Early detection of the fungal disease "apple scab" using hyperspectral imaging

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Apple scab

• The main cause of stress and fruit losses in apple orchards .

•Fungal disease.

• Caused by the ascomycete fungus ***Venturia inaequalis.***

• Requires 10 to 20 fungicide treatments applied per year on an orchard.

• Without treatments, it can **cause 100%** loss of the apple harvest.

• Best conditions for fungus development : **Temperature = 18°C et Humidity HR=90%**

• Attacks both **fruits** and **leaves**.

• Forms pale yellow or olive-green spots on the upper surface of leaves.

• Visible to the naked eye **: 21 days** after infection

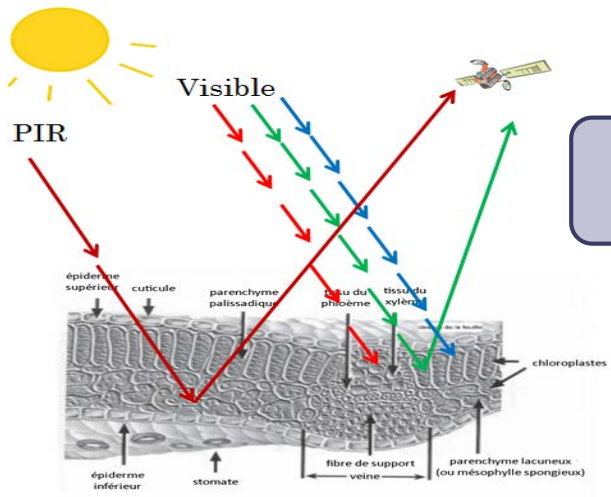
- Pressure to :

- Reduce pesticide use
- Reduce production costs
- Maintain a high level of crop quality

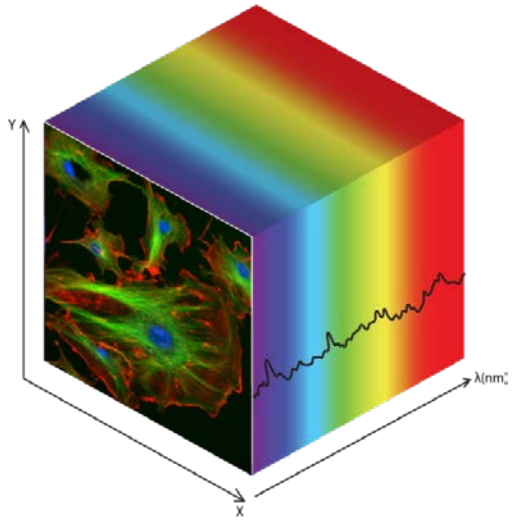
Early, accurate and non destructive detection of apple scab infection would be an efficient solution to optimize the management of the fruit disease

Issues

- Fungal infections modify the reflectance spectral properties of infected leaf:
- Delalieux.,al, 2007→ Spectroscopie (10 jours après l'inoculation)
- Oerke et al., 2010 → Thermographie (Taches)

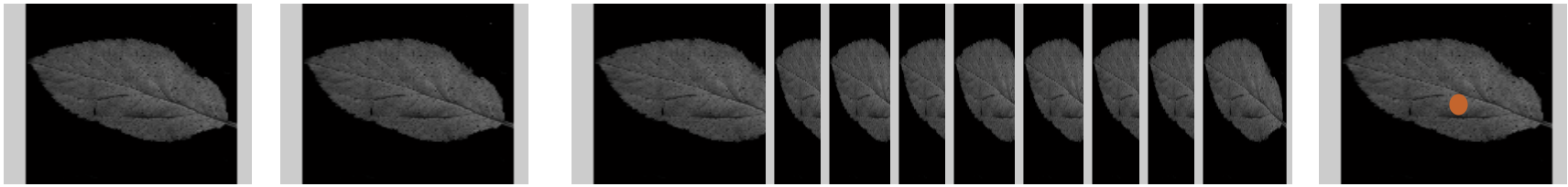


Hyperspectral imaging:
Spectroscopie + image



Assumptions

- Monitor the temporel and spatial evolution of the scab disease



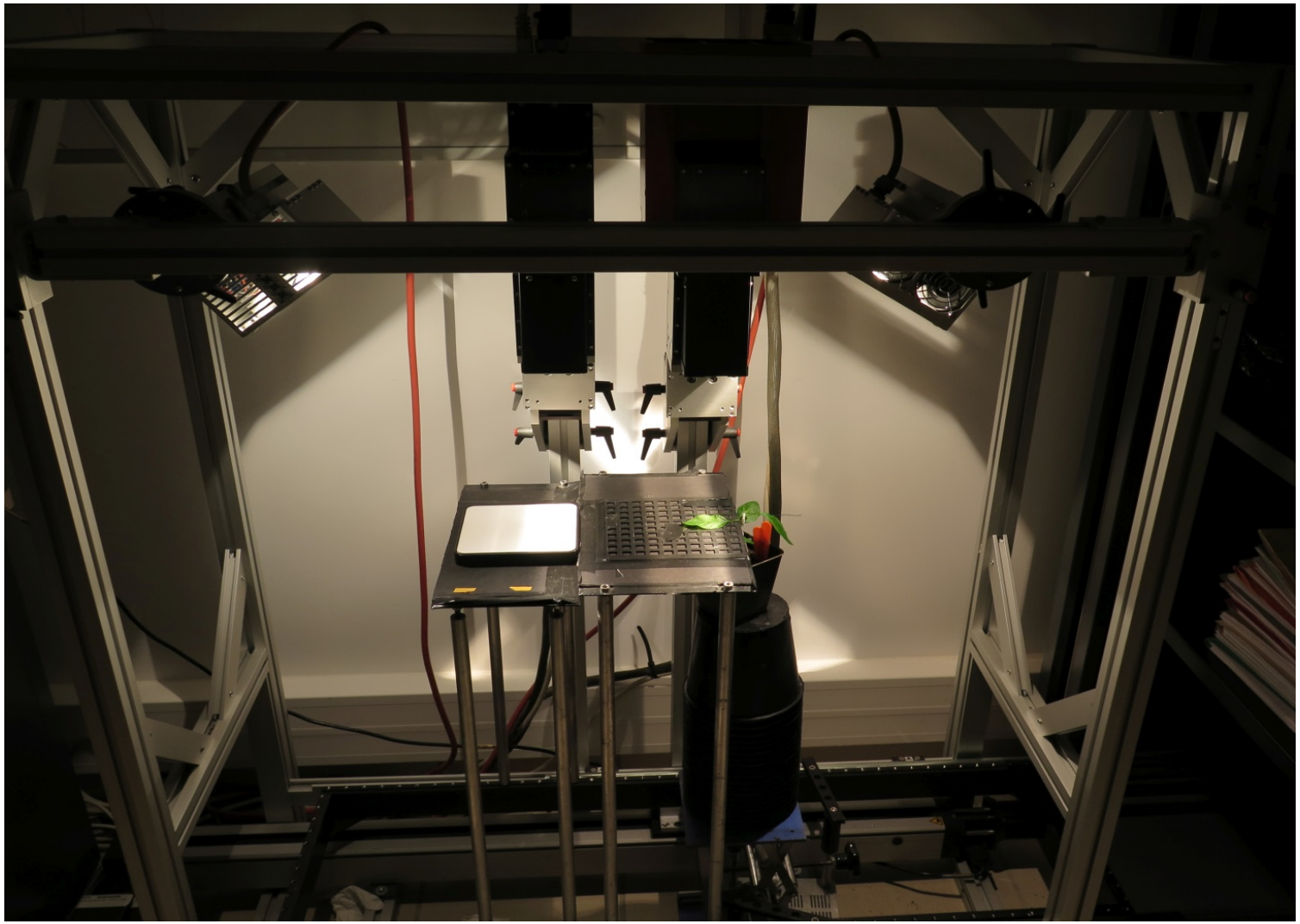
Experimental part

Greenhouse

Inoculation

Incubation

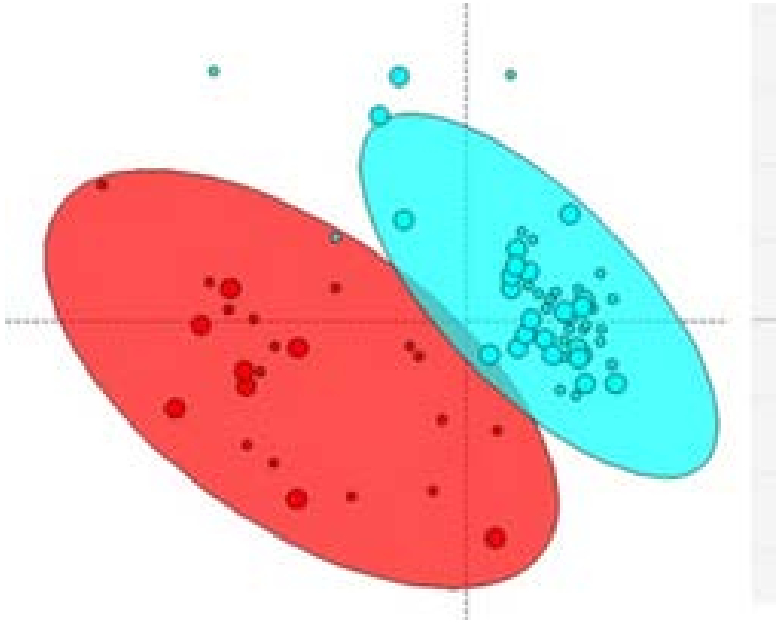
Experimental part



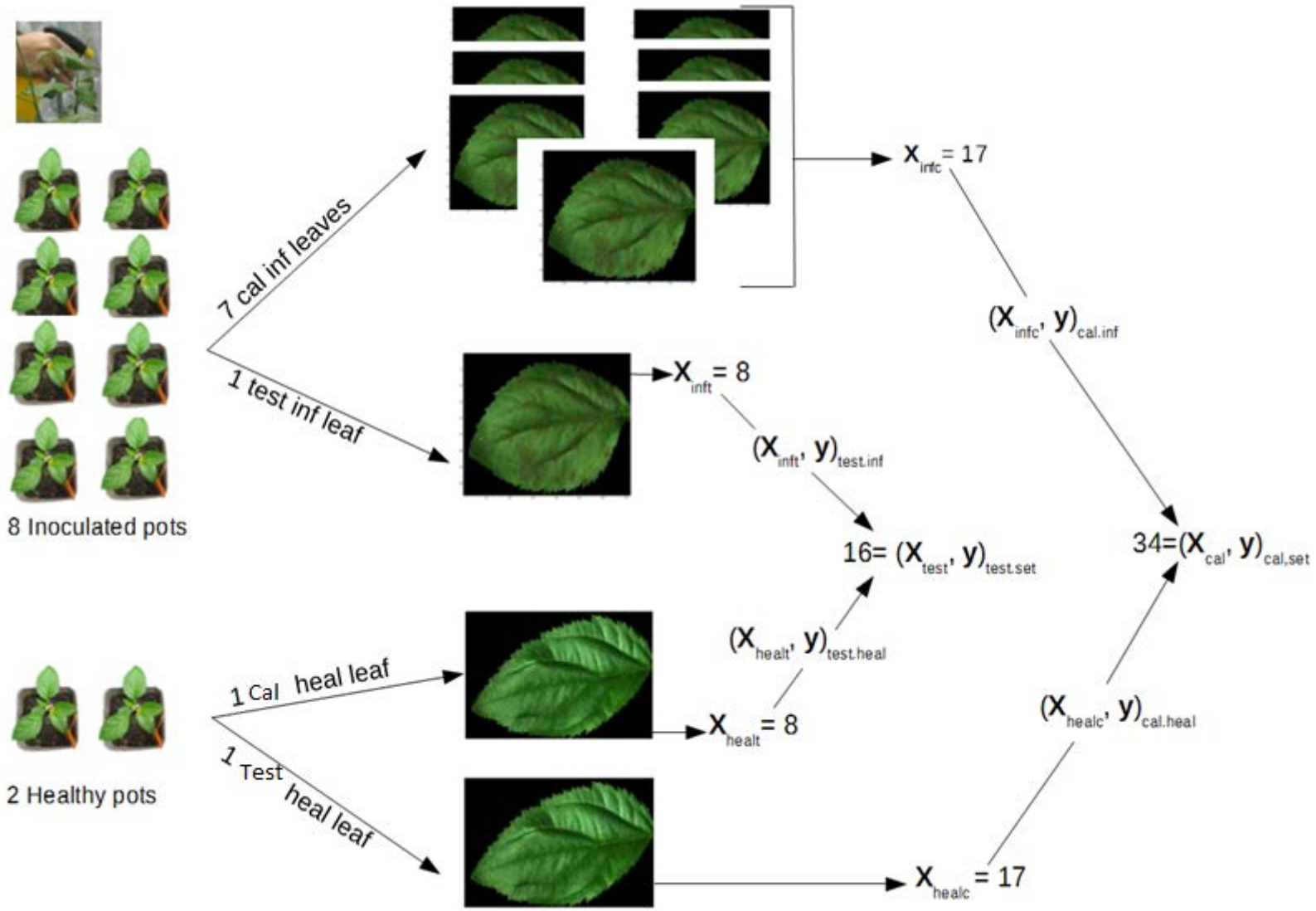
Hyperspectral image acquisition device

Images processing

- Chemometric classification method PLS-DA :
  - A PLS regression calculated between the spectra and their belonging degrees to the classes.
  - Followed by a discriminant analysis DA calculated on the PLS scores.

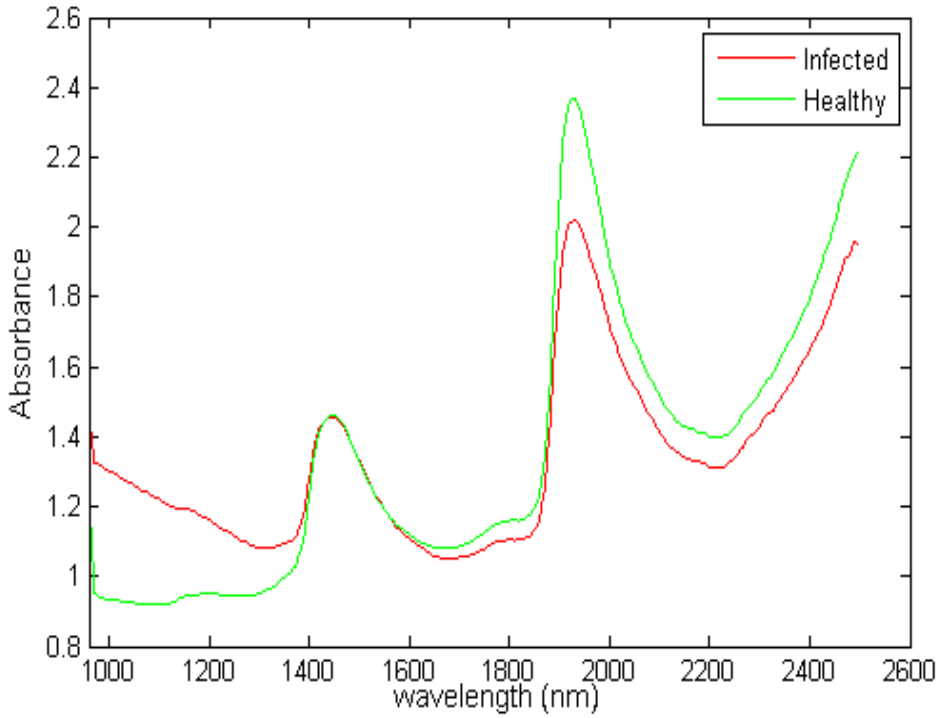


Calibration and test sets



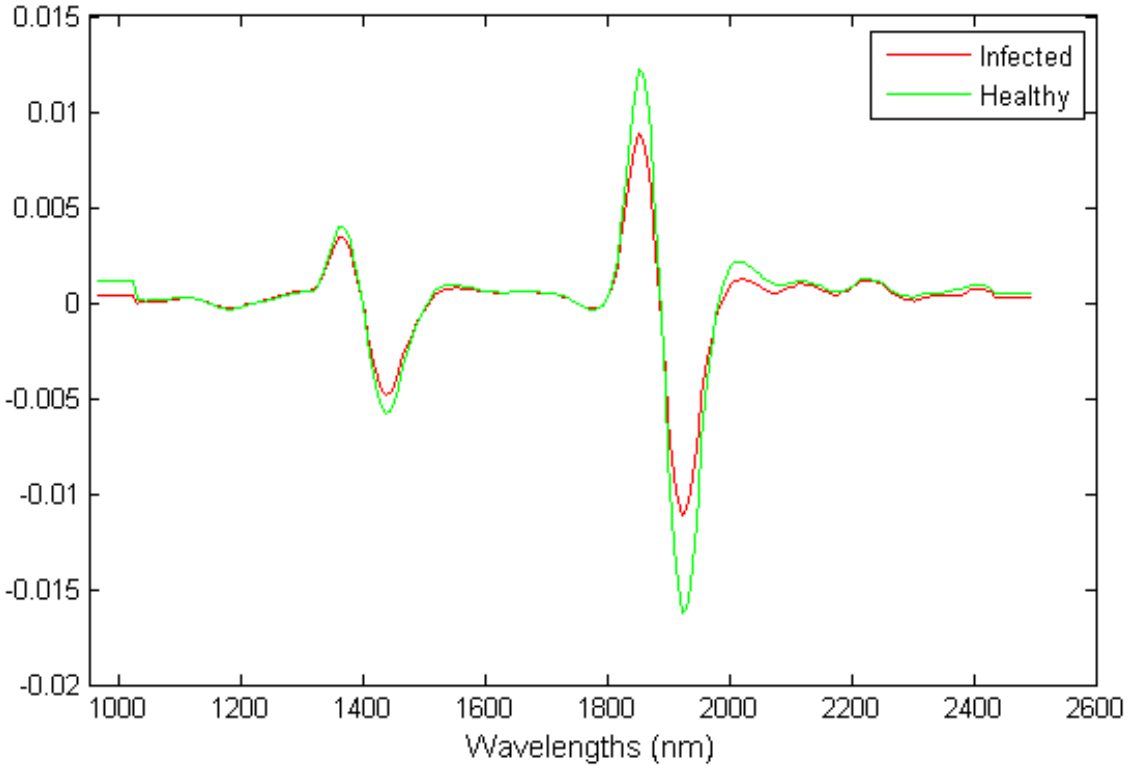
Images processing

Spectral analysis



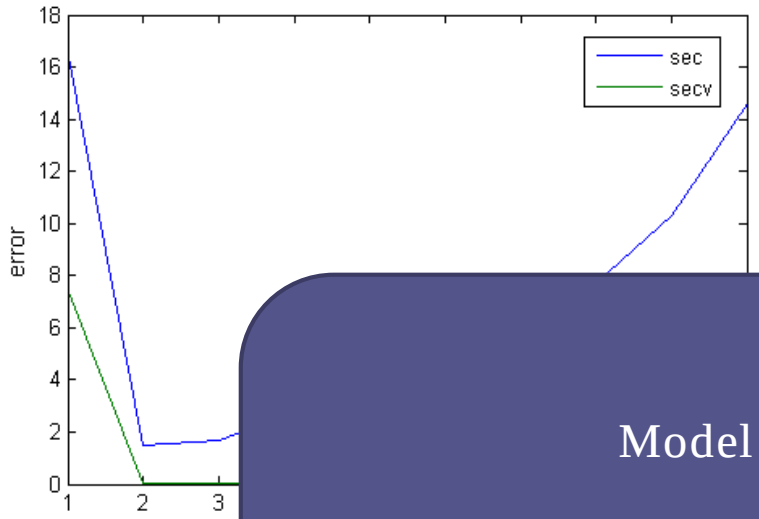
Average spectral curve of healthy and infected classes

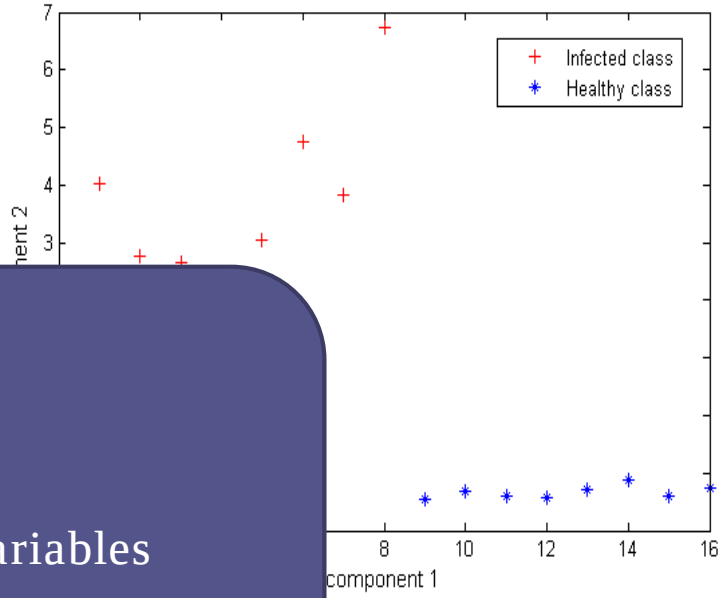
Images processing



Second derivative of healthy and infected average spectra

PLSDA model





Model is valid

Simple model : 2 latent variables

Good predictibility

			...hy spectra
Real classes	Infected test spectra	8	0
	Healthy test spectra	0	8

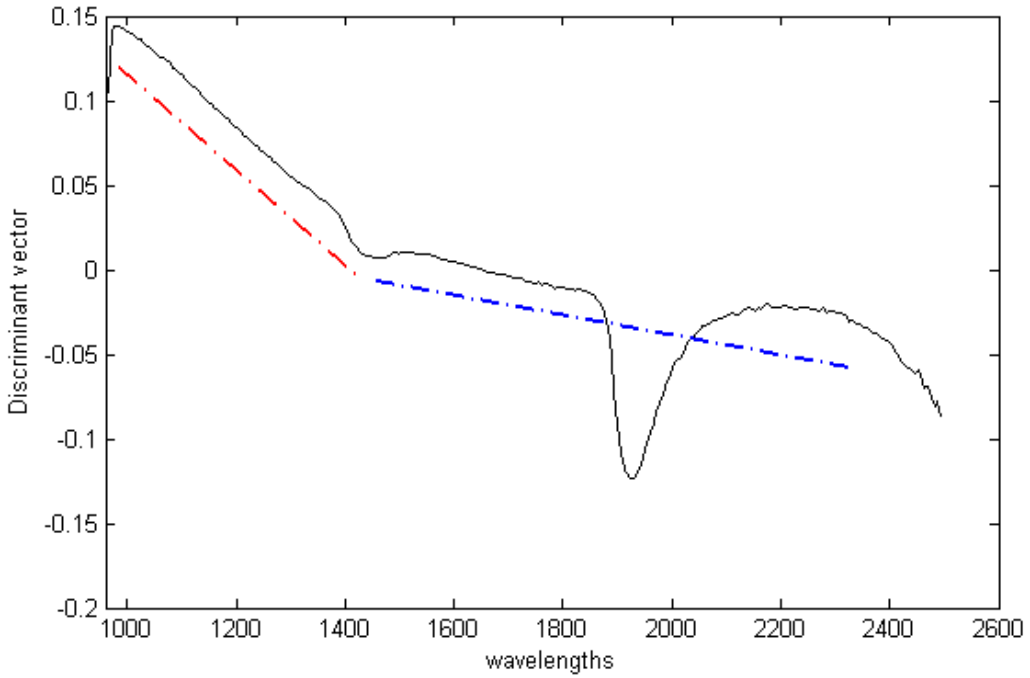
Images processing

Results :

Apple Scab:

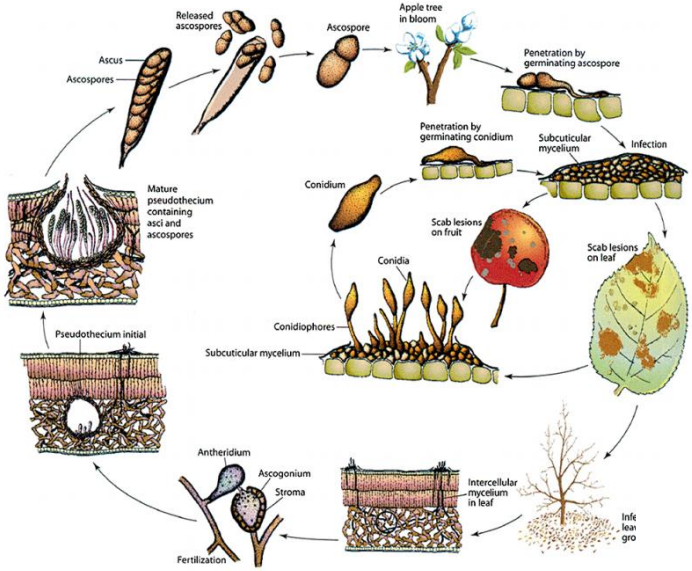
Structure modifications

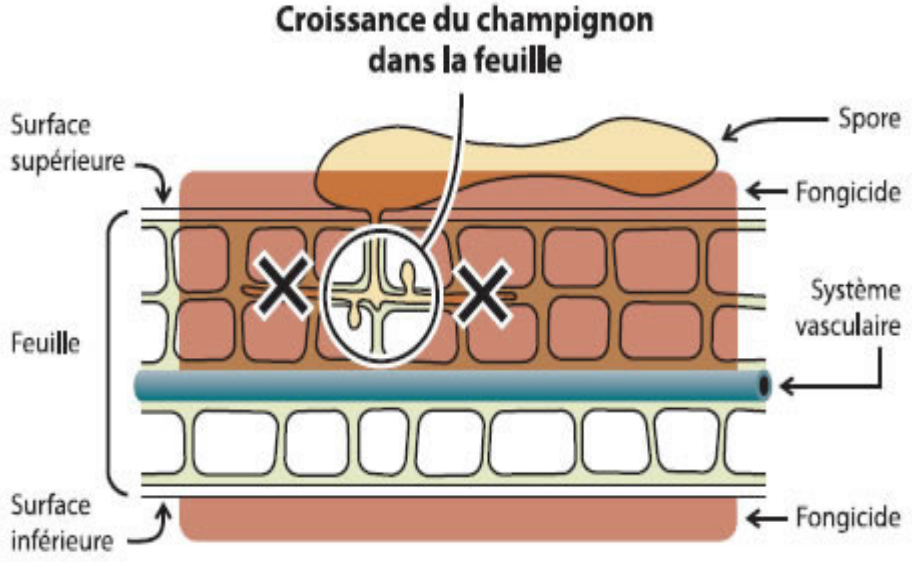
Water content



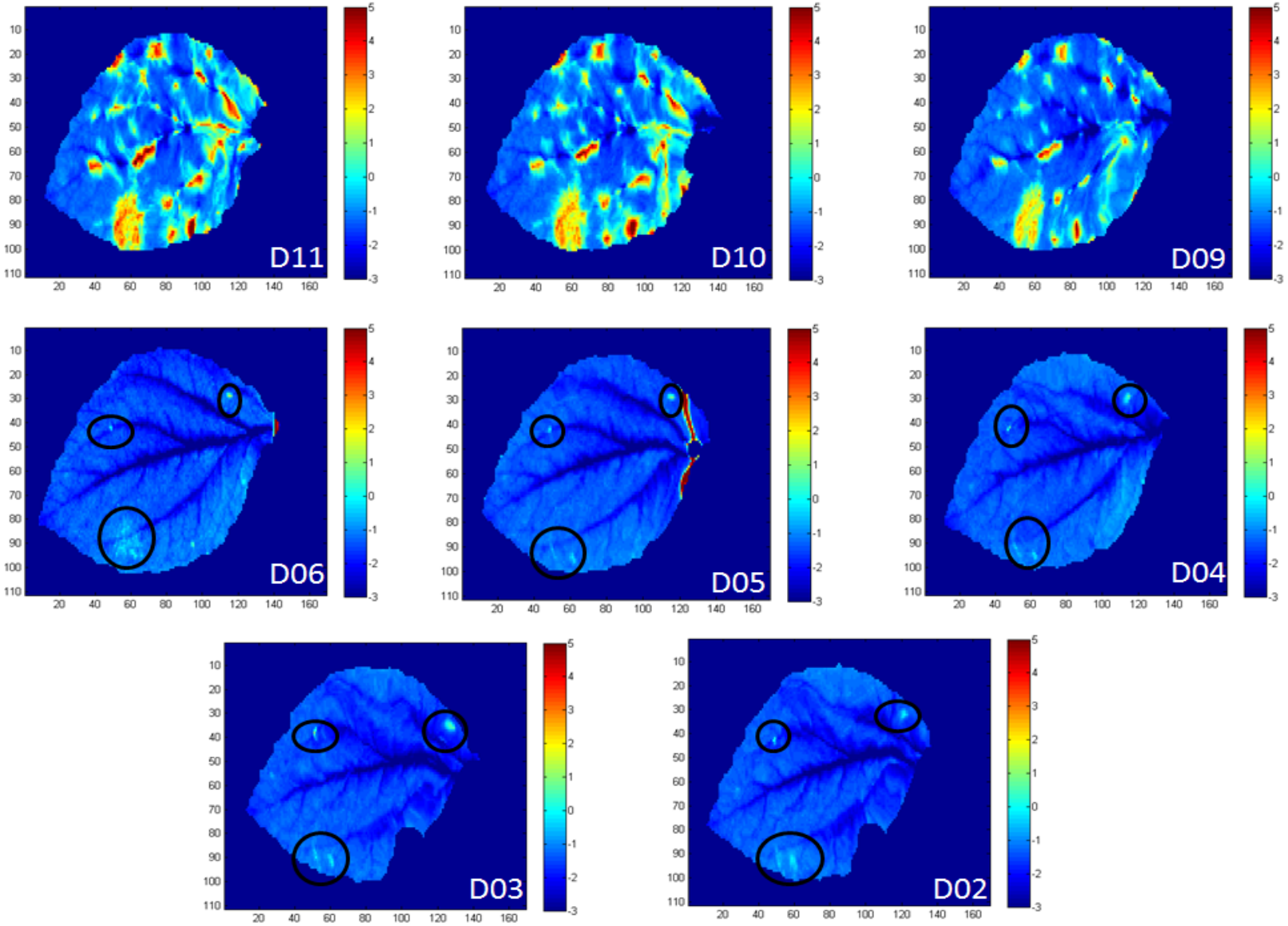
PLSDA discriminant vector

Physiological link

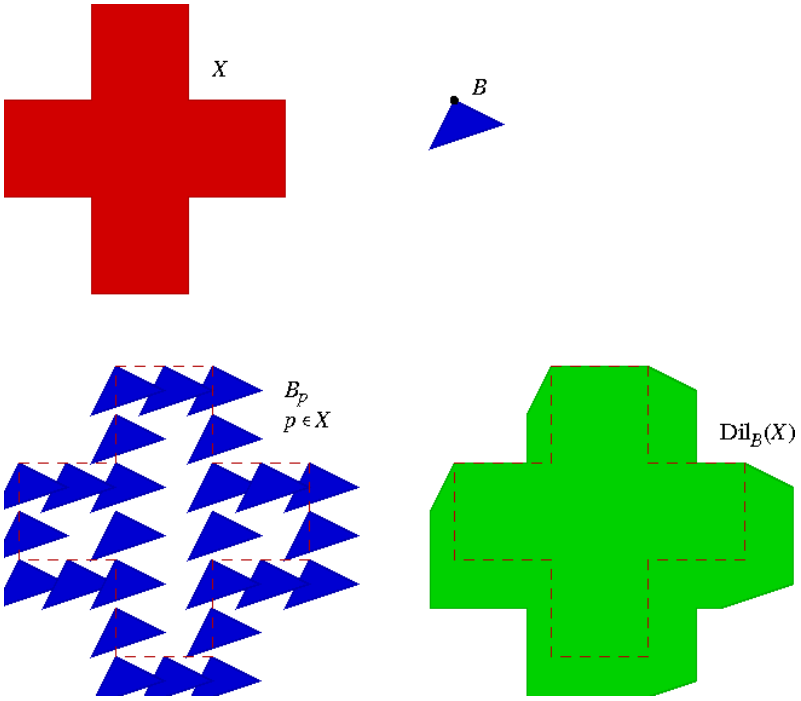




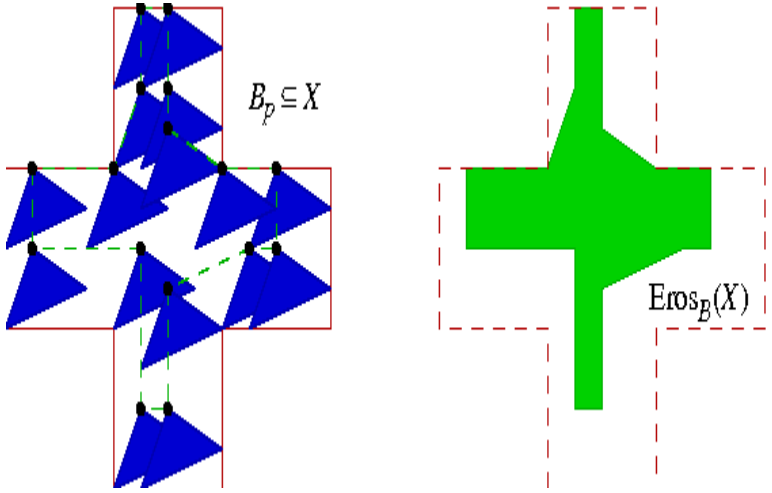
Test of the PLSDA model on Infected leaf series



Morphological operations

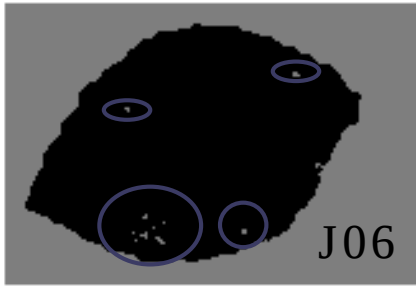


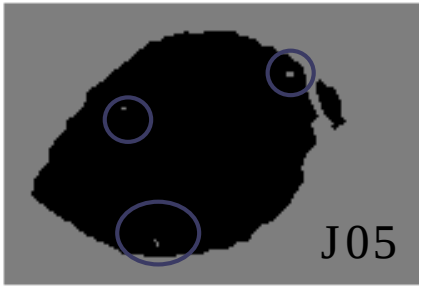
Dilatation

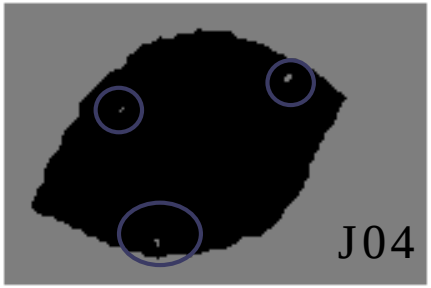


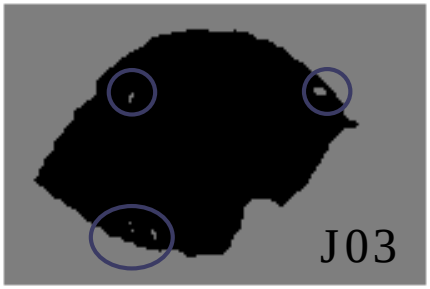
Erosion

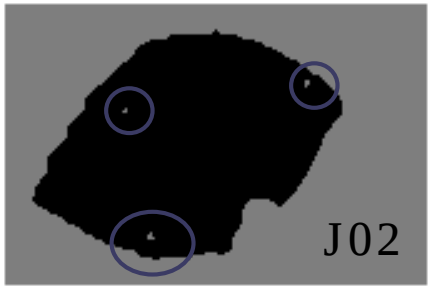
Opérations morphologiques ..



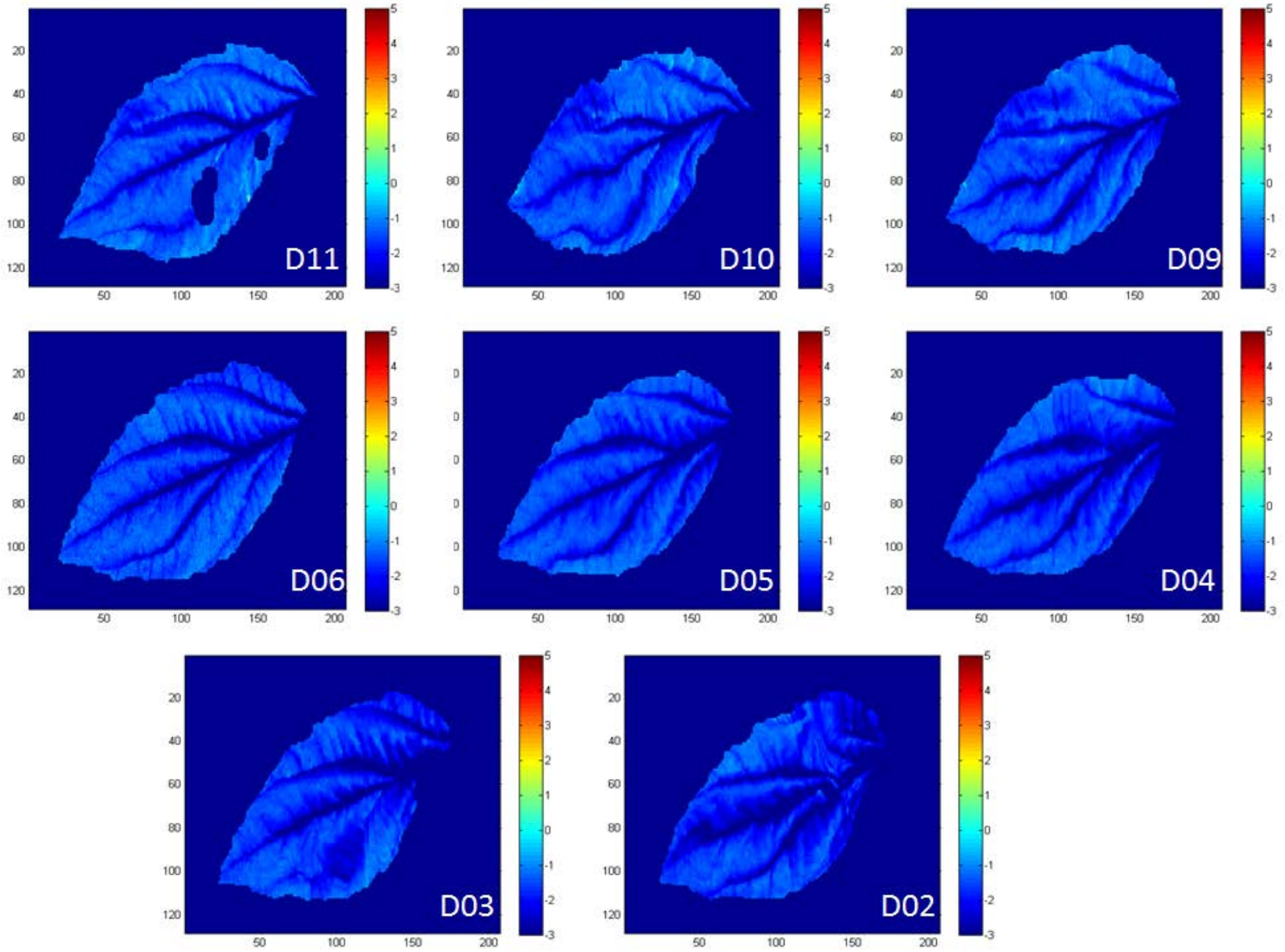




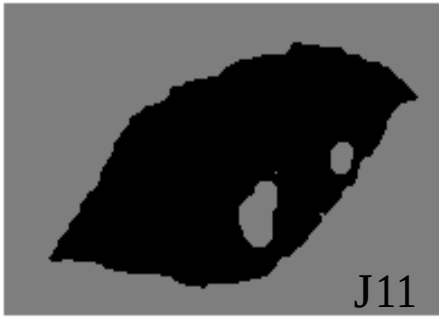


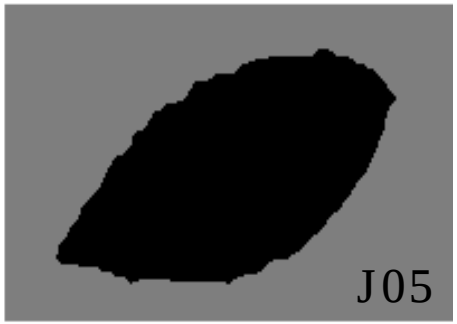


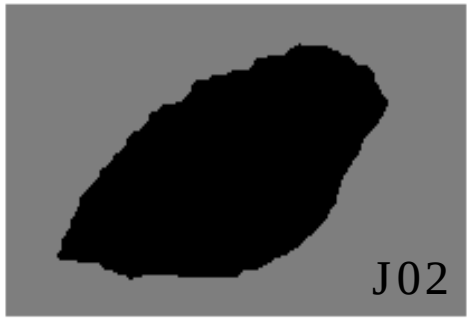
Test of the PLSDA model on Healthy leaf series



Morphological operations







Conclusions

- Hyperspectral imaging offers high potential as a non-invasive detection tool of apple scab infection.
- The most important disease effect is a change in the leaf physical structure
- The infection has a specific influence on reflectance spectra zone between 1950 nm: Zone carrying information on water content.
- SWIR (1000nm_2500nm) is adapted for the early apple scab detection.

Thank you for your attention

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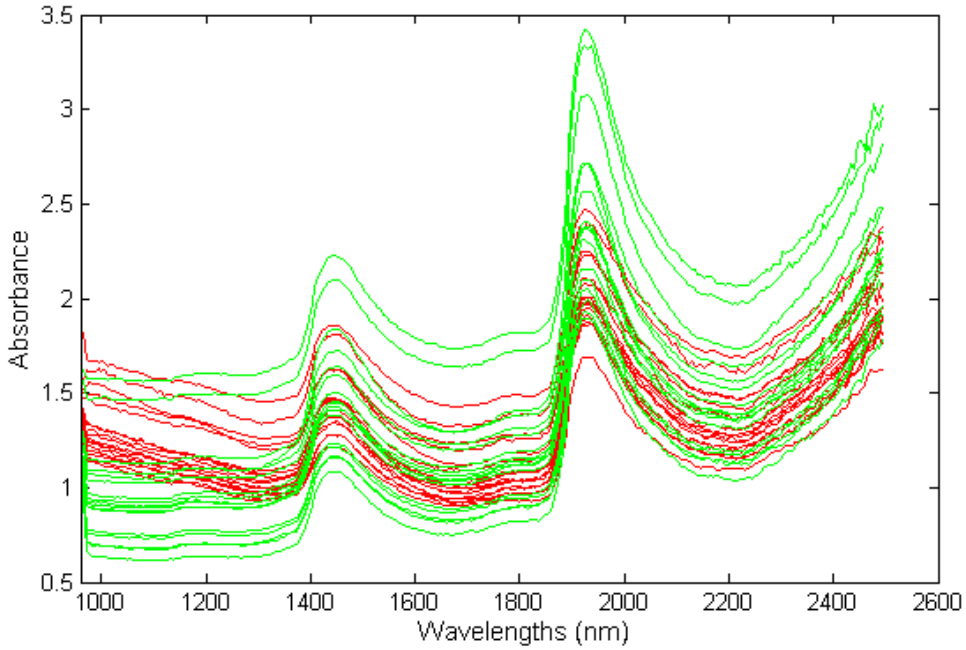
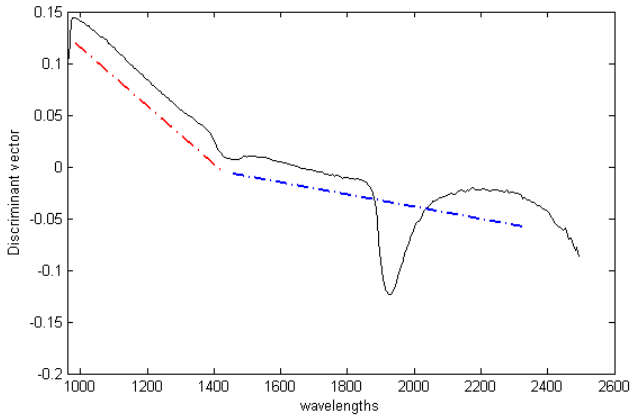


Spectral curve of healthy and infected classes

Spectroscopy approach

Infected leaf series



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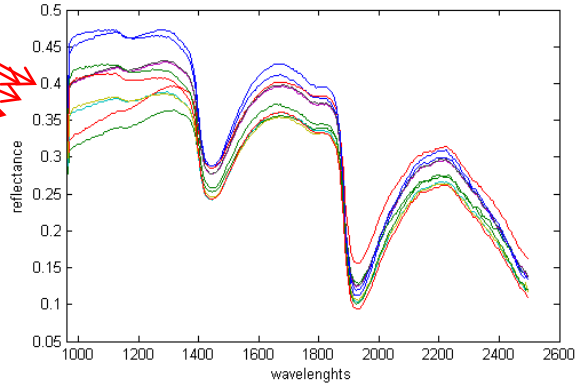

Spectroscopy approach

	Percentage of predicted infected spots (%)
D11	50
D10	40
D09	20
D06	0
D05	0
D04	0
D03	0
D02	0