THALES
Building a future we can all trust

LaBRI

# Evaluation of the Operational Contribution of the Use of Neural Networks on Hyperspectral Images for the Benefit of Airborne Surveillance

Christophe CAUBET
PhD supervisors : Gilles GUERRINI
Pascal DESBARATS
Jean-Philippe DOMENGER

Thales DMS Direction Technique
LaBRI department Image&Son
24/05/2022

# Summary







LaBRI

THALES
Building a future we can all trust

# Operational context

https://www.nerdninja.com/pics/real-size-cardboard-tank/
https://www.armaholic.com/page.php?id=35920

Example : Which of these tanks is real ? (Gulf War feedback)

## European instances (FRONTEX, EMSA…) demand for more and more uses of hyperspectral images to benefit marine surveillance

- Pollution detection
- Soils segmentation
- Materials discrimination
- …

## Objective of our work : To prepare mission systems to those needs





LaBRI THALES Building a future we can all trust

# Operational context

## Contribution of hyperspectral image processing

- Material discrimination with detection and segmentation of « non-natural » elements (vehicles, buildings, ships…)

False color reconstruction

Material classification


« Deep Recurrent Neural Networks for Hyperspectral Image Classification », Mou et al., 2017



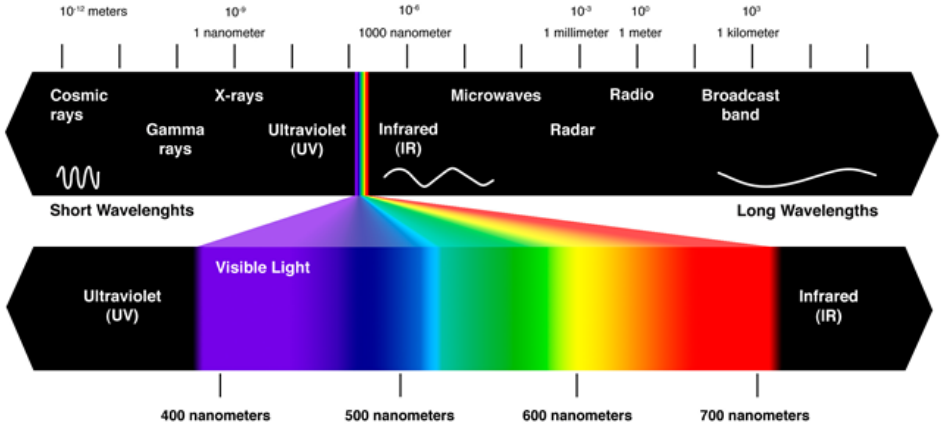


LaBRI

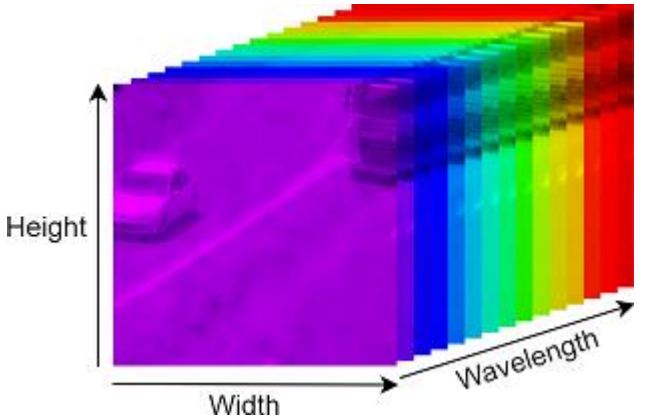
THALES
Building a future we can all trust

# Scientific context – Hyperspectral imaging

- Combination of imagery and spectrometry
- Collection of images wavelength by wavelength
- Simultaneously in the ultraviolet, the visible and/or the infrared




Repartition of spectral domains as a function of wavelength




Bands of the visible range of a hyperspectral image, colored according to their wavelength





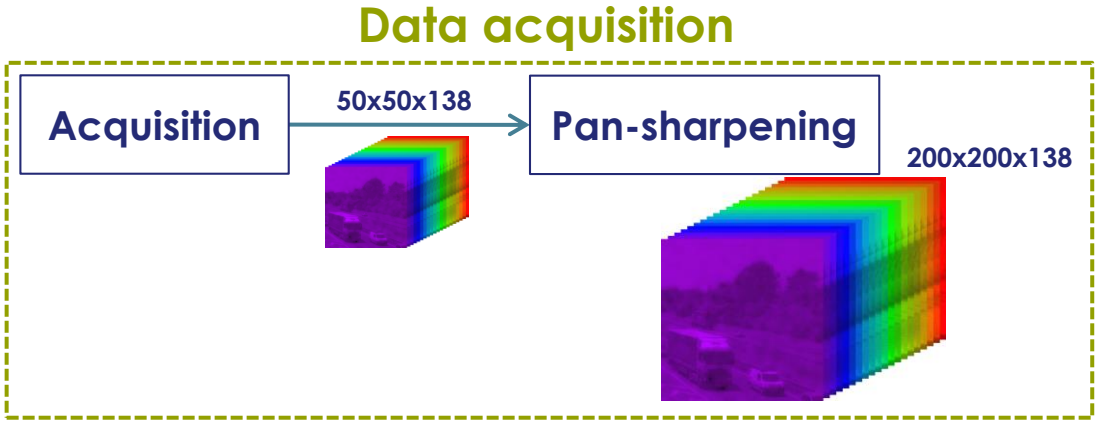
LaBRI THALES Building a future we can all trust

THALES
Building a future we can all trust

# Contributions

- Data acquisition
- Pre-processing
- Classification
- Network analysis

# Data processing synoptic








LaBRI THALES Building a future we can all trust

# Data acquisition

## Camera

- With 2 spatial dimensions
- In the visible and very-near infrared domains (450-1000nm)

## Creation of a hyperspectral database of vehicles

- Over 15000 images
- In different acquisition conditions
  - To learn characteristics independently from the scene
  - Azimuth from -70° to 70°
  - Inclination from 0° to 70°
  - From multiple positions
  - With varying sunlight exposure

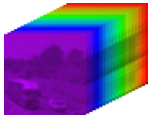
Image examples at different angles

# Data processing synoptic

## Data acquisition

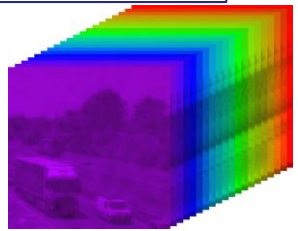
Acquisition

50x50x138



Pan-sharpening

200x200x138



## Pre-processing

Labelling (mask)

# Pre-processing

## Reconstruction of color images from the spectral bands

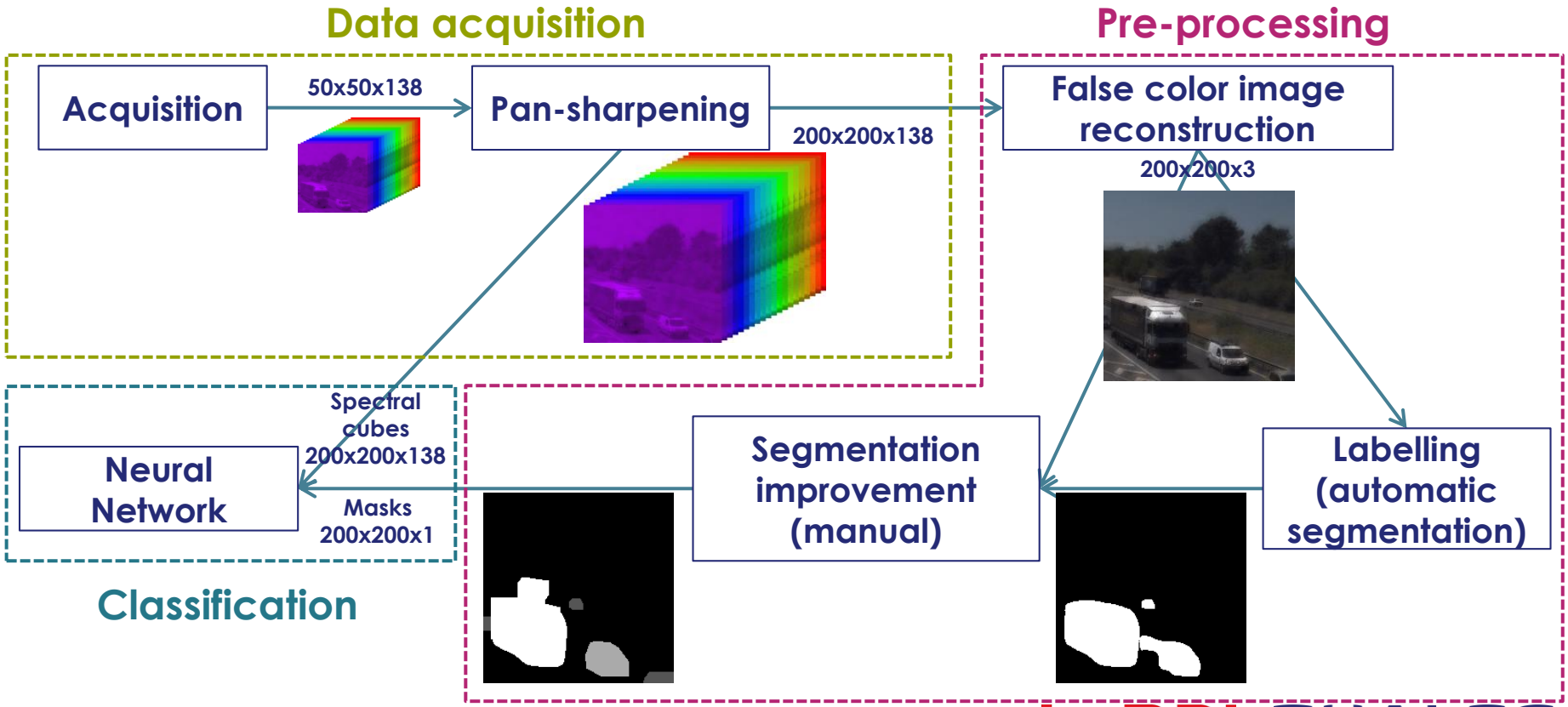
- To allow classical labelling approaches

## Automatic segmentation

## Manual segmentation

- To fix the errors from the automatic segmentation

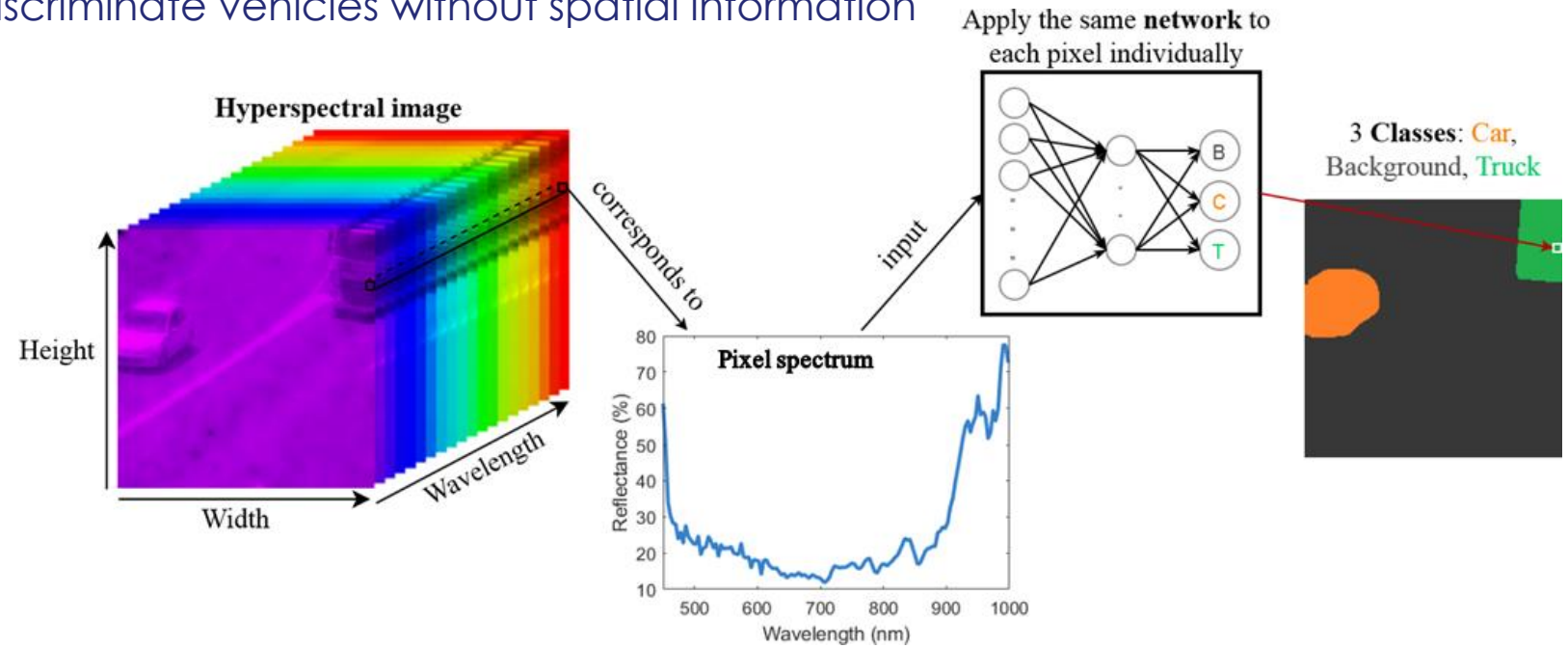
# Data processing synoptic



# Classification – Spectral network

## Analyze the pixels' spectral profile

- Discriminate vehicles without spatial information




Omit spatial dimensions to profit the spectral dimension

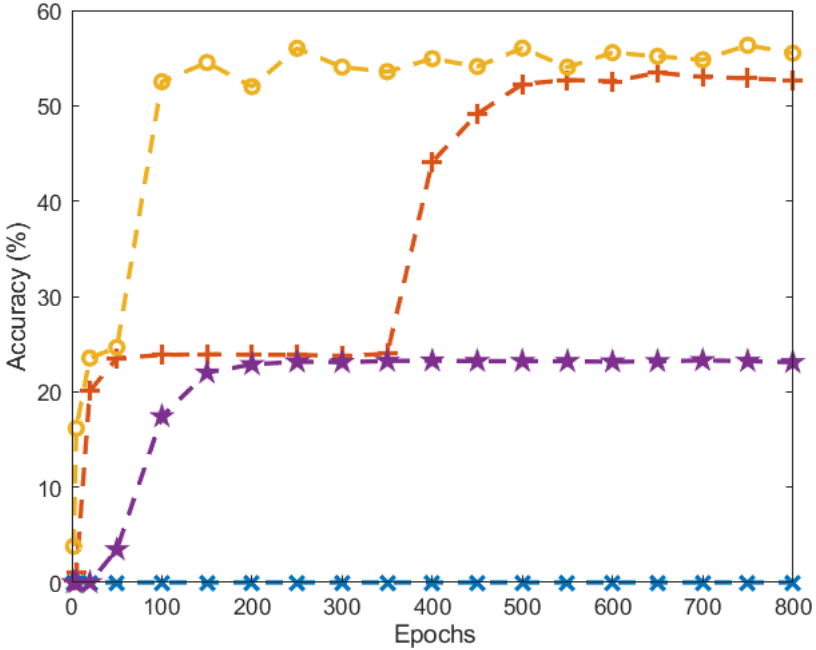




LaBRI THALES Building a future we can all trust

# Classification – Detection

## Trends of the spectral network over 800 epochs



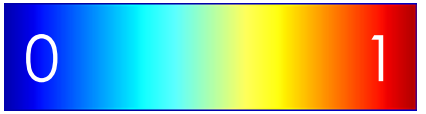

Some networks exceed 50% accuracy but fail to improve further





LaBRI THALES Building a future we can all trust

# Network analysis – Detection

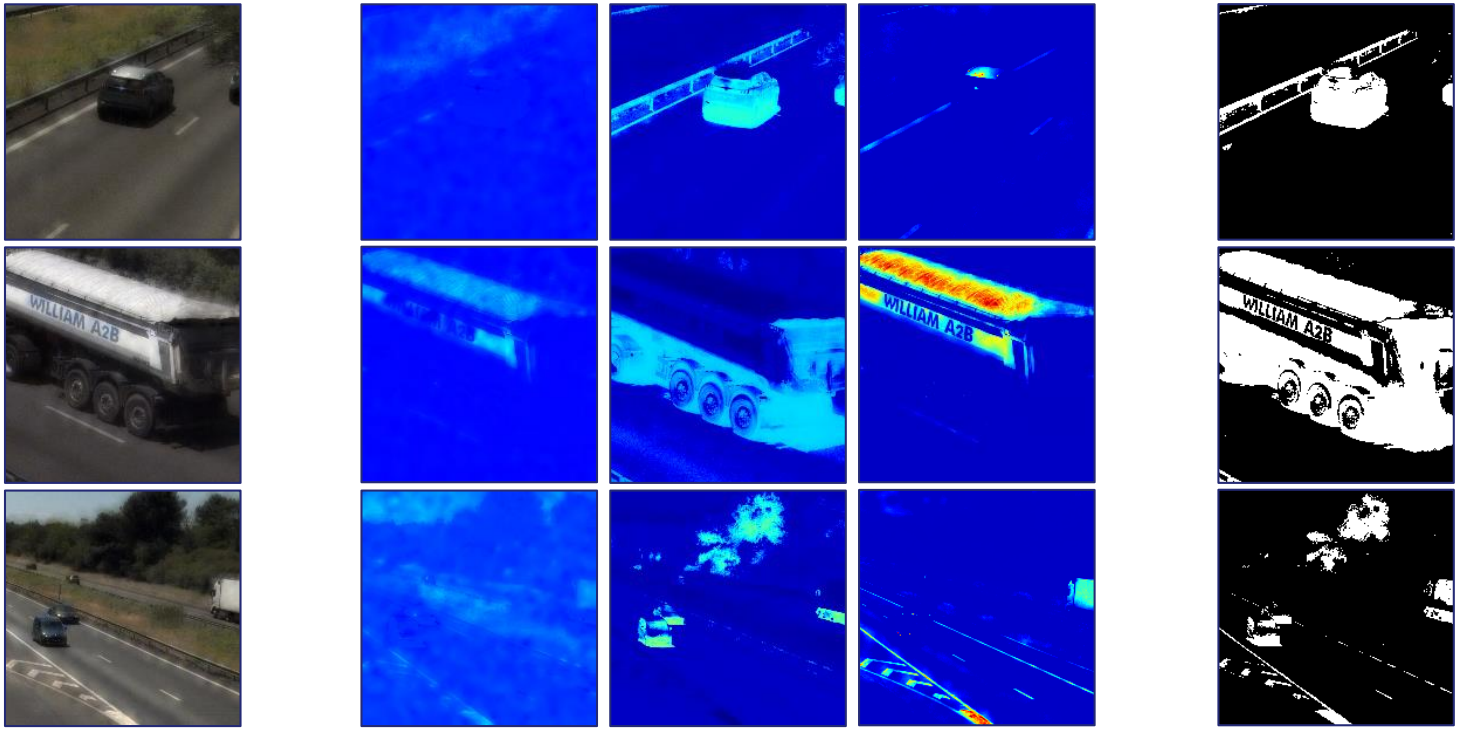



Color images

Neuron intensity for each spectral pixel

Neuron 1 | Neuron 2 | Neuron 3

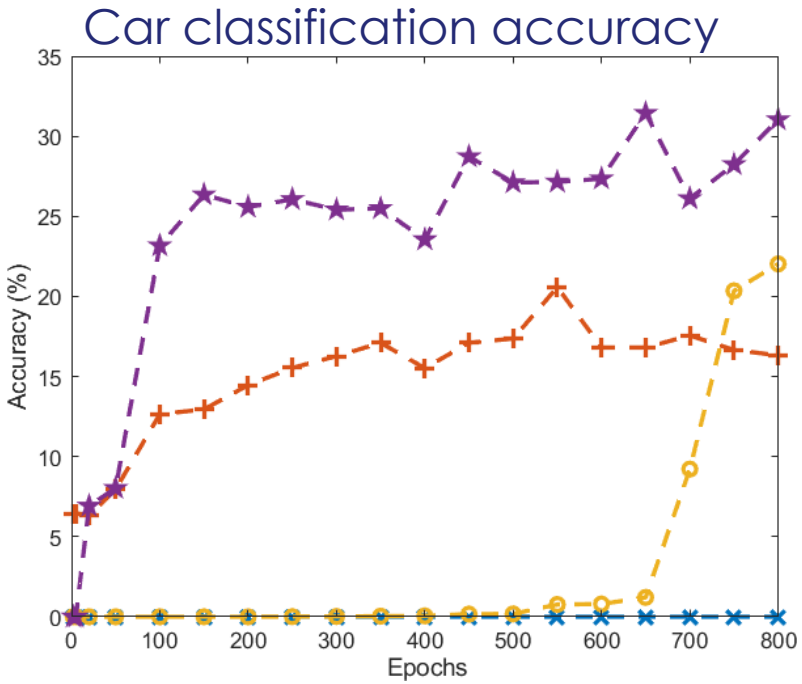
Classification

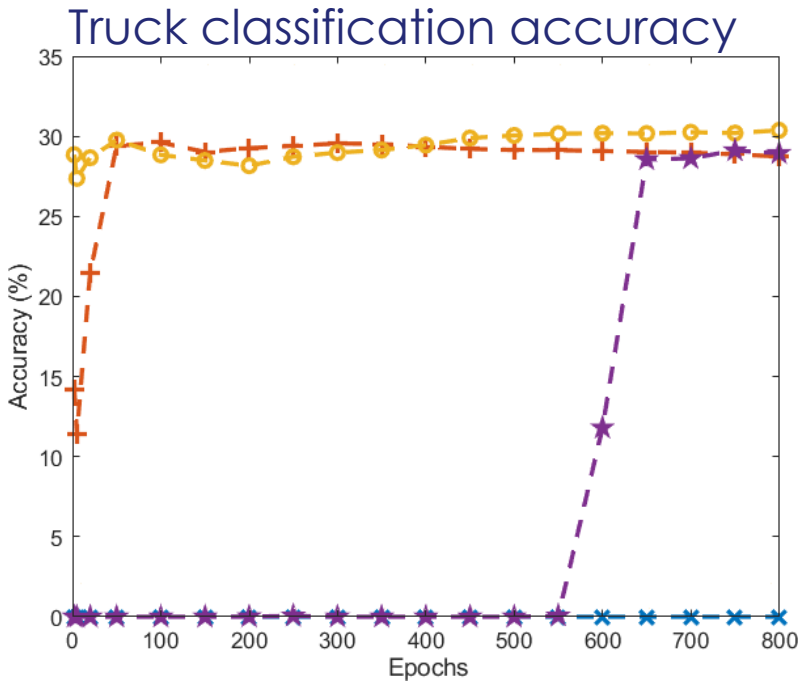



Vegetation | Shadows | Light

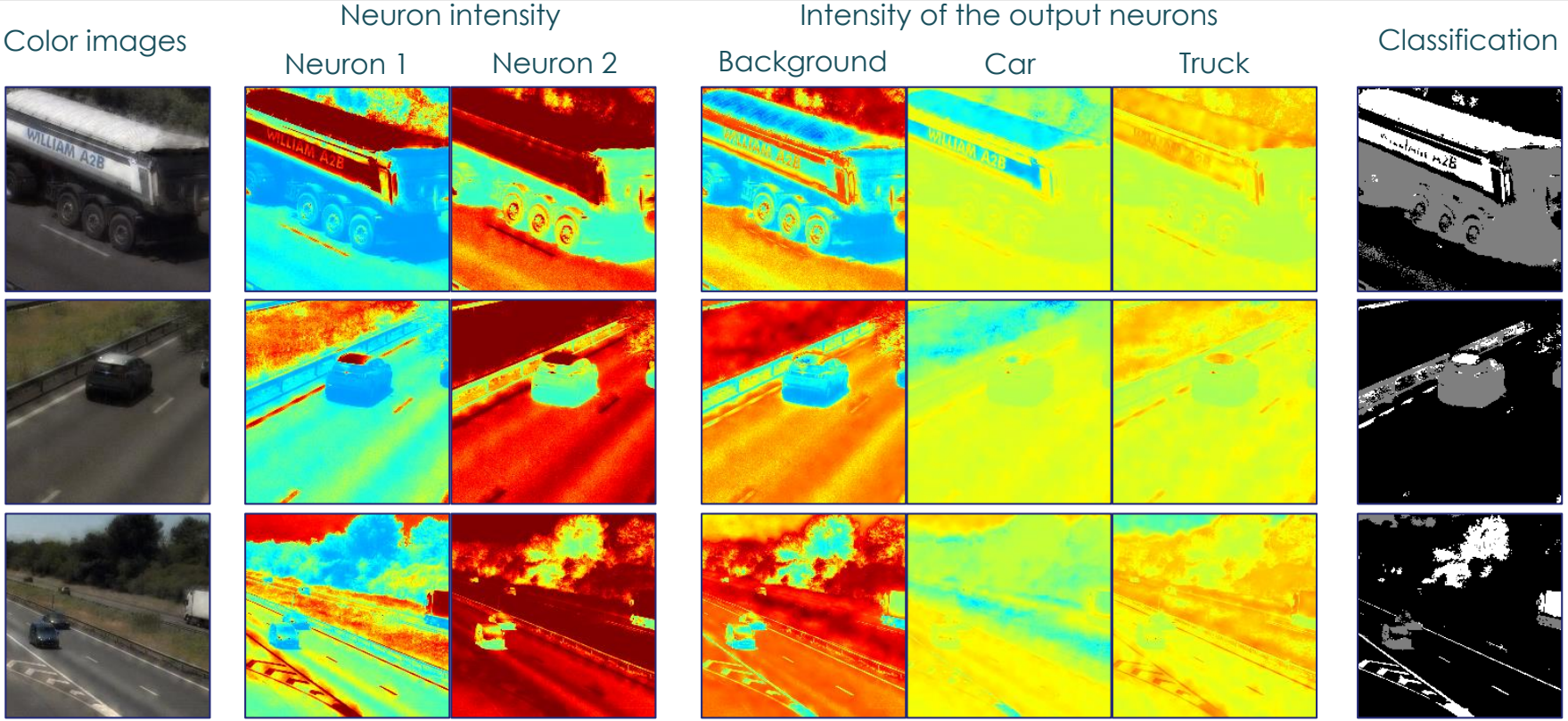
# Classification – Class attribution

## Trends of the spectral network over 800 epochs for classification



# Network analysis – Class attribution






LaBRI

THALES
Building a future we can all trust

# Conclusions and Future Work

## Conclusions

- Creation of a dataset of hyperspectral images of vehicles
- Our network's learned characteristics : Vegetation and light intensity

## Future Work

- Learn deeper models on higher volumes of data
- Study the usability of multiple spectral domains for vehicle classification
- Study the impact of illumination conditions on material discrimination

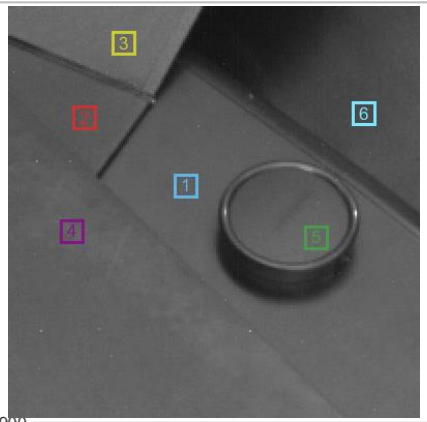
# Questions ?

# Appendices

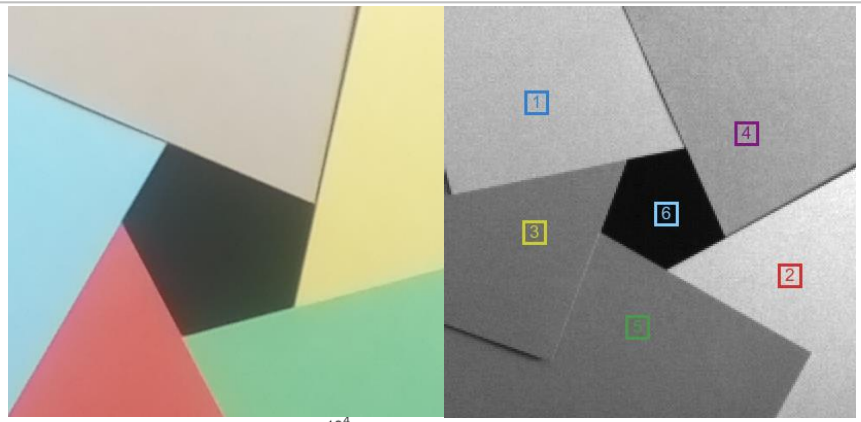
## Test acquisitions and analyzes

## Scientific context – Imaging and spectrometry

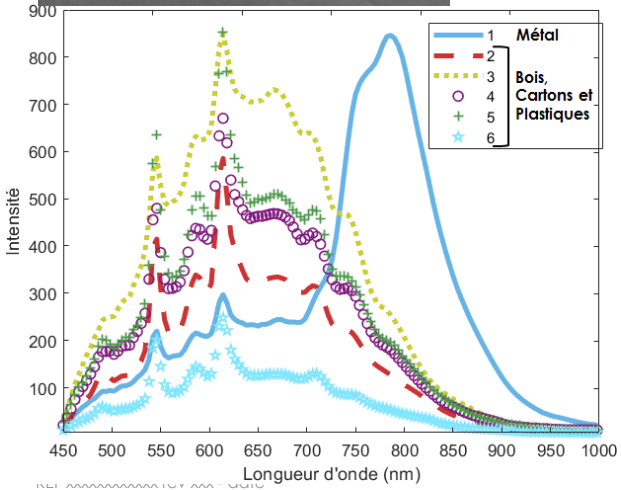
# Test acquisitions and analyzes

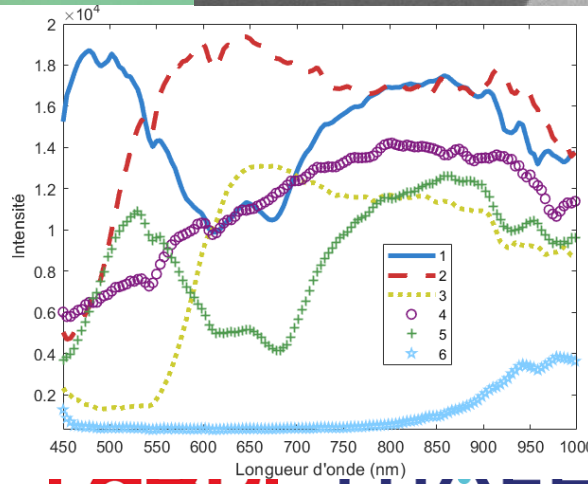



Same color
Different material




Same material
Different color



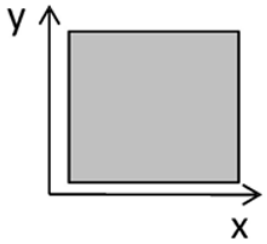



# Scientific context – Imaging and spectrometry

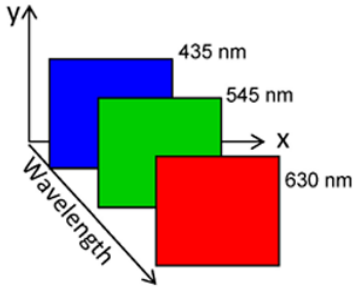


Spatial resolutions

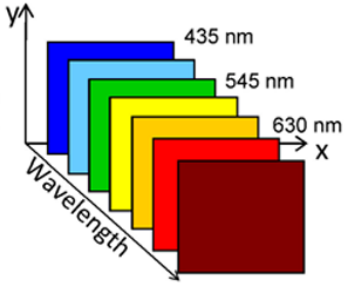
Spectral resolution



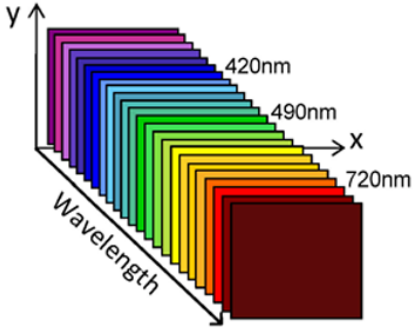

Monochromatic Image




Color Image




MultiSpectral Image




HyperSpectral Image


Spectrum

« Review of spectral imaging technology in biomedical engineering: Achievements and challenges », Li et al., 2013



LaBRI

THALES
Building a future we can all trust