Analysis of spectral signatures for the diagnosis of leaf diseases

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Networking sensor technology R&D
for crop breeding and management

The spectral reflexion at different wavelengths (visible (VIS), near-infrared (NIR), short wave IR, (SWIR)) varies with the physiological and biochemical conditions of the scanned crop. Hyperspectral sensors allow the recognition of different states of an object, i.e. plant. The interpretation of such signals, however, is cumbersome. Here, a new technique is introduced for the analysis of such signatures.

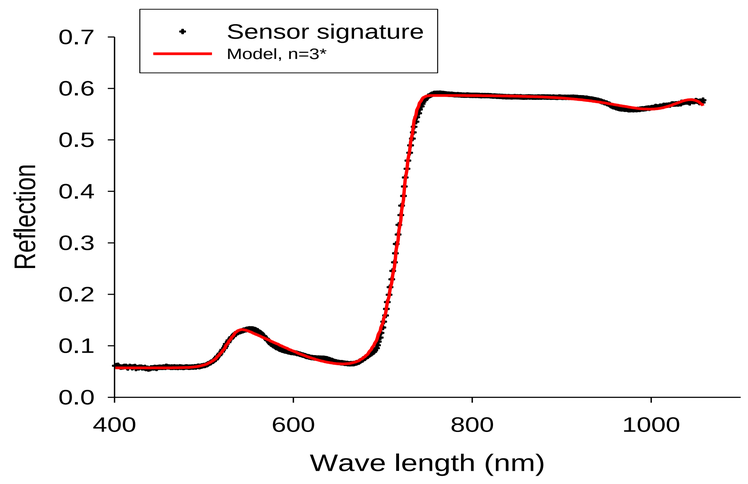
Proposed solution:
The analysis of spectral signatures can be achieved in a two-step procedure:

Step 1:
Development of a common model and fitting of the model to the data of spectral signatures:

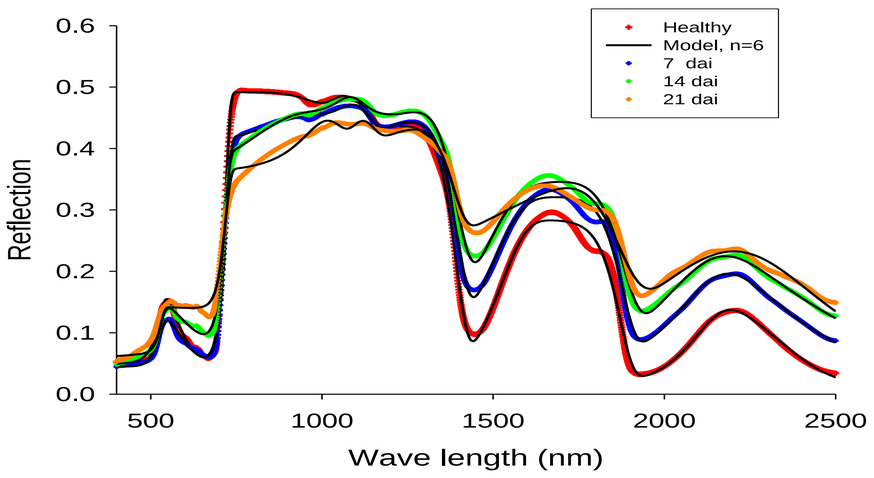
$$F_{(nm)} = A + \sum_{i=1}^{n} B_i \cdot \left(1 - e^{-\left(\frac{nm}{nm_{\alpha_i}}\right)^{\alpha_i}} \right) \cdot e^{-\left(\frac{nm}{nm_{\beta_i}}\right)^{\beta_i}}$$

with nm = wave length and n=2,3,..,6

Exp. 1: Fitting to data of VIS and NIR up to 1050 nm

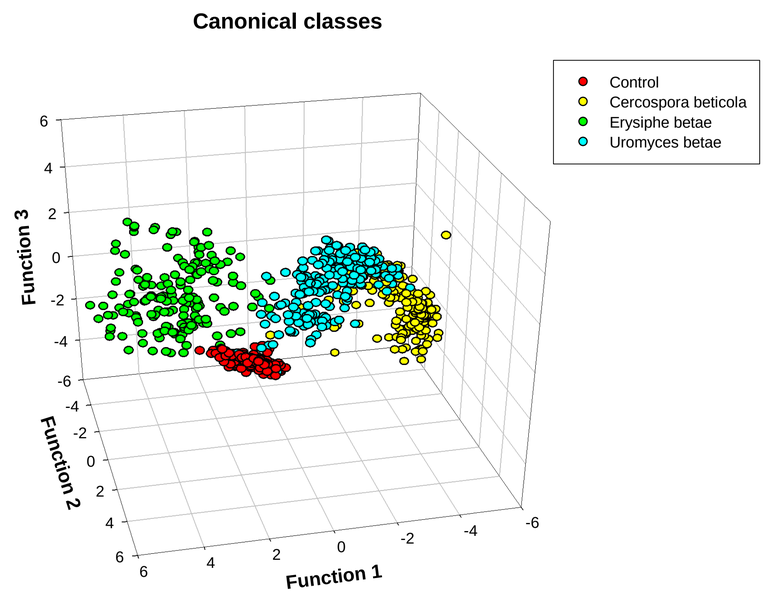


Exp. 2: Fitting to data of VIS, NIR & SWIR up to 2500 nm with disease progress of *Cercospora beticola*



The model is applicable for all signatures with high precision (R^2>0.99) and reduces the complex spectrum of 500 up to 2000 data points to 9 respectively 36 secondary parameters.

Step 2:
A discriminance analysis over the estimated parameters allows the identification of pathogen-specific classes, hence a distinction of various leaf diseases.



The complete analysis procedure is applicable for an automated diagnosis of different leaf diseases on sugar beet.

Tab. 1: Asymptotic parameter ranges for different crop conditions and diseases

Parameter	Healthy leaf	Light stress, undefined, premature	Medium Stress	Structural tissue decay strong stress	dead plant
A	0.03-0.07		0.03*,>0.1 **	0.03*	0.03*
B1	0.15-0.2		0.2-0.4 >0.5**		>0.4
$Nm_{\alpha 1}$	530		530	550	>550
α_1	>40		30-40	20	<20
$nm_{\beta 1}$	560*-570	580-600	>600	>600	>600
β_1	7-11		11-19	>20	30-40
B2	0.4-0.5				>1
$nm_{\alpha 2}$	719-723	710-718	710-700	<700	<700
α_2	50-54		40-49	20-39	5-19
		Repoting, Inoculation, nutrition	Mildew, Rust	*Cercospora, Rhizoctonia*	*Rhizoctonia*

Main parameters to assess stress intensities

Summary & Advantages

- Healthy“ is characterised by a narrow parameter vector
- Five specific parameters quantify stress conditions
- A diagnosis requires all 9 parameters simultaneously
- Exploits the current technical and sensorical resolution
- Addressing the complete information of a sensor
- Comprehension of the information to a few parameters
- Broad application potential
- High discriminatory power, even minor deviances are detectable
- relatively fast, open for statistical analysis

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