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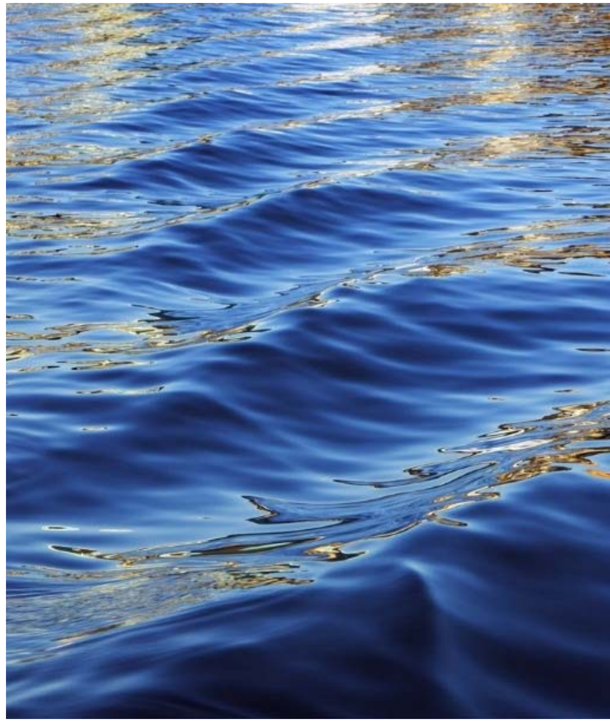
Mobility strand for teachers in Greece

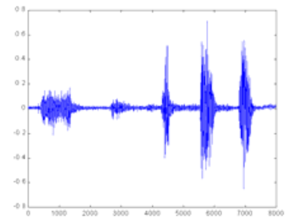
Thessaloniki, 22-26 May 2017



ΑΡΙΣΤΟΤΕΛΕΙΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ
ΘΕΣΣΑΛΟΝΙΚΗΣ

AGRICULTURAL Engineering laboratory

Agro-Machinery



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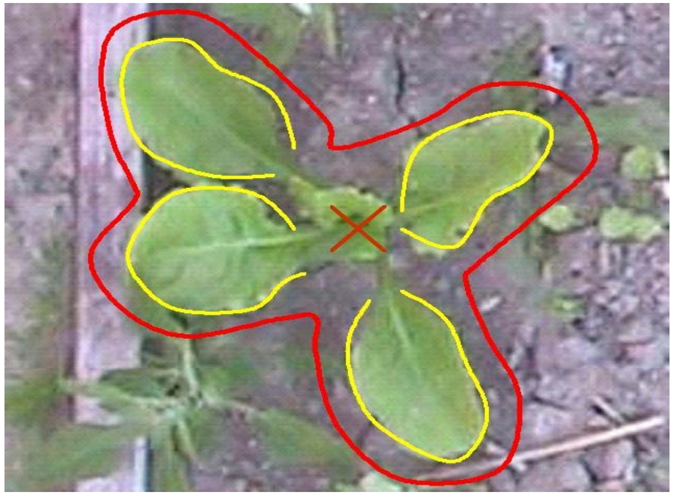
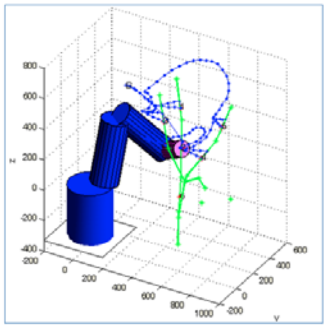
Automation-Robotics-Machine Intelligence





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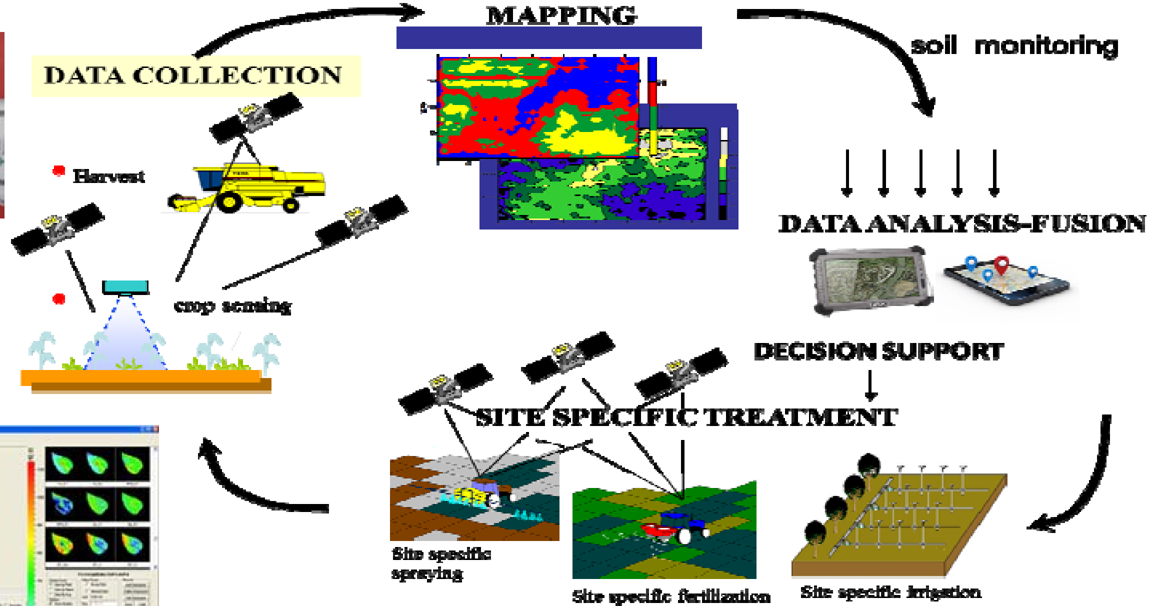
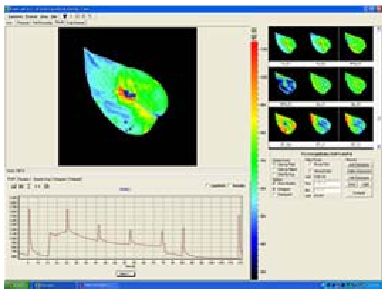
Precision Agriculture-Sensors





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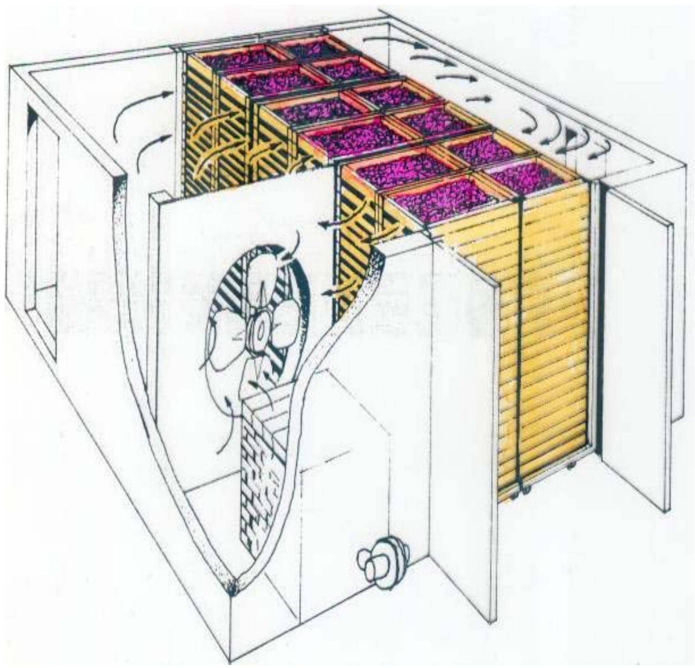
Post Harvest Handling–Drying -Quality



Proximal sensing for biotic and abiotic crops stresses in precision agriculture

D. Moshou, X.E. Pantazi

Aristotle University of Thessaloniki,
- Agricultural Engineering Laboratory,
Thessaloniki, Greece

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- *Intelligent autonomous system for the detection and treatment of fungal diseases in arable crops*

OPTIDIS
QLK5-1999-01280

- *Active learning sensor fusion system for combined water stress and crop disease detection*

FarmFUS
Optimising Production Efficiency

ICT AGRI era-net

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overview

- Site-specific disease control
  - Biological background
  - 3 detection systems
  - Prototype
  - Spraying Strategy

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Disease Control

- Disease type
- Comparison of 3 disease detection techniques
  - Some biological background
  - Fluorescence
  - Spectral reflectance
  - Multispectral imaging
- A disease detection prototype
- Spraying strategy

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Disease Control

Yellow Rust

Septoria *tritici* (Leaf Blotch)

Site-specific treatments

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Site specific farming:

1. Apply fertilizers, herbicides and pesticides only where needed!
2. Reduction of production costs, reduction of chemicals
3. At the correct time (as early as possible)



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Disease Control

- Which are the best disease sensing methods?
- Look @ infection mechanisms!

Disease Control

- Disease sensing methods

1. infection
   - spores form hyphen
   - hyphen penetrate stomata and cells
2. metabolic changes
   - from photosynthesis to respiration
   - nutrient flows
3. early senescence
   - pigmentation and chlorophyll loss
   - cell wall collapse
4. overall plant stress
   - stomatal closure

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Infection mechanisms

1. infection

Disease Control

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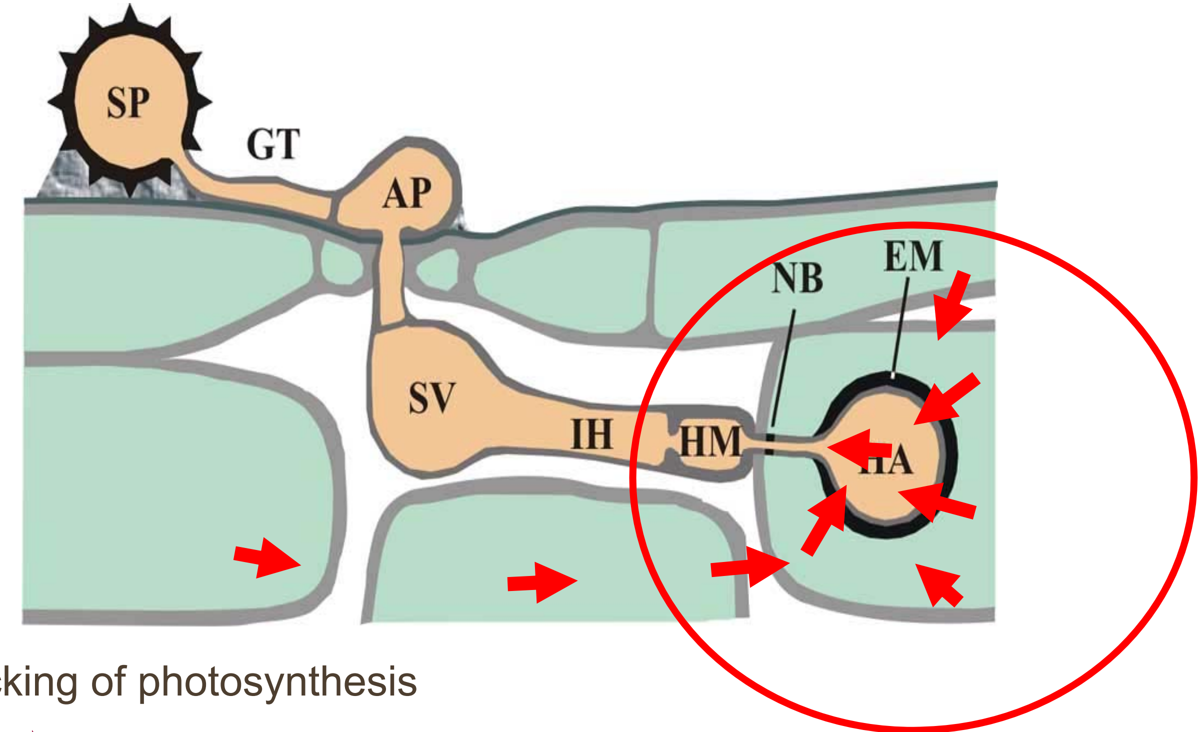
Infection mechanisms

2. metabolic changes



Blocking of photosynthesis

LOWER PS activity!!!!

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Infection mechanisms

3. early senescence

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Disease Control

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- Disease sensing methods

1. infection
2. metabolic changes
   - on diseased parts
   - from photosynthesis to respiration
   - nutrient flows
3. early senescence
   - on diseased parts
   - pigmentation and chlorophyll loss
   - cell wall collapse
4. overall plant stress
   - stomatal closure

fluorescence

reflection sensing

thermography

Disease detection: Fluorescence imaging

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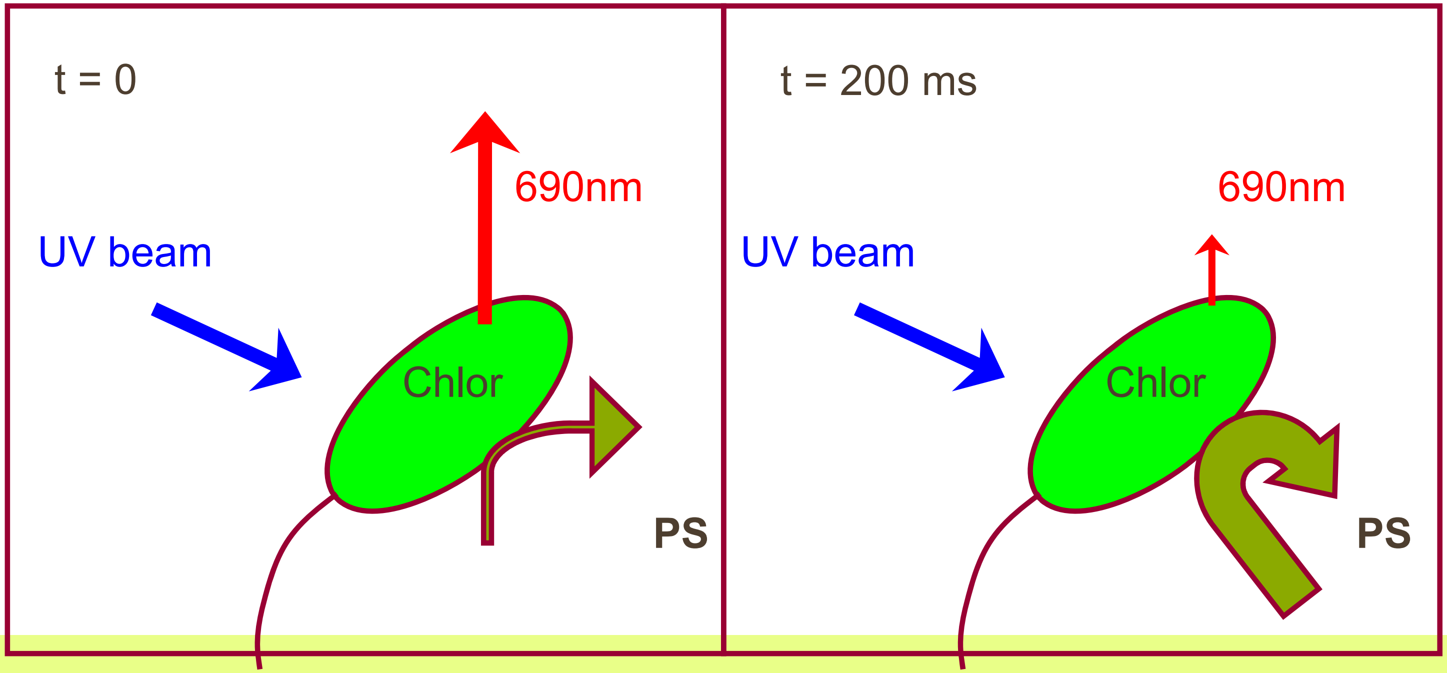
Fluo measures
- Chlorophyll content
- Photosynthetic activity

→
- infected cells: lower PS activity!
- thus higher fluorescence!

'Photochemical imaging'



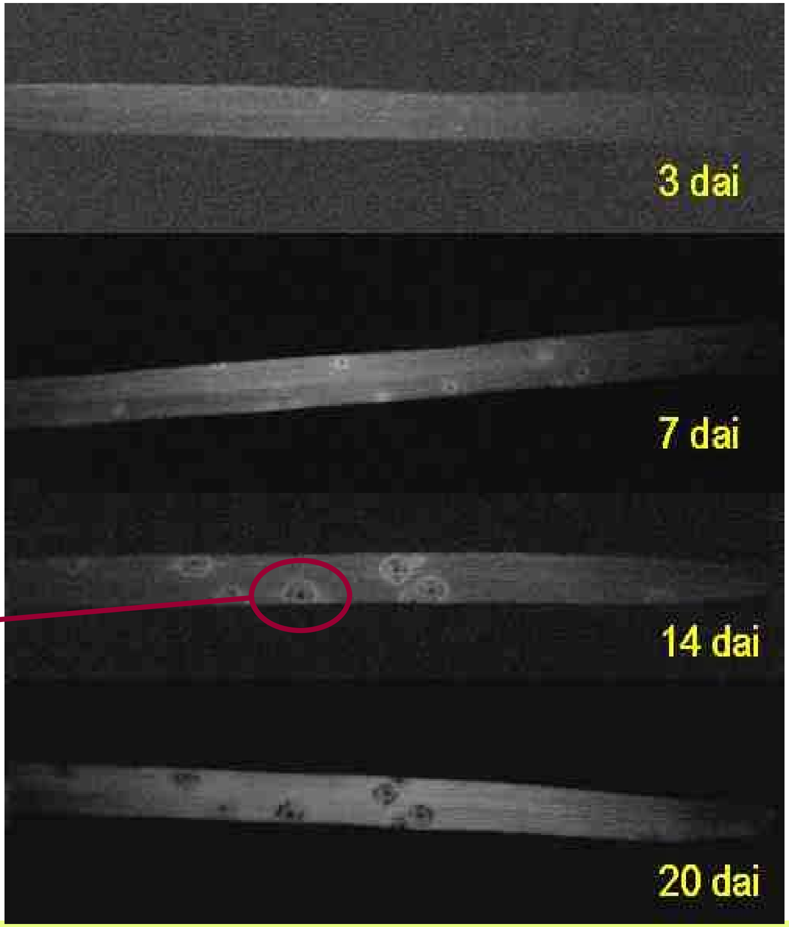
Disease detection: Fluorescence imaging

Laboratory example

Fluorescence at 690nm

Brown Rust infection

suspected lesion



Disease detection: Spectral systems

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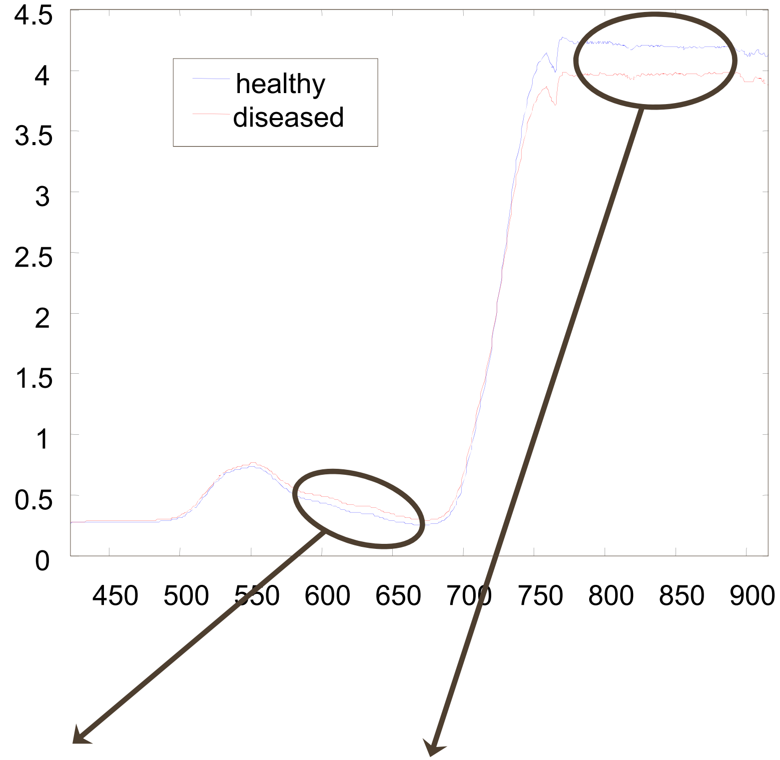
- Disease detection in greenhouse: Yellow Rust

wheat in trays → healthy plants (control!!!)

wheat in trays → diseased plants



$$StressIndex = \Delta spec(red) - \Delta spec(NIR)$$

Disease detection: Spectral systems

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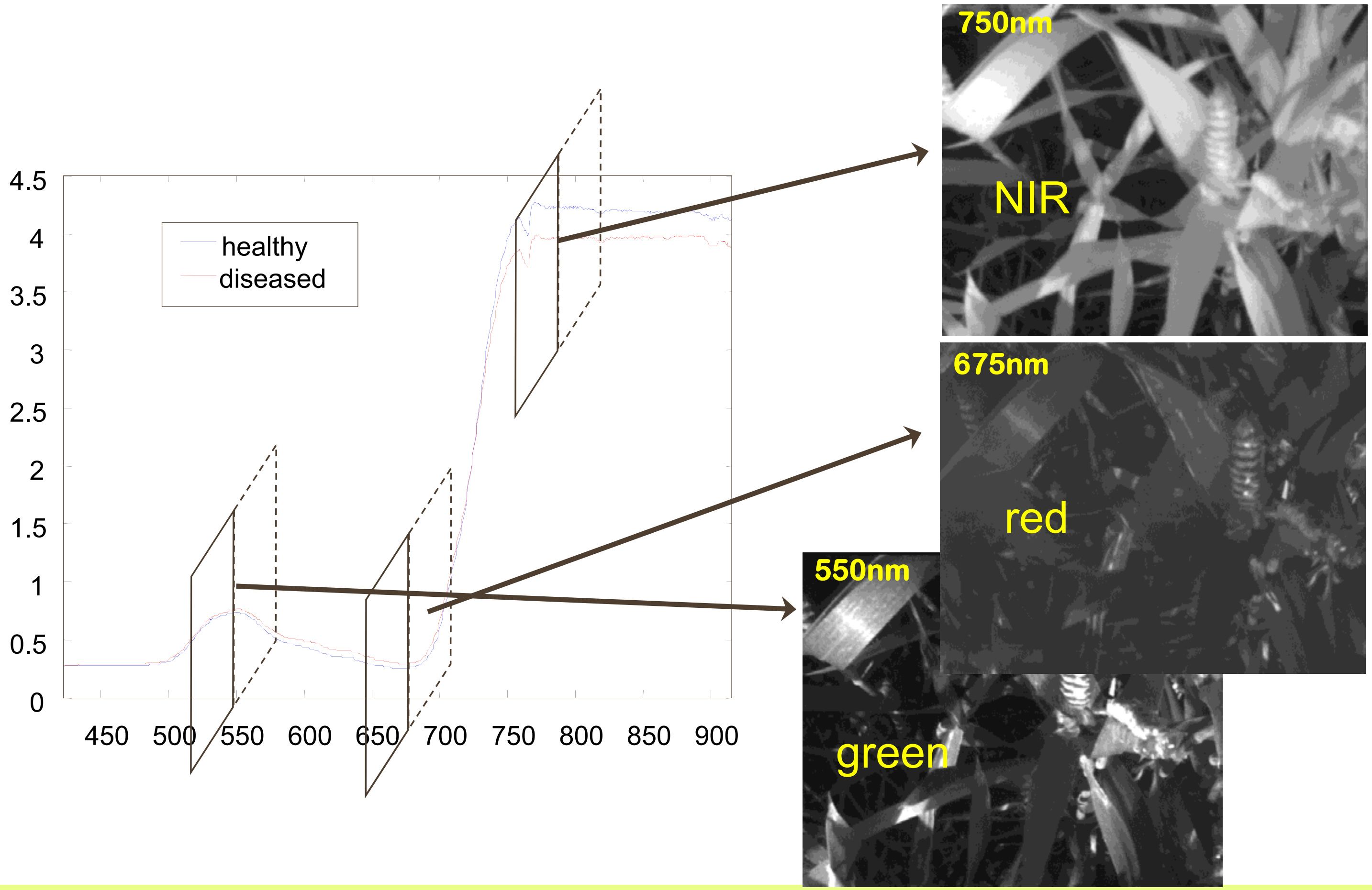
- Stress identification

Δspec	550nm (green)	550-620nm (yellow)	620-650nm (orange-red)	650-670nm (red)	>750nm (NIR)
Septoria	low	increasing	increasing	max	negative
Yellow rust	low	increasing	max	decreasing	negative
Fertilizer deficiency	max	decreasing	decreasing	low	negative

Disease detection: Multispectral imaging



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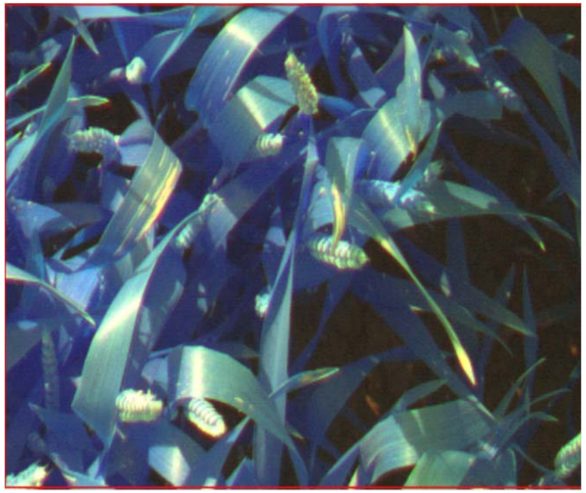
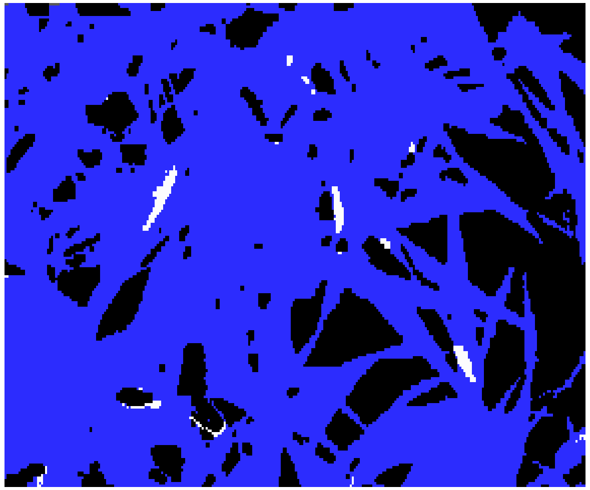
Disease detection: Multispectral imaging

CIR image



Lesion image



Not R-G-B

but R-G-NIR!

Lesion index =

Nbr of lesions/leaf area

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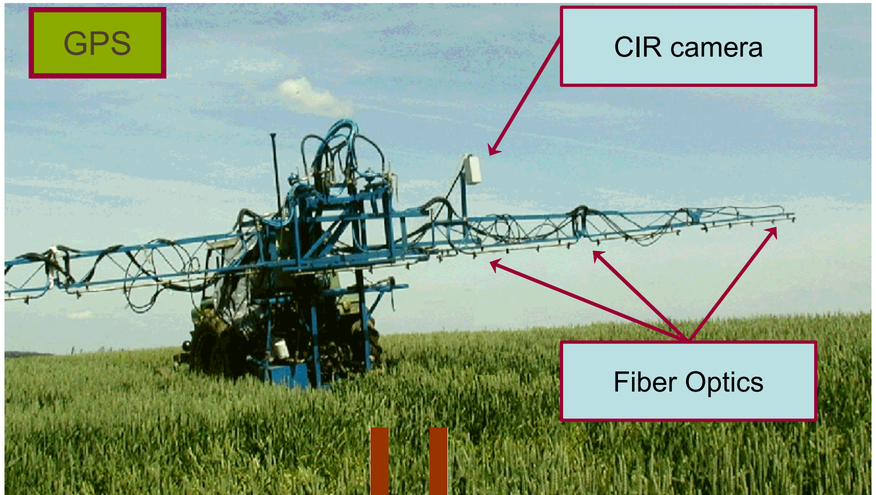

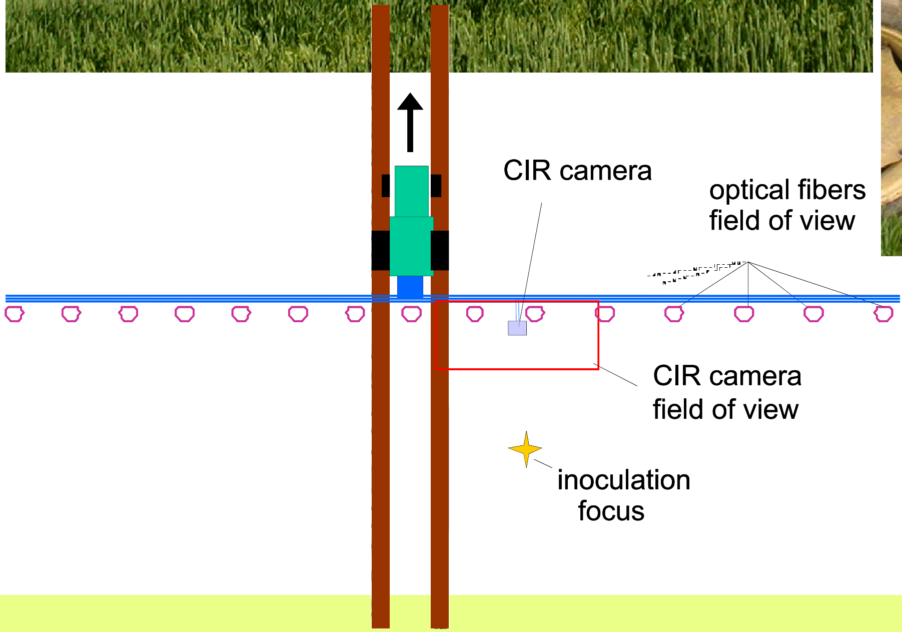

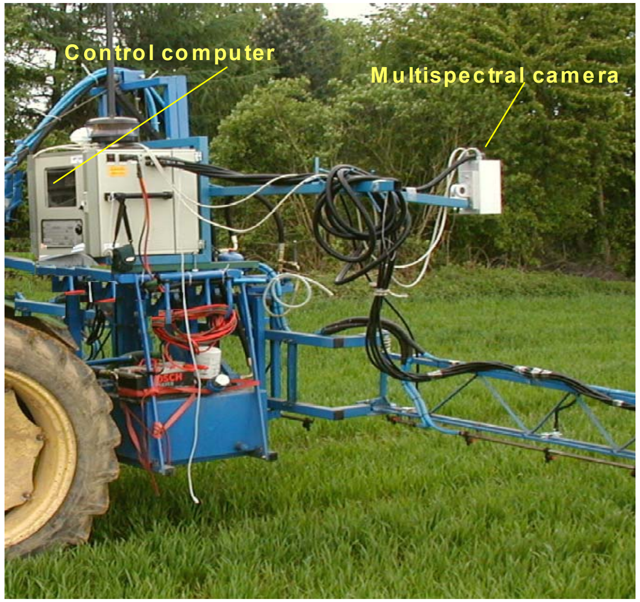

Disease control: Spraying strategy

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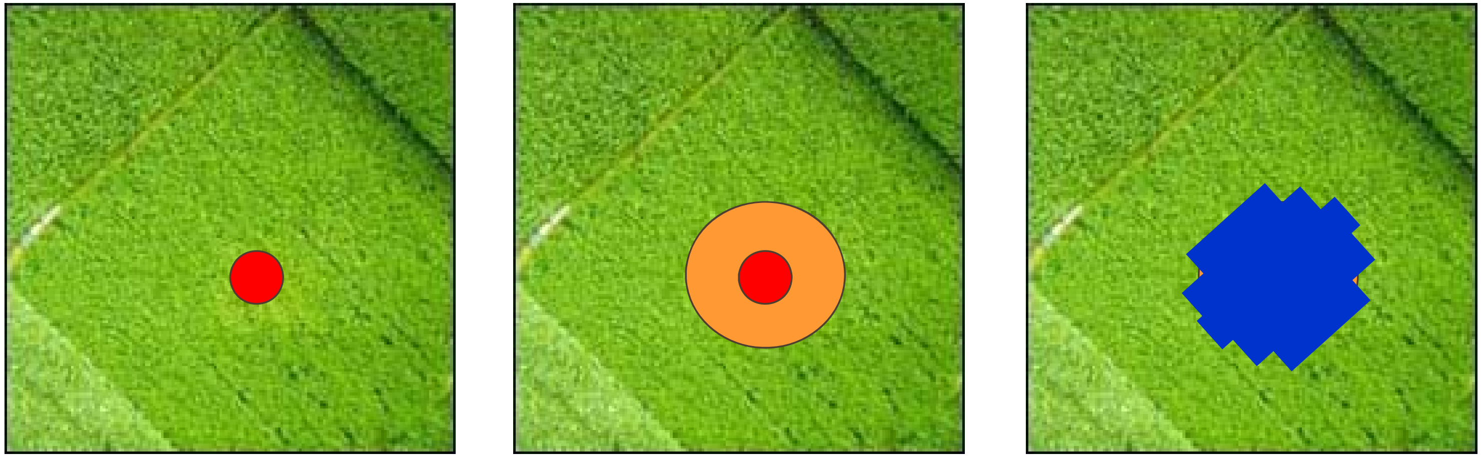
Optical detection | Epidemic model | Spraying recommendation map



- Estimate effective disease presence
- MAPPING approach is necessary (to apply epidemic model)
- Early detection means maximum reduction!

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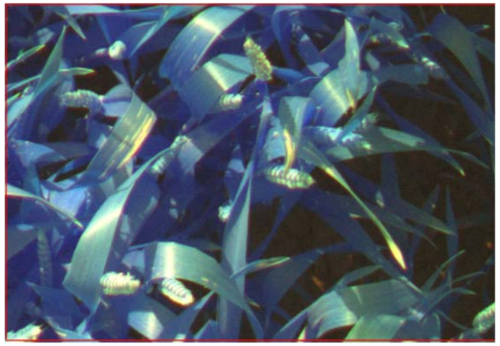
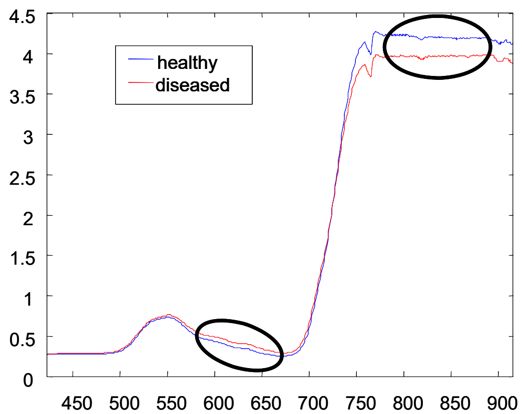
Intelligent sensor fusion systems

- Sensor fusion is a method of integrating signals from multiple sources
- Information received from multiple-sensors is processed using "sensor fusion" or "data fusion" algorithms
- These algorithms can be classified into three different groups
  - probabilistic models (Bayesian reasoning, evidence theory, robust statistics, recursive operators)
  - least-squares techniques (Kalman filtering, optimal theory, regularization and uncertainty ellipsoids)
  - intelligent fusion (**neural networks**, fuzzy logic and genetic algorithms)– **feature based fusion**

sensor fusion systems





Lesion index = Nbr of lesions/leaf area

+

Spectral data between 450-900 nm were divided into 25 wavebands

=

sensor fusion systems

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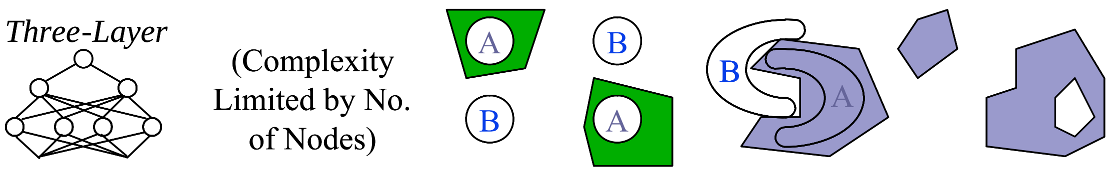
	Lesion Index (LI)	Wave band index	Error percentage
QDA	YES	NO	7.8
QDA	YES	3 17 22	6.6
NN	YES	3 17 22	5.9
QDA	YES	All 25	8.6
NN	YES	All 25	5.1

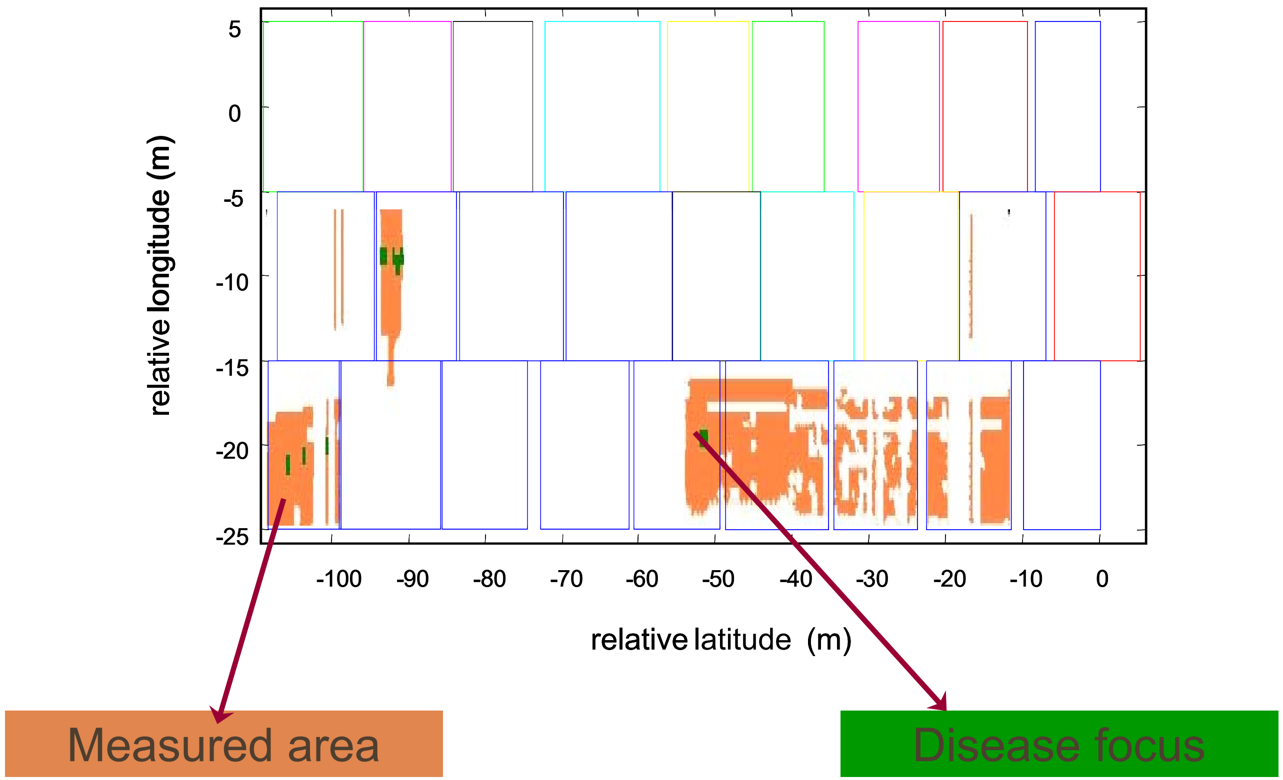
•Results of disease detection using a two hidden layer bayesian regularisation neural network with respectively 30 and 15 hidden neurons,

• NN: between 1 and 26 inputs (25 spectral bands and LI) and two outputs (diseased-healthy).



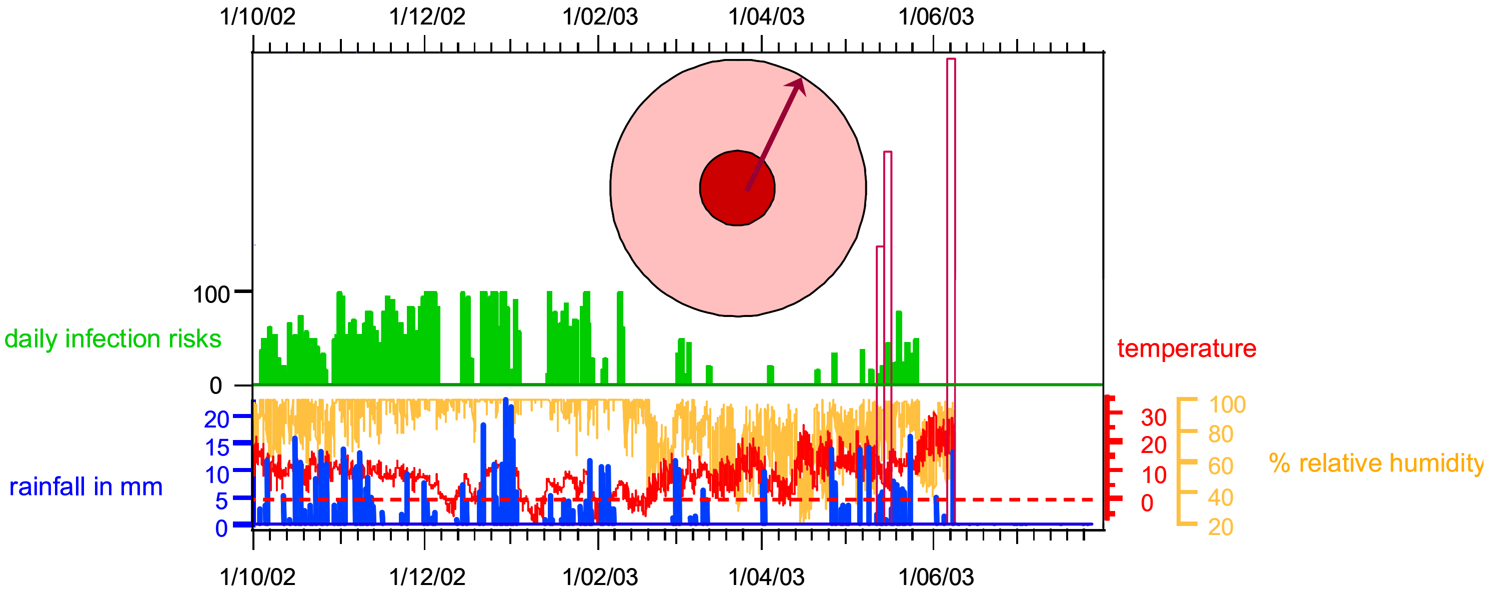
Disease control: Spraying strategy

- Build a SPRAY-map
  - 1. detect disease (by prototype)



Disease control: Spraying strategy

- Build a SPRAY-map
  - 1. detect disease (by prototype)
  - 2. use an epidemiological model service (internet)
  - 3. and calculate minimal protection radius



daily meteorological data

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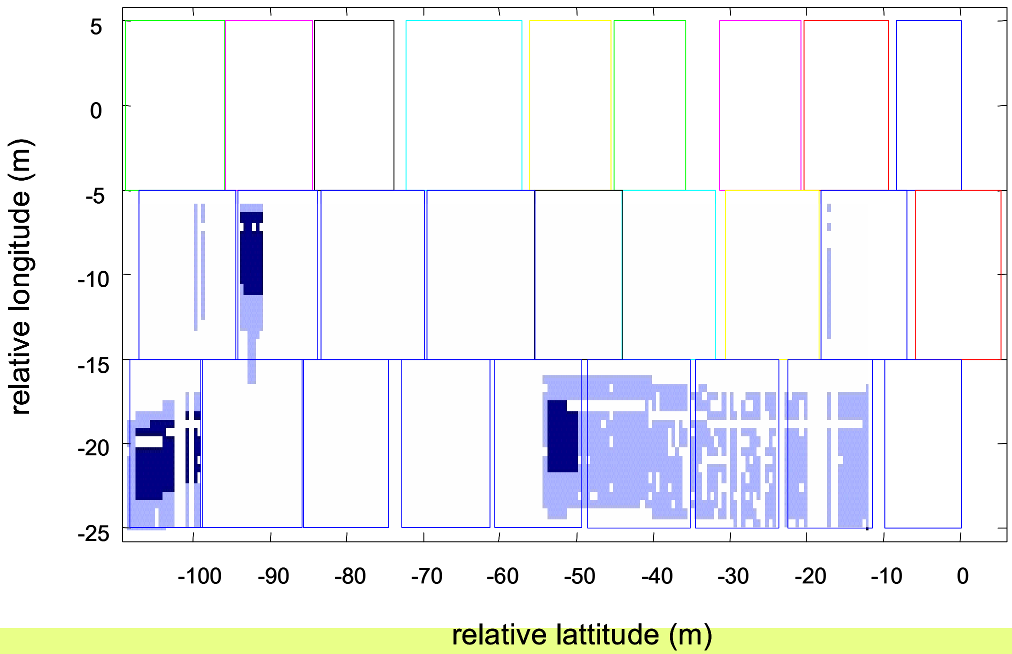
Disease control: Spraying strategy

- Build a SPRAY-map
  - 1. detect disease (by prototype)
  - 2. use an epidemiological model service (internet)
  - 3. calculate minimal protection radius
  - 4. calculate a spray requirement map



Comparison with weed control

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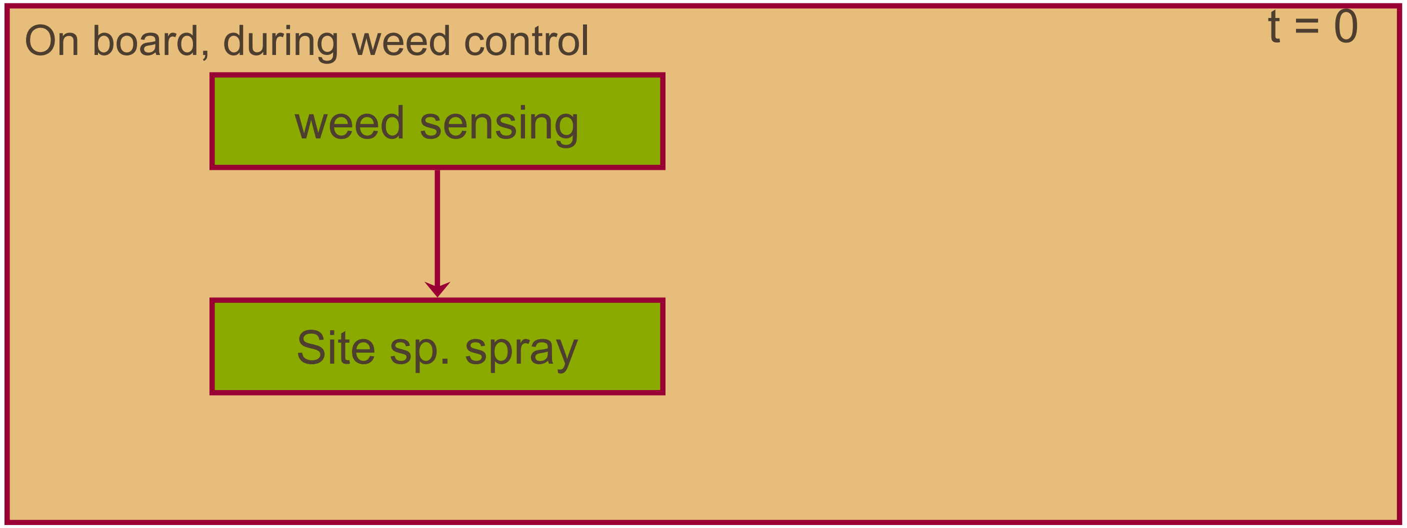

Two passes needed

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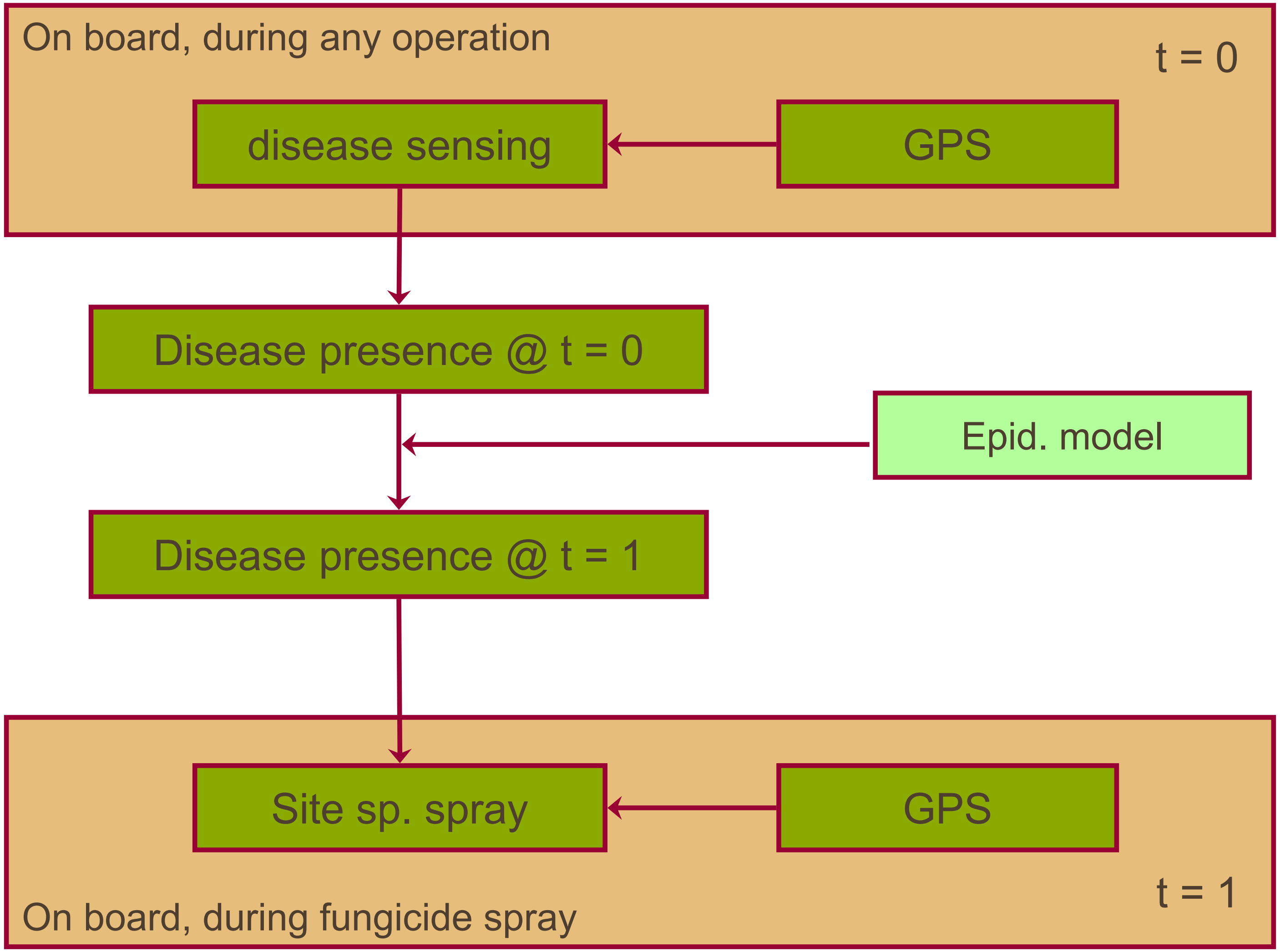

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Conclusions

- The functionality of automatic disease sensing and detection devices is crucial in order to conceive a site-specific spraying strategy against fungal foliar diseases.
- Due to their limitations, disease presence will be detected above a certain infestation threshold, and a certain infestation stage.
- Pre-visual disease assessment is only possible 3 to 7 days after infestation using fluorescence imaging. However this method was not practical in field circumstances.
- On the other hand, light reflection systems (spectral analysis and multispectral imaging) are only useful when the disease symptoms are visible.

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Conclusions

- In order to protect the field efficiently, the sprayer needs to know the spatial distribution of diseases during incubation.
- For radially propagated diseases, it is possible to determine a perimeter around a detected infection hazard using advanced epidemiologic models.
- These consider the disease presence above the detection threshold at the moment of detection and therefore estimate real disease presence. By combining this presence with meteorological data these models provide a minimal protection radius around the initially detected infection hazard.

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Conclusions

- As it is **impossible to estimate effective disease presence** during measurement, a **two stage approach** is proposed:
  - a. **location** of diseases during an earlier field operation
  - b. **site-specific spraying** when the effective disease presence is known.

- The example of this article shows in brief steps how the acquired spatially **accurate disease detection data** are efficiently processed towards **practical spraying decisions**.

- **Highly accurate disease detection** and infection estimation are therefore the most crucial and delicate parts of this process and to this end a multisensor **data fusion system** is a critical performance enhancing component.