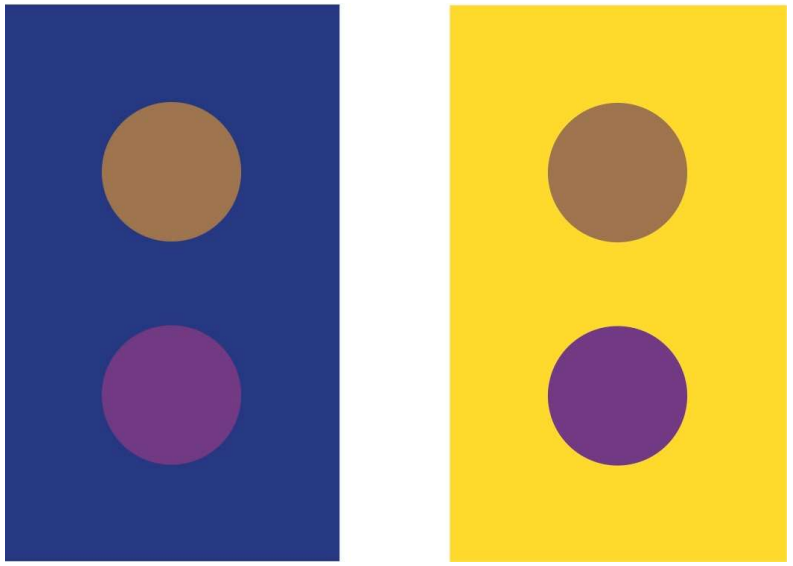
Vision



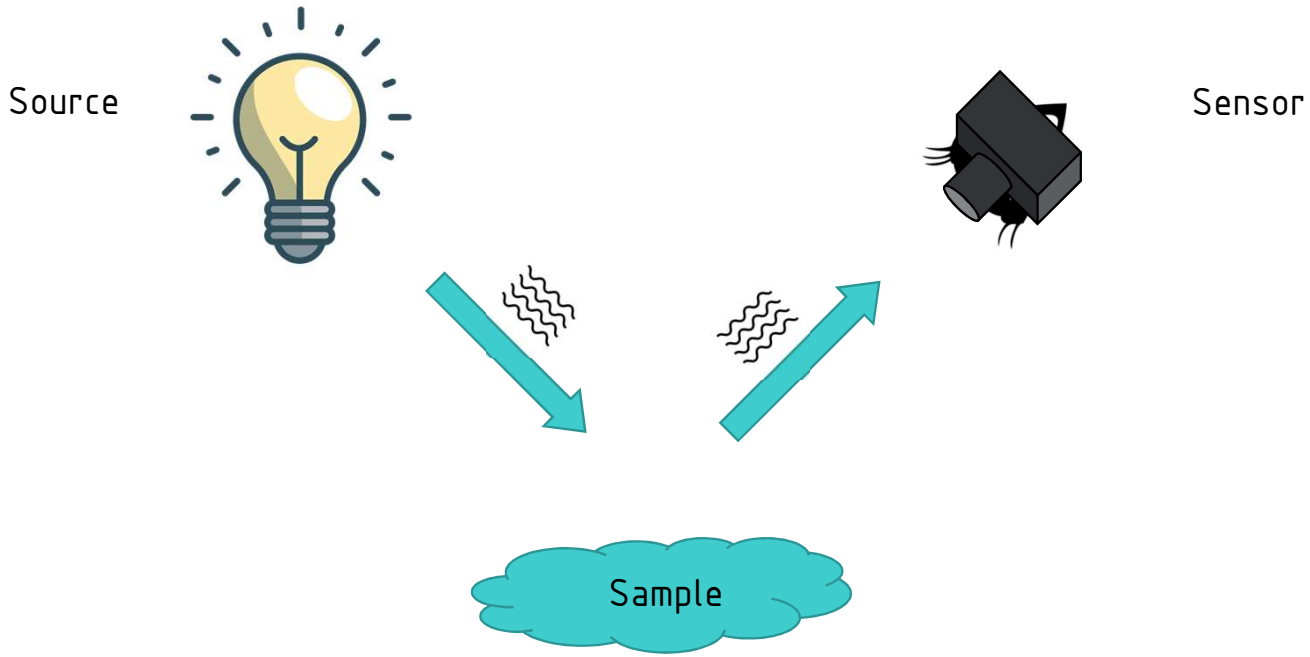
Color



Perception

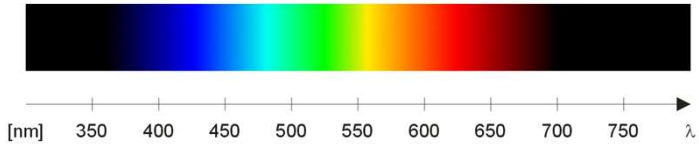


Machine Vision



Camera types

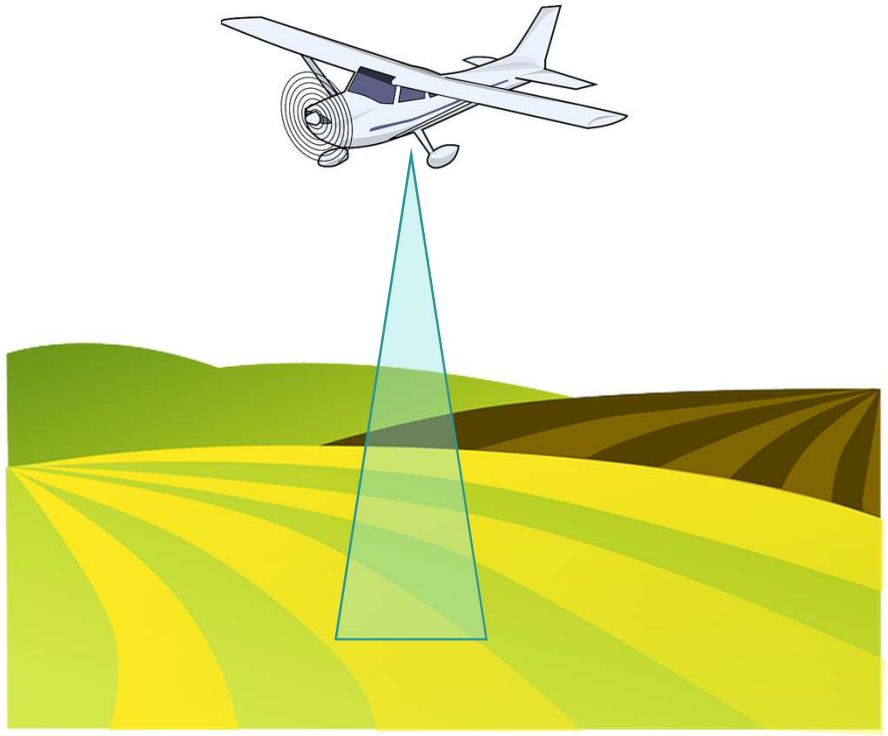
- B/W
- UV, IR, SWIR, …
- RGB
- Hyperspectral VisNIR
- Hyperspectral SWIR

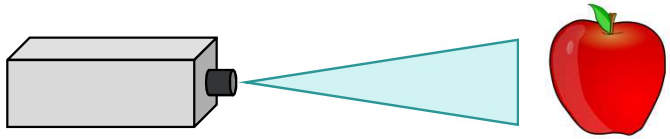


Camera types

B/W	RGB	SWIR	Hyperspectral VisNIR	Hyperspectral SWIR
				
• Monochromatic • Si, 400–1000 nm • Eventual spectral filter	• RGB • Si, 400–1000 nm • Bayer filter	• Monochromatic • InGaAs, 950–1700 nm • Eventual spectral filter	• Camera B/W • VisNIR spectrograph	• Camera SWIR • SWIR spectrograph • Temperature control

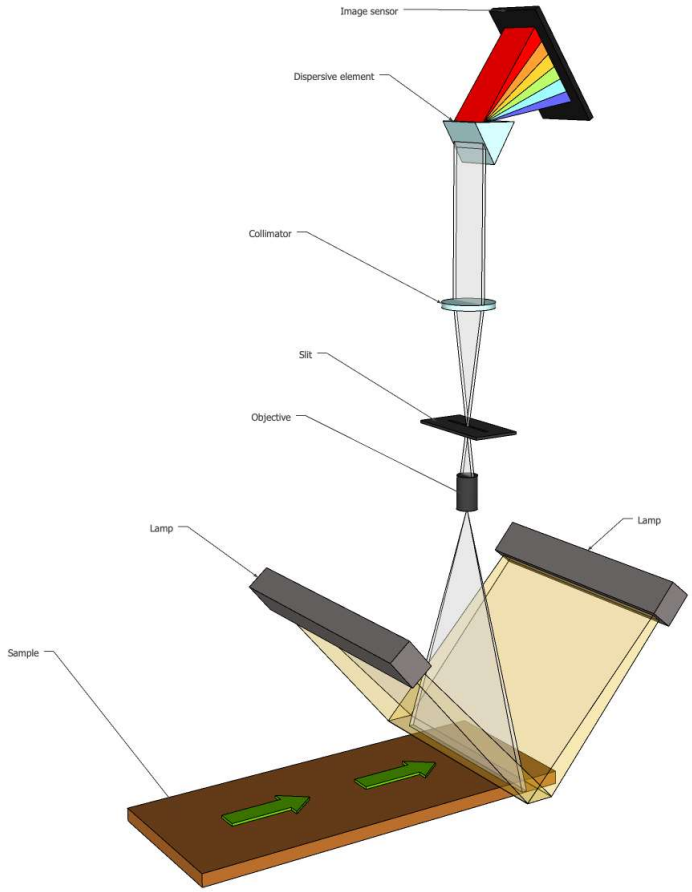
Hyperspectral imaging



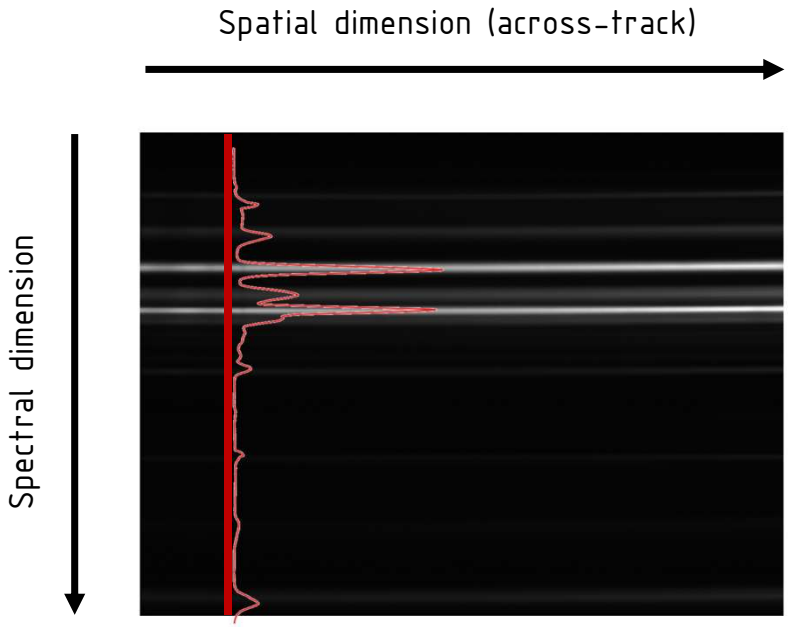


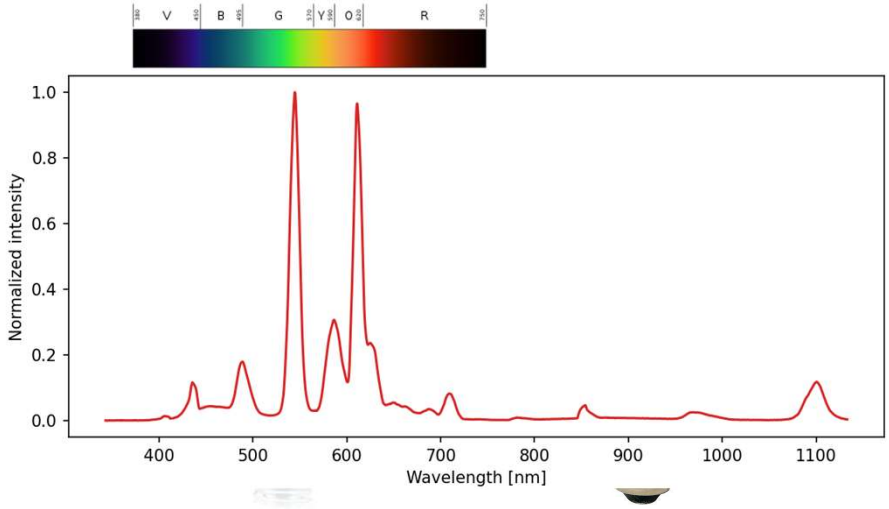
Hyperspectral hardware

- Spatial scanning configuration (push-broom)
- Hyperspectral camera
  - Objective lens
  - Hyperspectral optics
  - Camera



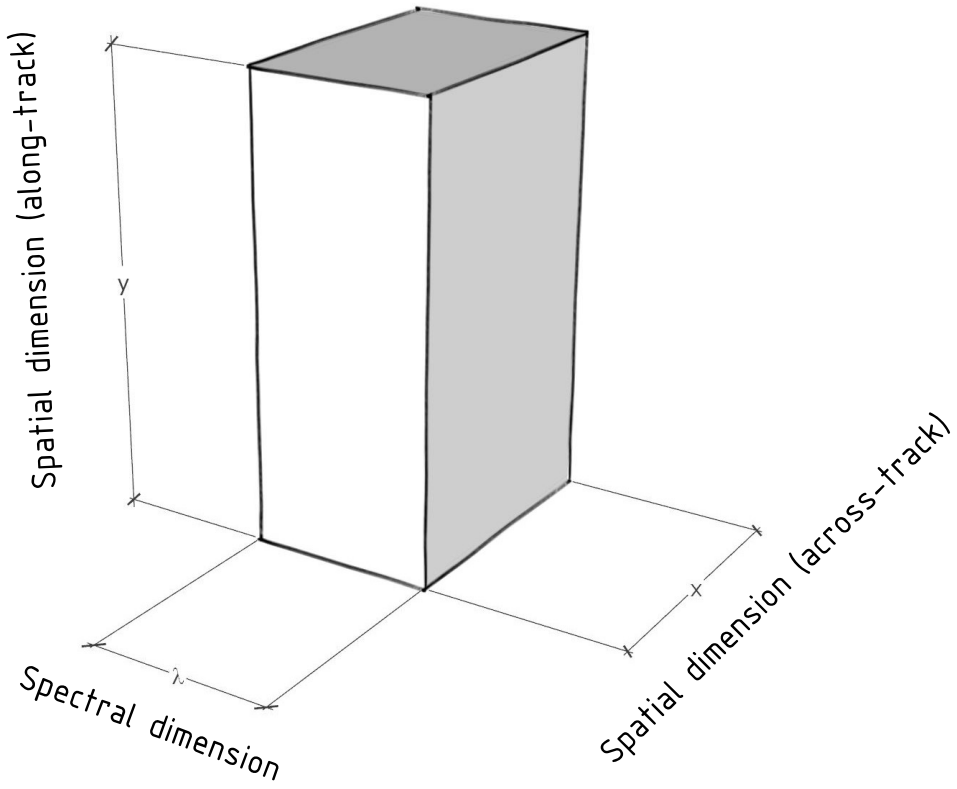
Hyperspectral data



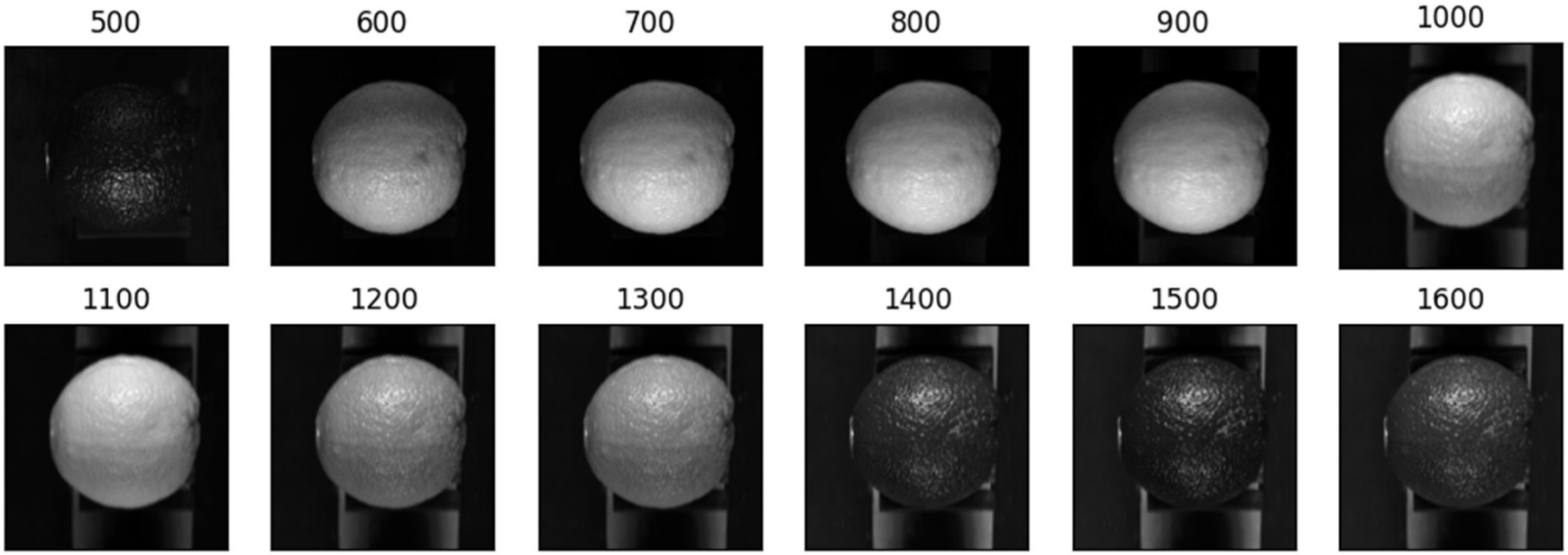


Hyperspectral cube

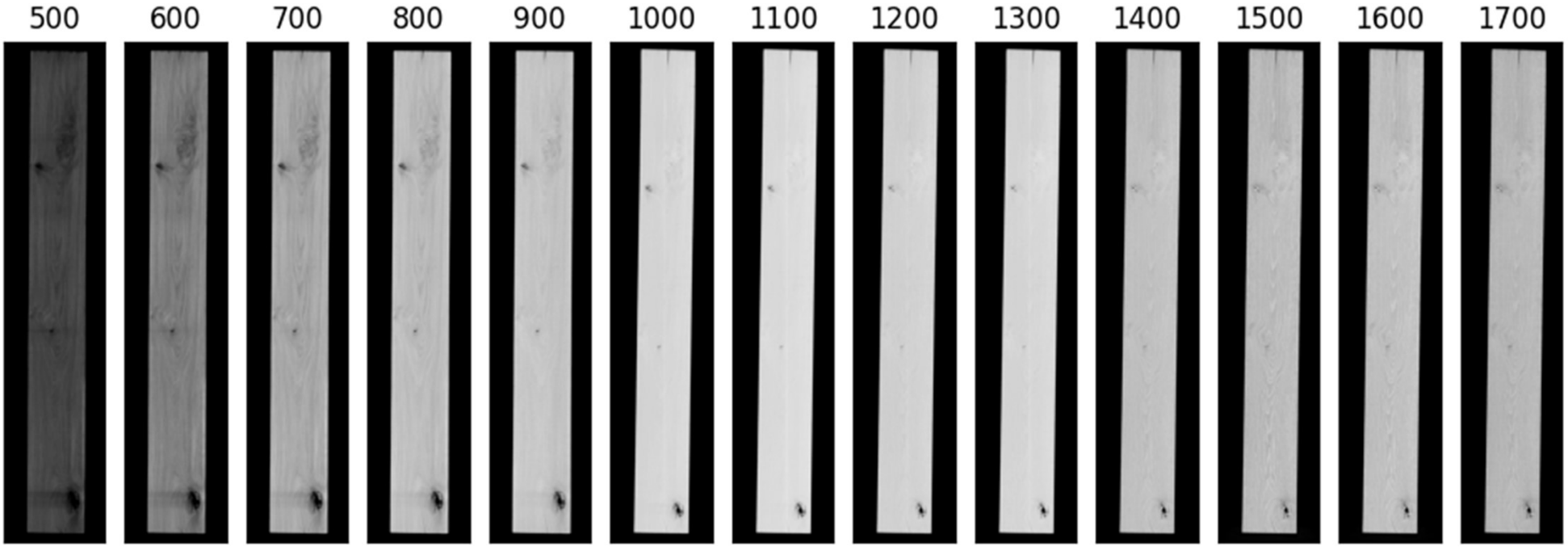
- 3D dataset (x, y, λ)
  - x: Spatial dimension (across-track)
  - λ : Spectral dimension
  - y: Spatial dimension (along-track)



Slicing the cube



Slicing the cube



Chemometrics

- Spectral reflectance (color) as a fingerprint
- Training set to develop a mathematical model capable of classifying future samples

Model fitting and data classification

TRAIN

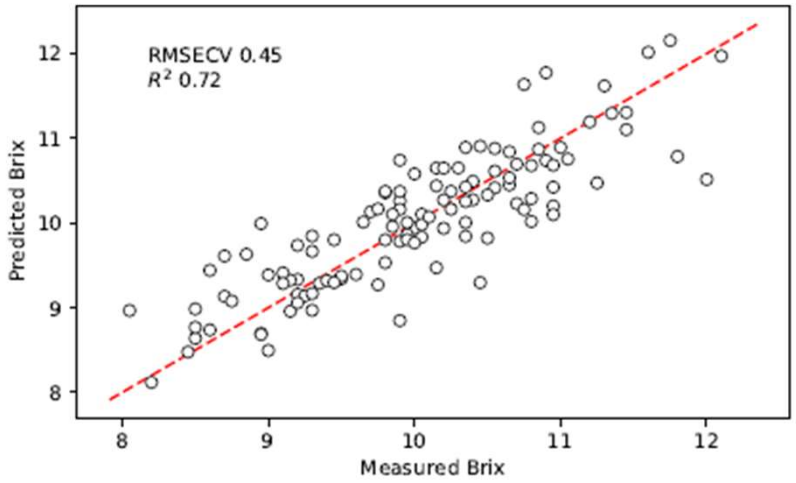
- Image labelling (supervised method)
- Preprocessing
  - Spectral bands selection
  - Binning/Smoothing
- Train/test random sampling
- Cross-validation (*k*-fold)

PREDICT

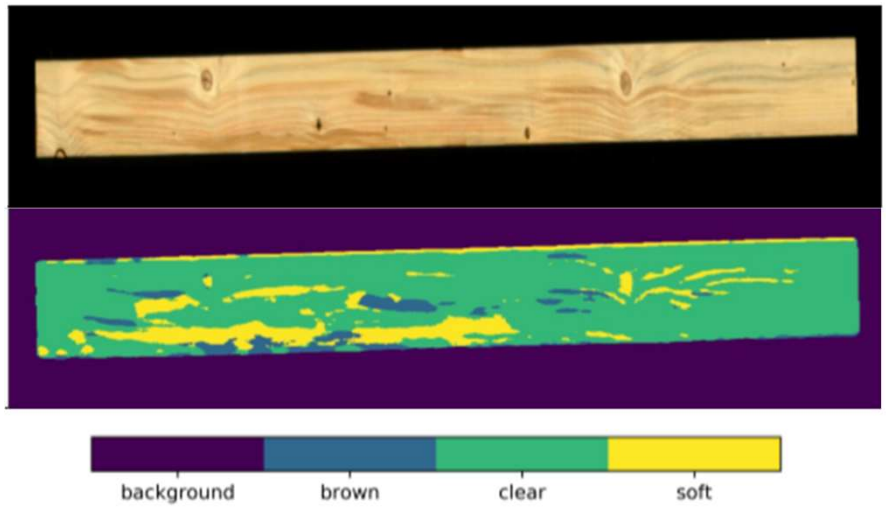
- Classification of unknown samples

Two Kinds of Application

- Regression



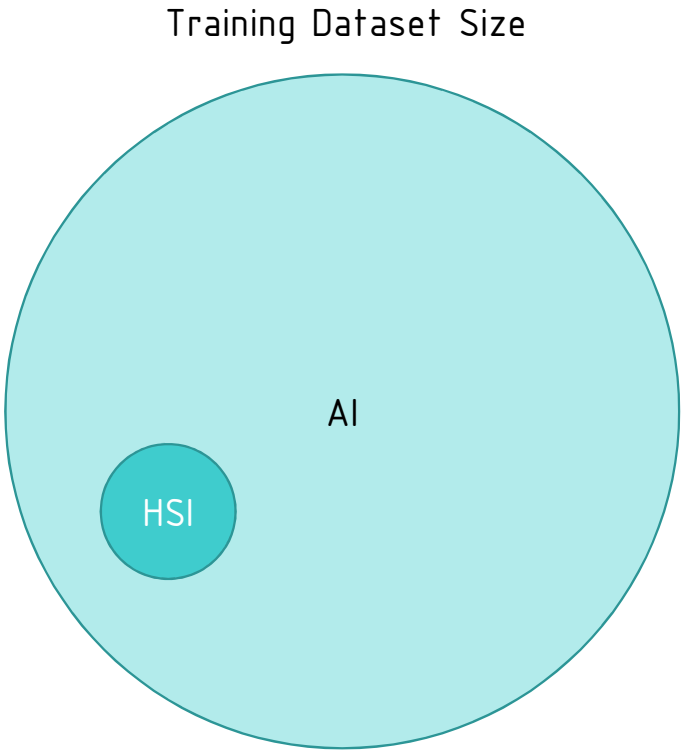
- Classification



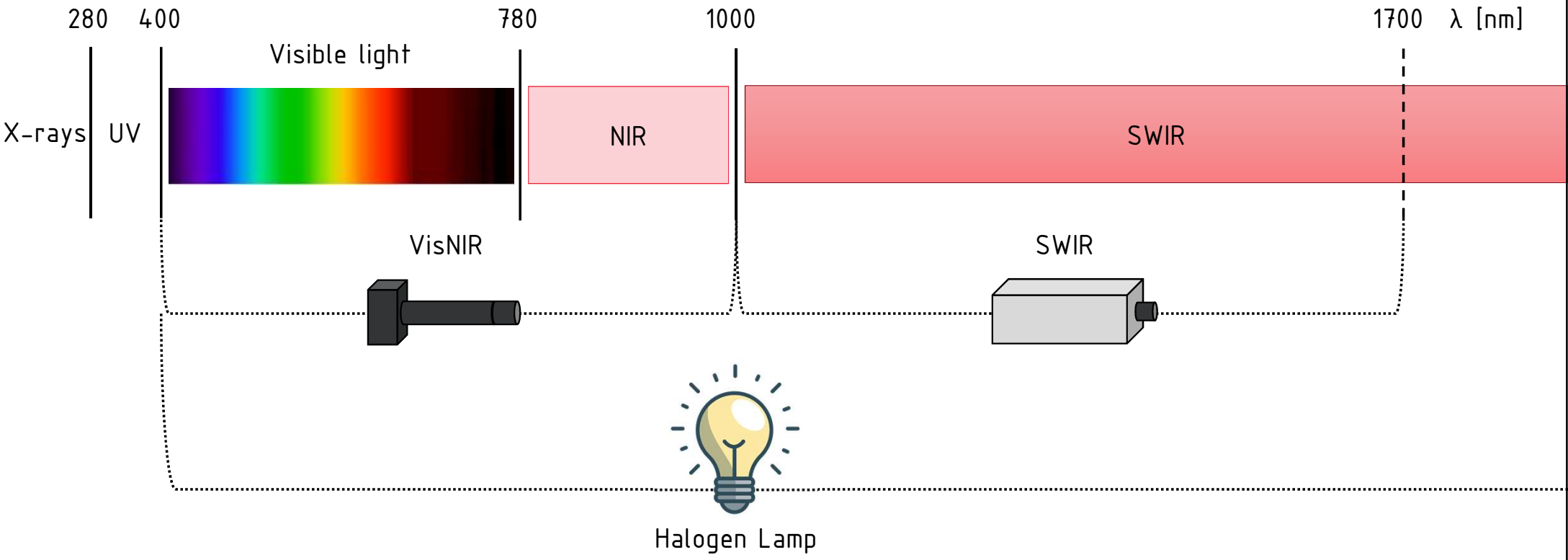
HSI Classification Model

- Spectral features (color) only
- Precise and conservative labelling
- Relatively small and exemplary training set
- Bigger test set to evaluate performance

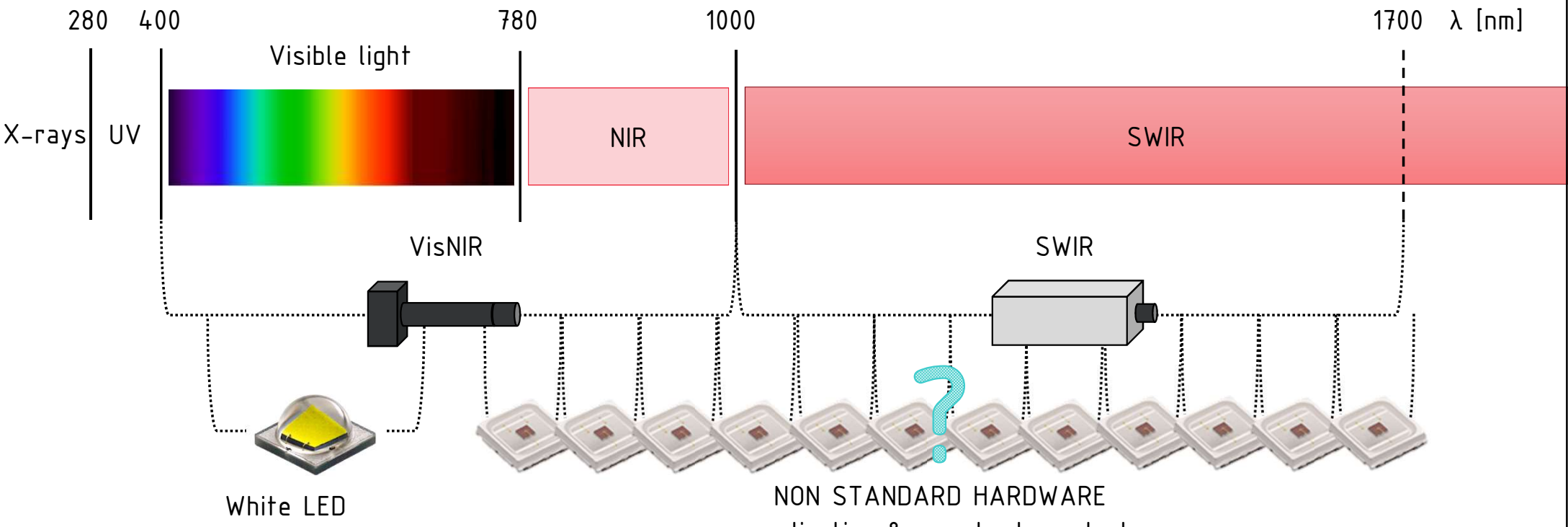
- PRO: Lightweight & fast computation
- CON: Spatial features are ignored!



Halogen lamps

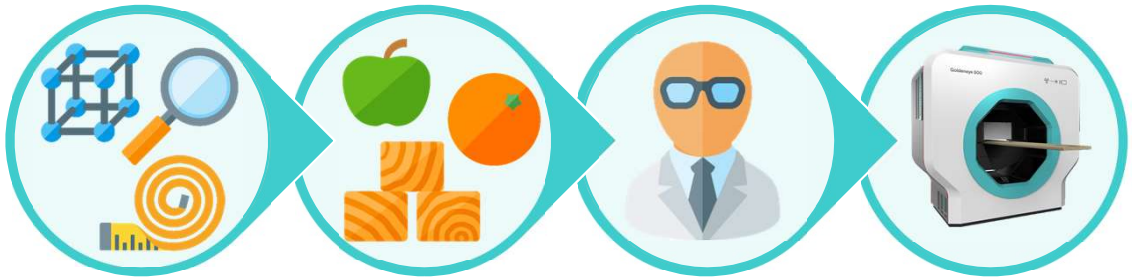


LEDs


280
400
780
1000
1700
λ [nm]
Visible light
X-rays
UV
NIR
SWIR
VisNIR
SWIR
?
White LED
NON STANDARD HARDWARE
application & sample dependent

Development protocol

- Problem definition
  - What feature needs to be seen?
  - How can we measure it?
- Sample collection
  - Multiple samples per class
  - Good distribution of features
- Lab testing & validation
- Wavelength range analysis
- Design & production



Thank You

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