COMPARISON OF PLS AND SVM DISCRIMINANT ANALYSIS FOR NIR HYPERSPECTRAL DATA OF WHEAT ROOTS IN SOIL

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Context: Quantification of **roots** and **crop residues** is important to understand the impact of agricultural practices on root system development and crop residues decomposition. Current method based on hand sorting is tedious, time-consuming and depends on operator subjectivity. **Near Infrared Hyperspectral Imaging** (NIR-HI) combined with **chemometric tools** could be a good alternative as rapid method to sort crop residues and roots extracted from soil samples and to quantify them. NIR-HI combine NIR spectroscopy and imaging technologies allowing the acquisition of a large number of data per sample (Dale et al., 2012) taking into account the heterogeneity of the products. Robust models are therefore needed to analyze the data. **The aim of this work was to compare the chemometric tools PLS and SVM on NIR-HI spectra** in order to reach the most accurate discrimination between spectra of soil, root and crop residues of winter wheat.

Methodology

Sampling

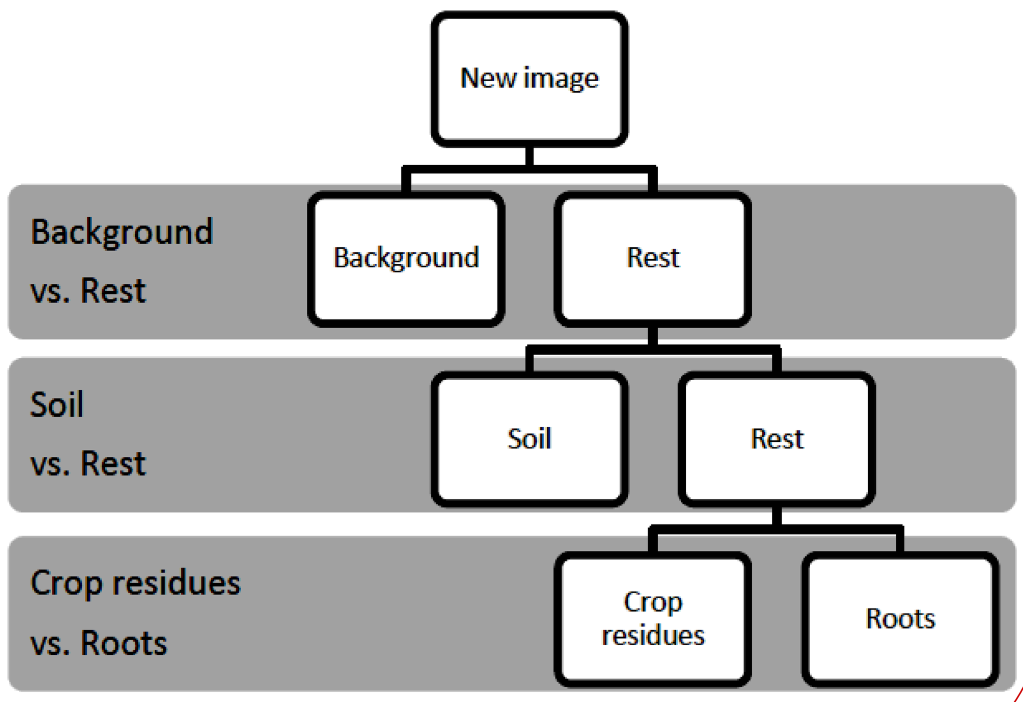
Roots and crop residues of winter wheat were collected in fields by soil coring and extracted from cores using tap water.

Image acquisition

NIR images were acquired with a **NIR hyperspectral line scan** (= push-broom) (Vermeulen et al., 2012). Samples were laid on a conveyor belt placed under the NIR camera. For each pixel of the NIR image, a complete spectrum including 209 wavelengths (1100-2498 nm) was collected.

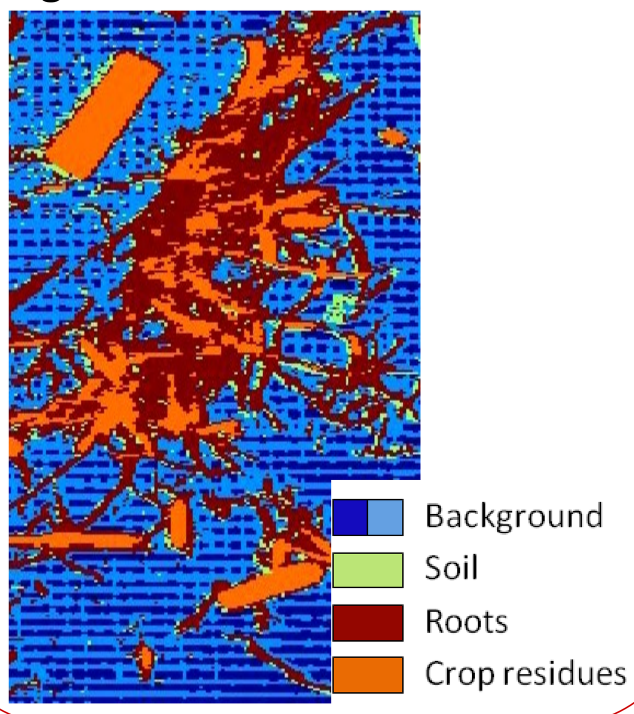
Spectra discrimination

A **dichotomist classification** tree based on **3 successive PLS or SVM models** was used to separate spectra into **4 distinct classes**: background, soil, crop residues and roots (Eylenbosch et al., 2014; Fernández Pierna et al., 2004).

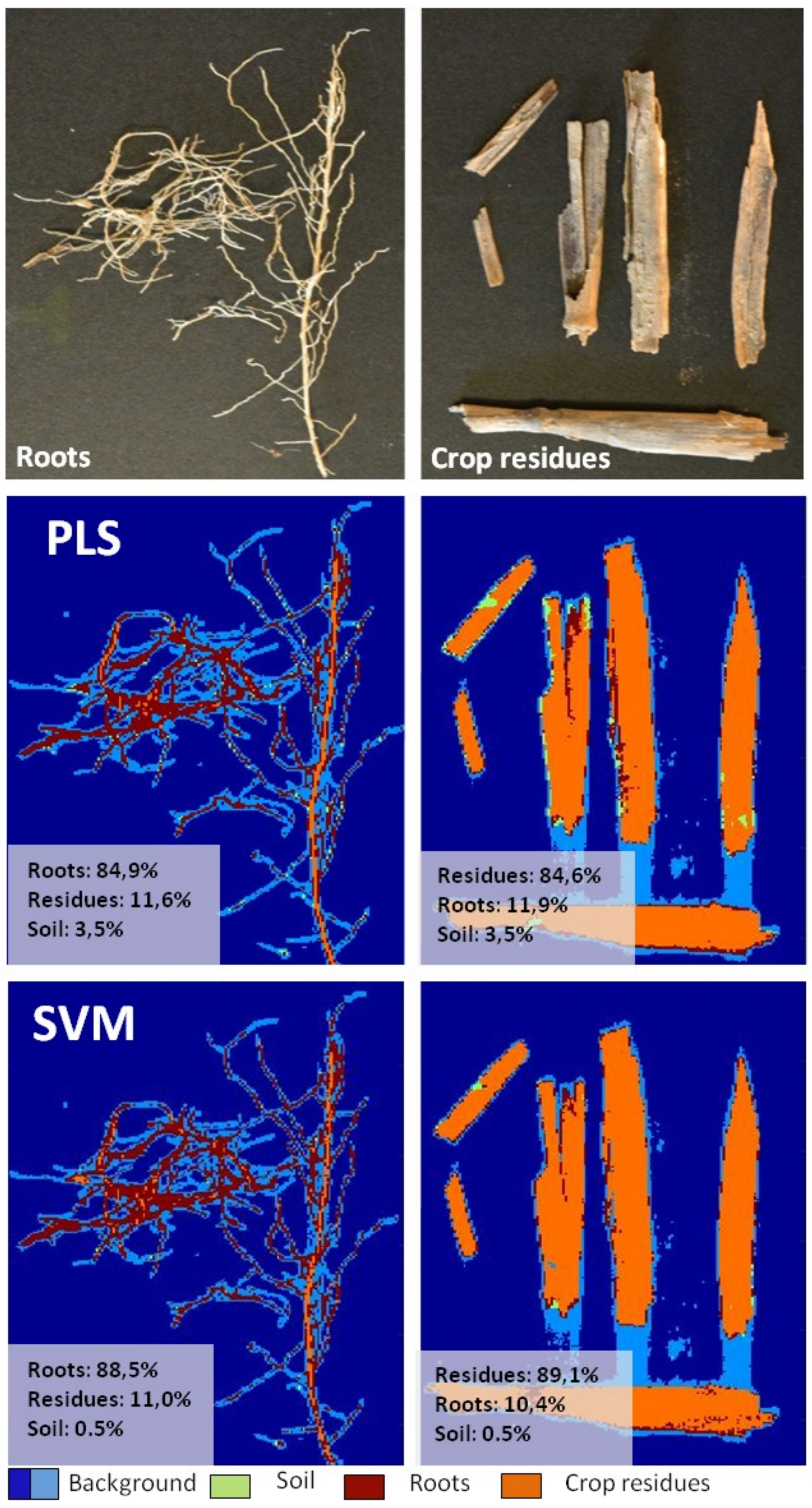


Prediction and quantification

A color was assigned to each class allowing to create a **prediction image**. Quantification of crop residues and roots is based on the number of pixels detected as such using the dichotomist tree.



Results and conclusions



Validation on spectral data:

Regardless of the spectral class, **SVM gave always equal or better results than PLS**, both during the calibration and the validation on an independent test set. The most difficult separation between NIR spectra appeared between roots and crop residues, which have, among the 4 spectral classes, the most similar chemical composition. The highest difference between both models was reached in this particular case during the calibration: 9.1% of NIR spectra of crop residues were better predicted with SVM.

	Model	Calibration		Validation	
		Sensitivity	Specificity	Sensitivity	Specificity
Background vs. Rest	PLS	0,961	0,975	0,921	0,942
	SVM	0,979	0,996	0,996	0,980
Soil vs. Rest	PLS	0,993	0,982	0,986	0,962
	SVM	0,992	0,997	0,990	0,994
Crop residues vs. Roots	PLS	0,880	0,865	0,850	0,822
	SVM	0,971	0,926	0,934	0,849

Sensitivity: proportion of spectra detected as positive for the positive class in the model.
Specificity: proportion of spectra detected as negative for the negative class in the model.

Validation on NIR images:

To estimate the ability of the equations to predict the right nature of pixels on hyperspectral images, predictions were done on NIR images taken on single elements (soil, crop residues or roots) directly placed on the conveyor belt. The percentage of correctly predicted pixels was calculated by dividing the number of pixels predicted as belonging to the class by the total number of predicted pixels for these 3 classes. On hyperspectral images, as illustrated on the figure, **SVM gave also better results than PLS**. Less pixels are predicted as soil and pixels on the border of crop residues are better predicted.

Conclusions:

Based on these results, SVM has therefore been considered as the most robust model and it was combined with Near Infrared Hyperspectral Imaging to develop a new rapid and reliable method to quantify roots in soils.

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