

# QUALISPECTRA - Deep Learning Algorithms for Hyperspectral Image Analysis Applied to Quality Control of Agri-Food Products

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## 1 CONTEXT

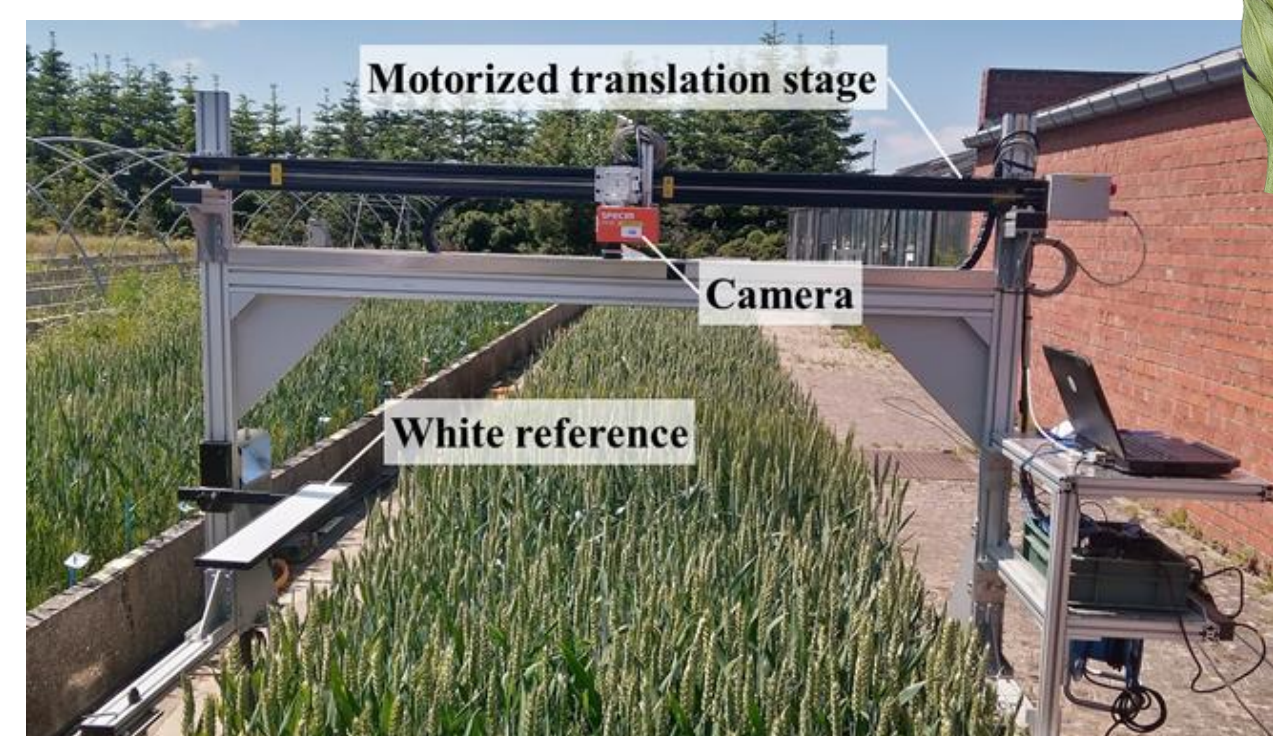
As demands for food authentication and safety continue to rise, cutting-edge analytical tools are generating larger, more complex datasets while enabling faster processing and sorting. Because traditional methods can show limitations in such conditions, the CRA-W and the CETIC decided to join efforts in the context of the **QUALISPECTRA** project to investigate the potential of **Deep Learning (DL)** Algorithms in terms of speed, efficiency and adaptability for the **quality and authentication of food and feed products** based on **hyperspectral images (HSI)**.



## 2 USE CASES

### Wheat Phenotyping – Detection of the fusarium head blight

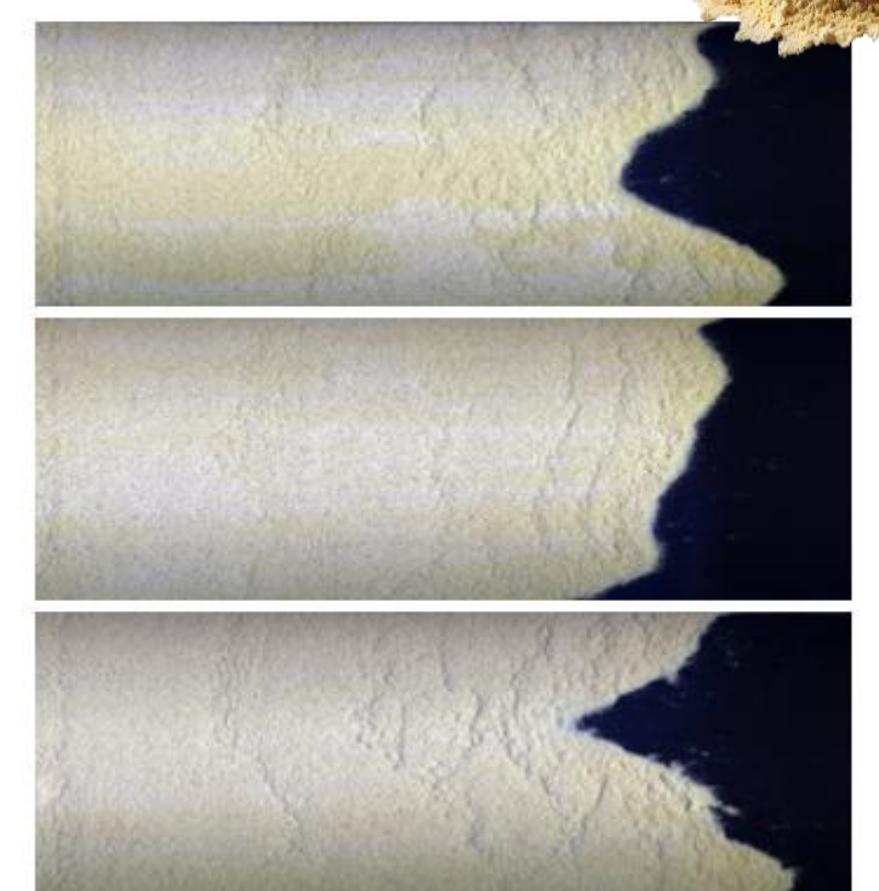
- Damages the grain, reduces yield and quality
- Hazardous to human and animal health (can produce mycotoxins)
- Fungicide treatment only preventive and not fully effective



Potential of hyperspectral imaging for automatic detection of FHB in crops

### Homogeneity of powder mixtures

- Critical to ensure uniform distribution of mixture properties
- Challenge for food, feed and pharmaceutical industries
- Current monitoring methods are destructive, time-consuming and sensitive to sampling bias



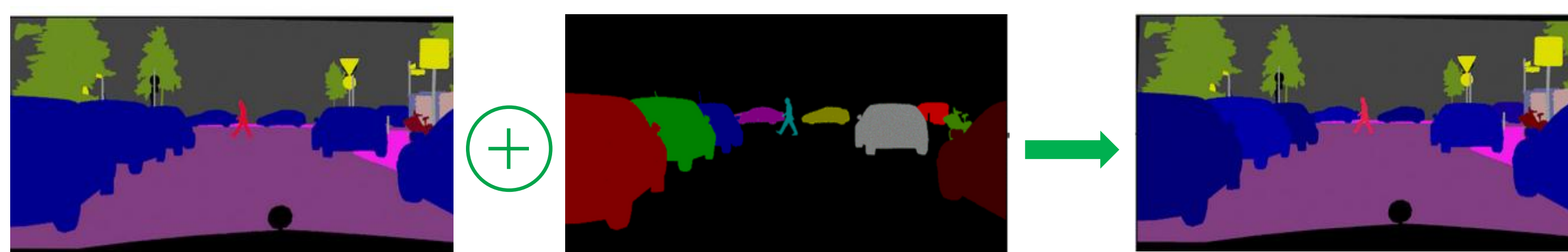
Potential of hyperspectral imaging for continuous and non-destructive monitoring of the homogeneity

## 3 CHALLENGES AND SOLUTIONS

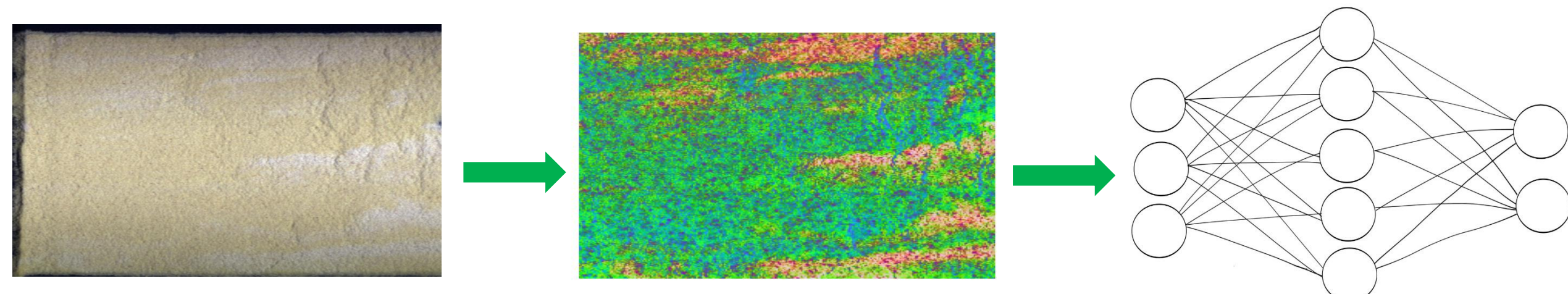
The goal of **QUALISPECTRA** is to focus on traditional challenges in hyperspectral imaging (HSI) and explore how Deep Learning can effectively address these issues, rather than leveraging DL only for performance gain. For now, the project focusses on the following challenges:

**Loss of spatial information (unfolding):** Traditional pipelines unfold hypercubes, ignoring pixel spatial distribution critical for some applications (e.g. homogeneity assessment + discrimination of FHB vs other diseases inducing same spectral response but different spatial patterns).

- Panoptic segmentation: Combine semantic segmentation (ear delineation) with instance segmentation (healthy/diseased pixel).



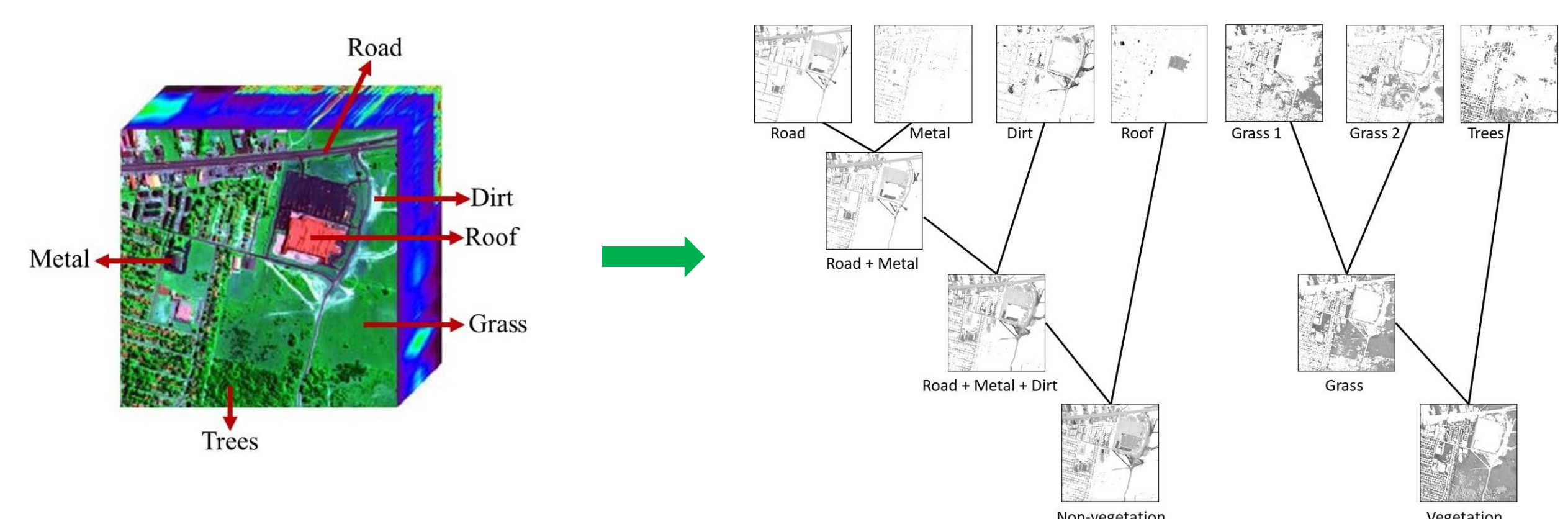
- RGB representations of HSI to apply simple CNN architectures and well-known computer vision algorithms on the full images.



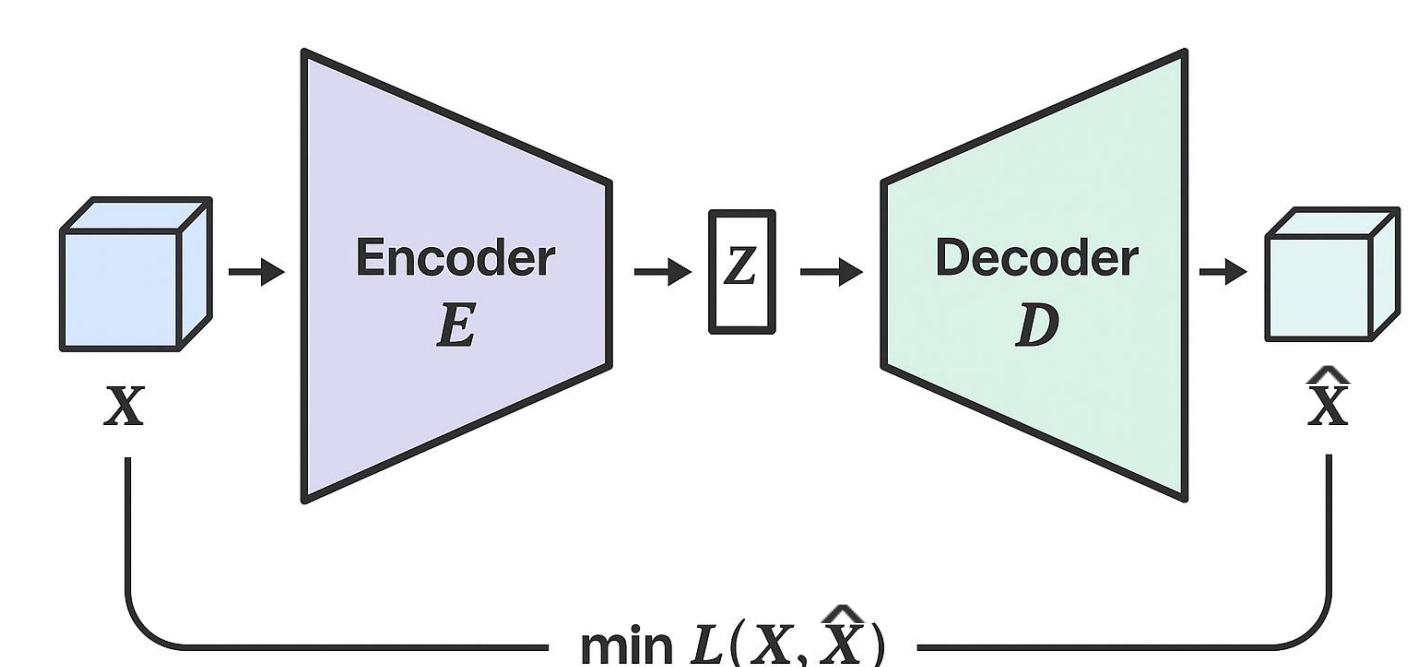
**Lack of independent samples:** Supervised methods prone to overfitting, unsupervised methods do not always yield satisfactory results (e.g. homogeneity assessment - 9 independent samples blended several times).

**Lack of pixel labels:** Traditional methods often assign the same label to all pixels in an image, which fails with inhomogeneous samples.

- Extension of Non-negative Matrix Factorization (NMF) to multiple layers: Advanced unsupervised algorithm extracting several levels of materials with hierarchical relationships.



- Autoencoders: Self-supervised approach that uses the input (or part of it) as its own target output. Here, they compress the data into a latent space encoding component abundances and then reconstruct the original spectra (allowing extraction of component spectra).



In addition to those 4 main challenges, the high storage requirements and computational costs associated with HSI processing will be tackled in the 2<sup>nd</sup> phase of the project, although the RGB representations of HSI already addressed those.