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CBQF/LAE RESEARCH SEMINAR

The use of Photonics in Horticulture and Phenotyping

**September 22nd,
at 2:30 pm**

 **GERRIT POLDER**
Wageningen
University & Research




CATOLICA
CBQF - CENTRO DE BIOTECNOLOGIA
E QUÍMICA FINA LABORATÓRIO ASSOCIADO
PORTO


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Introduction

Contact: gerrit.polder@wur.nl

- Gerrit Polder,
 - 30 years at Wageningen University & Research.
 - Senior scientist computer vision for plant phenotyping
- Background: Electronics/Applied Physics.
 - PhD on Spectral Imaging
- Aim of this presentation:
 - To give an overview of the photonics applications at WUR, related to agriculture and plant phenotyping.



 **WAGENINGEN**
UNIVERSITY & RESEARCH


STARGATE
Sensors and daTA tRaining towards
high-performance Agri-food systems

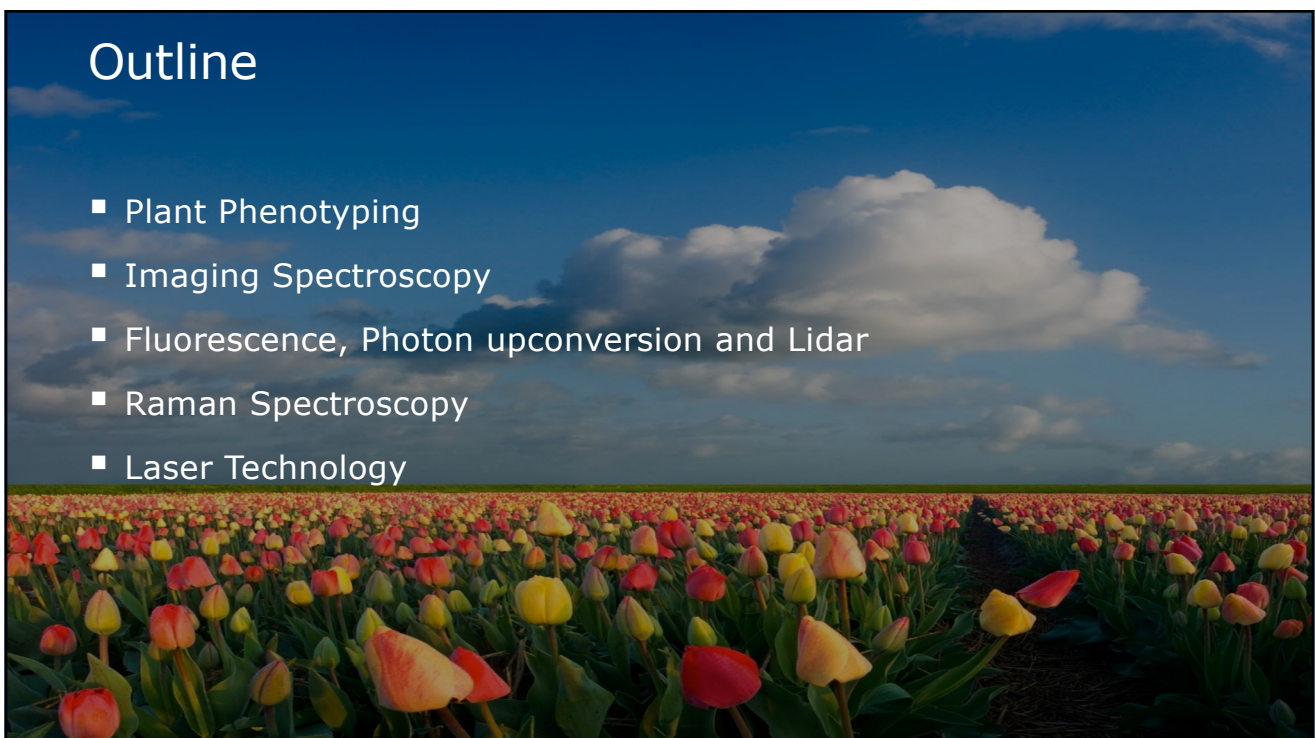
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Wageningen University & Research

- A university plus R&D organisation for innovation in the agrifood sector.
- Working with industry, governmental authorities and other knowledge institutes
- 7.500 employees
- 15.000 students (BSc/MSc/PhD)
- > 100 countries
- 65 researchers on Agro Food Robotics

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Outline

- Plant Phenotyping
- Imaging Spectroscopy
- Fluorescence, Photon upconversion and Lidar
- Raman Spectroscopy
- Laser Technology

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Plant Phenotyping



Rick van de Zedde
Peter van der Zee
Lucas Schmitz



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Sensors and thus photonics play a key role in all modules

module

Ecotron module

Plant-microbe Interaction module

Multi-Environment module

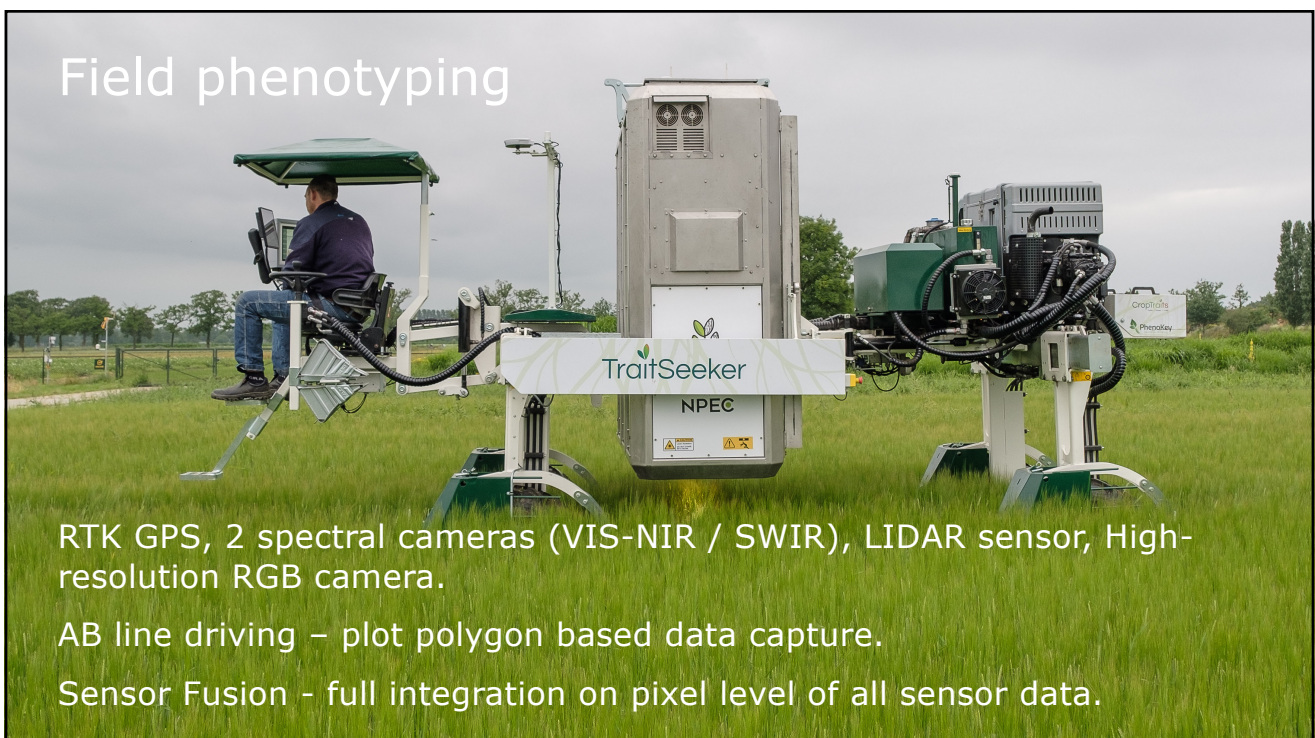
High Throughput Chamber module



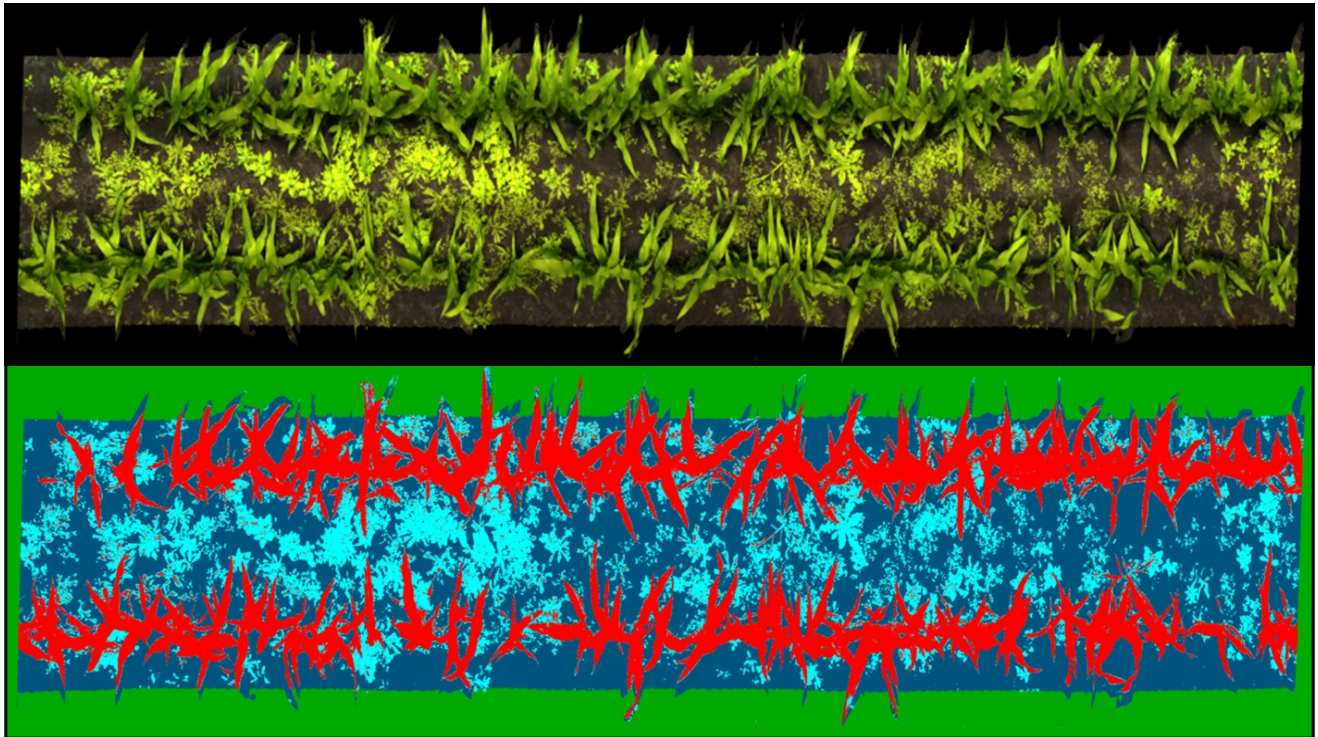
6



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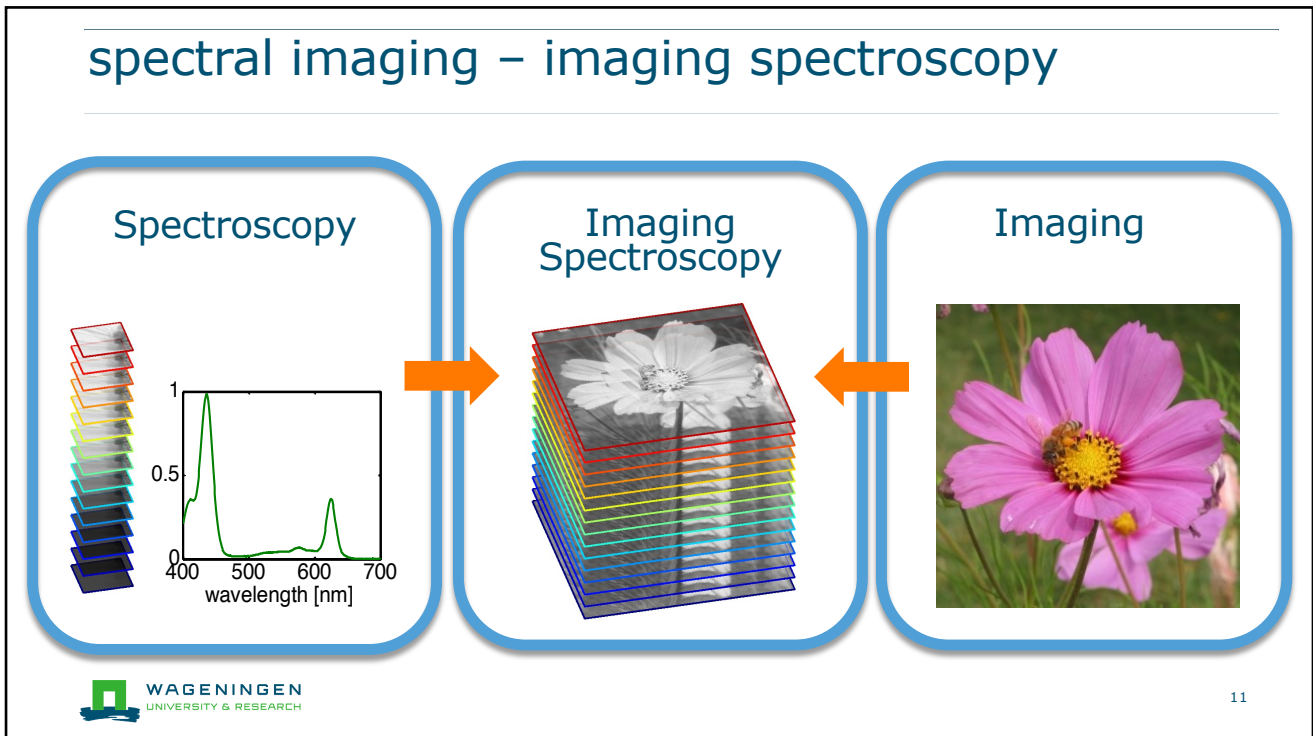
9

Imaging Spectroscopy

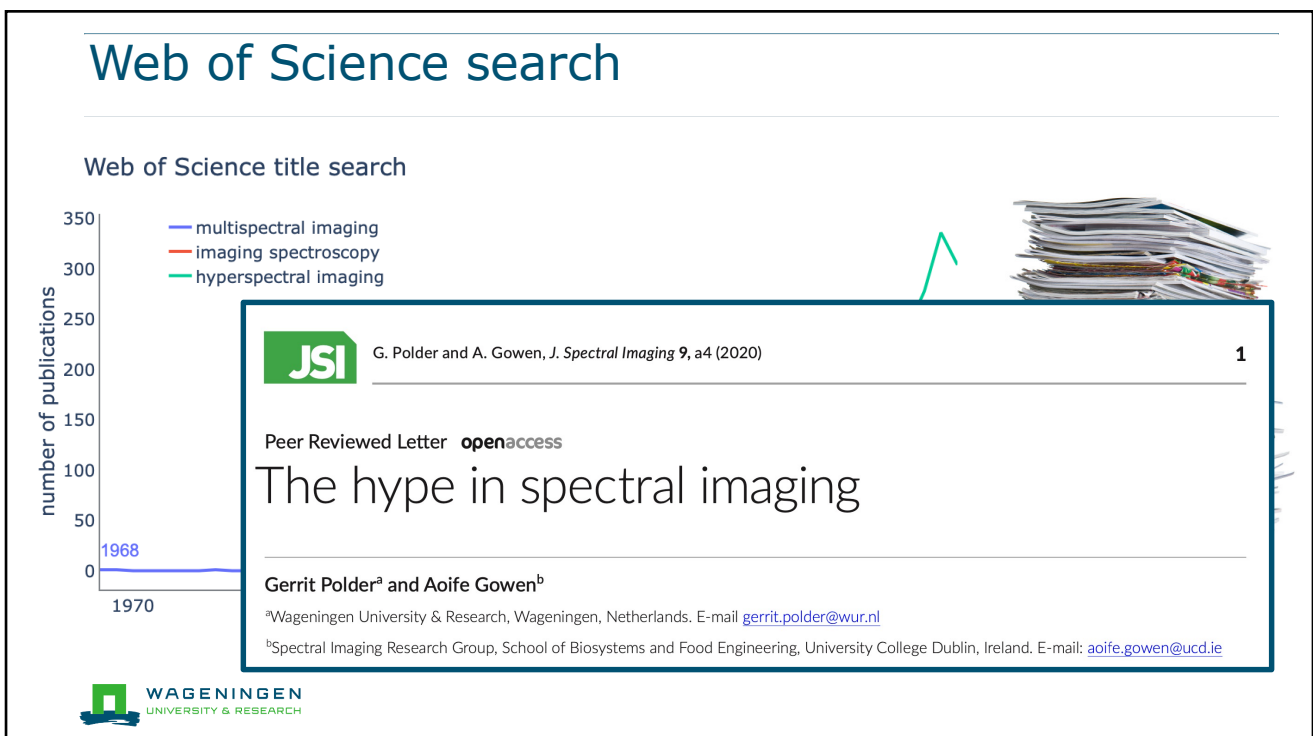
Selwin Hageraats
Joseph Peller
Puneet Mishra
Hendrik de Villiers
Pieter Blok
Robert Rouš
Toon Tielen



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Why spectral imaging?

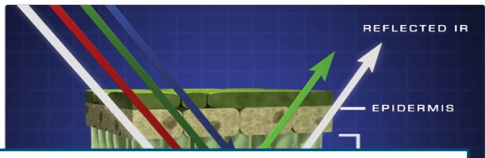


Biosystems Engineering
Volume 164, December 2017, Pages 49-67

Review

Close range hyperspectral imaging of plants: A review

Puneet Mishra ^{a, d}, Mohd Shahrime Mohd Asaari ^a, Ana Herrero-Lapere ^b, Santosh Lohumi ^c, Belén Diezma ^d, Paul Scheunders ^a



@Humboldt state University

lipids, proteins and internal structure of plant leaves

Springer Link


Agriculture Robotics (J Billingsley, Section Editor) | Open Access | Published: 02 April 2020

Close Range Spectral Imaging for Disease Detection in Plants Using Autonomous Platforms: a Review on Recent Studies

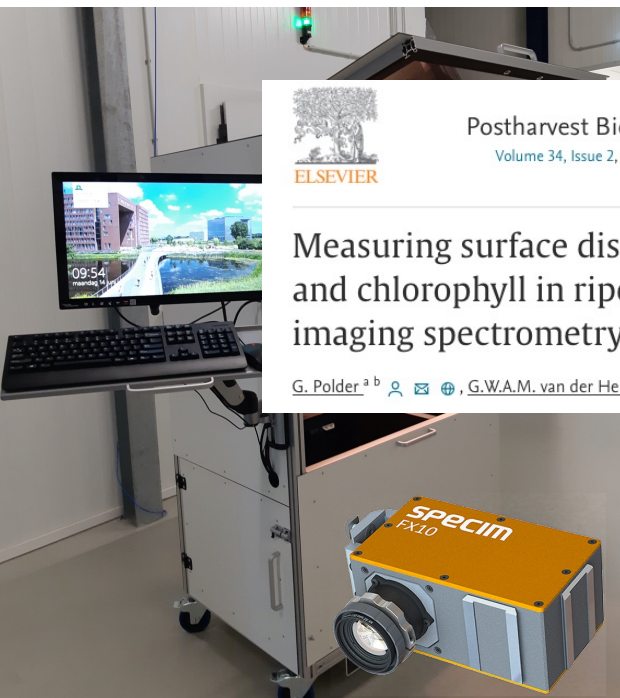
Puneet Mishra ^a, Gerrit Polder & Nastassia Vilfan

Current Robotics Reports 1, 43–48 (2020) | [Cite this article](#)

2266 Accesses | 9 Citations | 1 Altmetric | [Metrics](#)



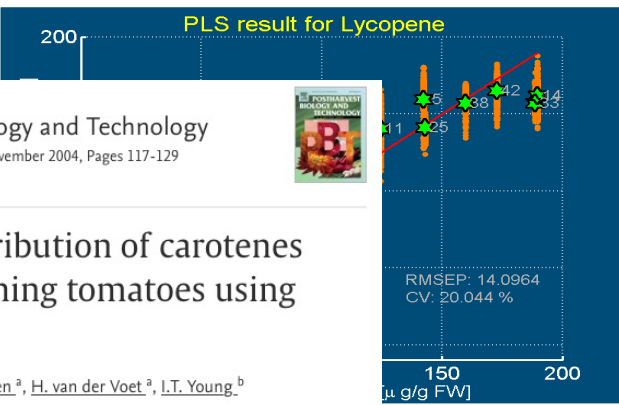
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Measuring surface distribution of carotenes and chlorophyll in ripening tomatoes using imaging spectrometry

Postharvest Biology and Technology
Volume 34, Issue 2, November 2004, Pages 117-129

G. Polder ^{a, b}, G.W.A.M. van der Heijden ^a, H. van der Voet ^a, I.T. Young ^b

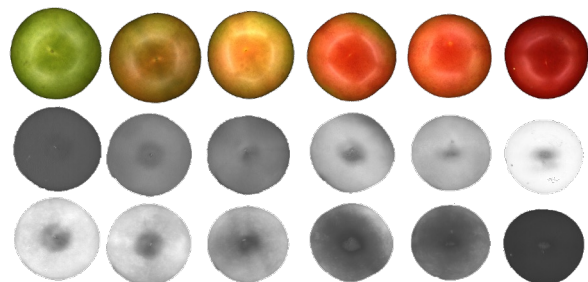


PLS result for Lycopene

Index	Value
1	11
2	25
3	5
4	38
5	42
6	14
7	33

RMSEP: 14.0964
CV: 20.044 %

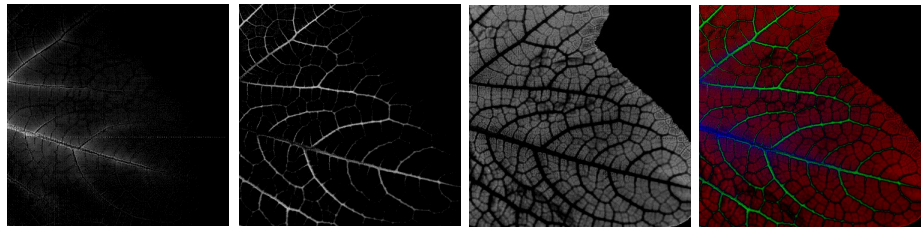
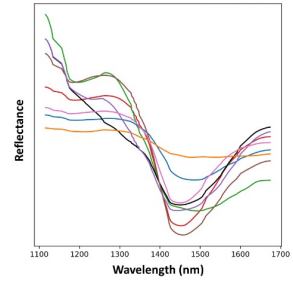
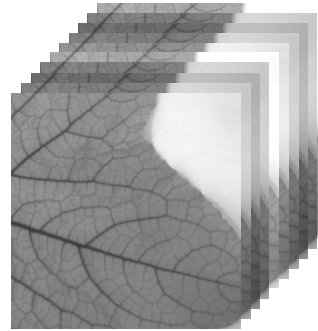
150 200
[μg/g FW]



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Simplex Volume Maximization (SiVM)

- An efficient tool to find spectral archetypes
- Archetypes represent a distinct spectral character
- If you model each pixel's spectrum as a linear combination of spectral archetypes:
 - Mapping of different types of tissue in a leaf from a SWIR spectral image




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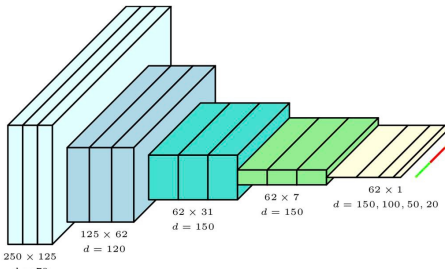


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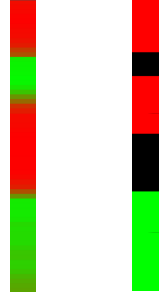

Virus Y detection in seed potatoes



Input
500 × 250
d = 35




Output
62 × 1
d = 1

- Deep learning on spectral line images
- Network adapted to $x \times \lambda$ (2D) images

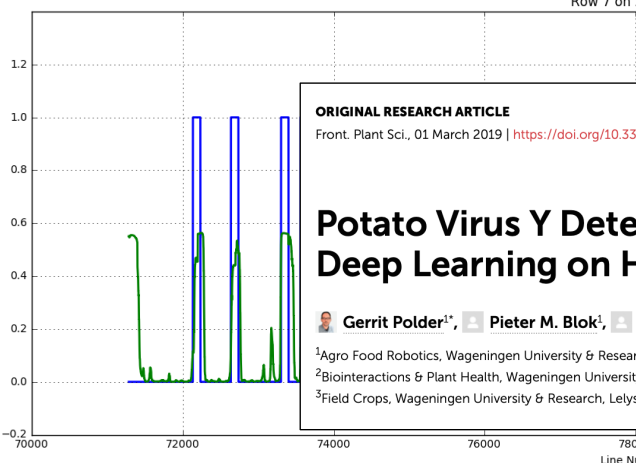
Prediction Target

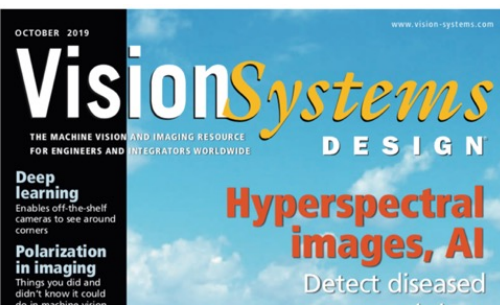


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Disease detection in seed potatoes






- Results: Row 7 (Vermont) 3/7/2019






ORIGINAL RESEARCH ARTICLE
Front. Plant Sci., 01 March 2019 | <https://doi.org/10.3389/fpls.2019.00209>

Potato Virus Y Detection in Seed Potatoes Using Deep Learning on Hyperspectral Images

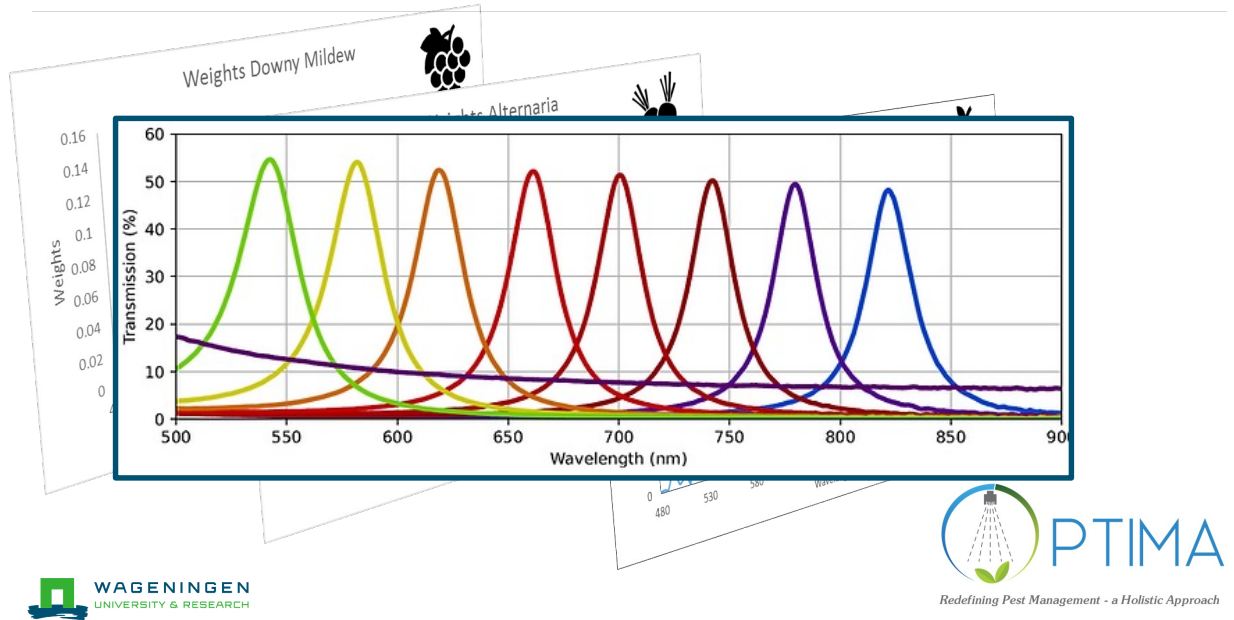
 **Gerrit Polder**^{1*},
  **Pieter M. Blok**¹,
  **Hendrik A. C. de Villiers**¹,
  **Jan M. van der Wolf**² and
  **Jan Kamp**³

¹Agro Food Robotics, Wageningen University & Research, Wageningen, Netherlands
²Biointeractions & Plant Health, Wageningen University & Research, Wageningen, Netherlands
³Field Crops, Wageningen University & Research, Lelystad, Netherlands



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H2020 OPTIMA – disease detection



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H2020 OPTIMA – disease detection



- Apple scab
- MS images (8 wavelengths)
- Increases Contrast from RGB



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Fluorescence Photon upconversion and Lidar



Lammert Kooistra
Harm Bartholomeus
Hasib Mustafa



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The I-Seed project: environmental sensing

Laboratory of Geo-information Science and Remote Sensing



<https://iseedproject.eu>

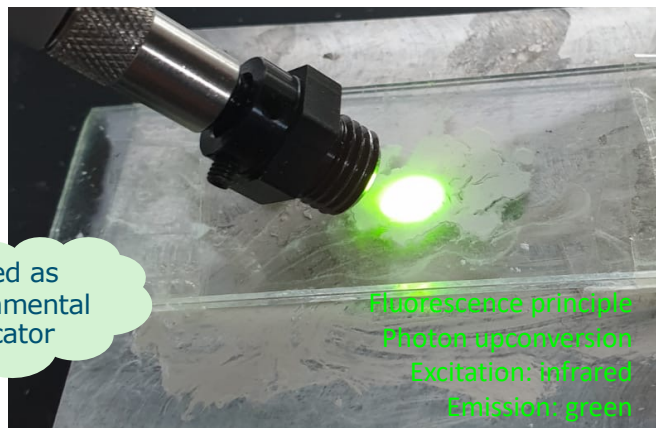


biomimicry

self-deployable
biodegradable
miniaturized robots
with **fluorescence**
sensors
(nano coating)



I-seed as
environmental
indicator



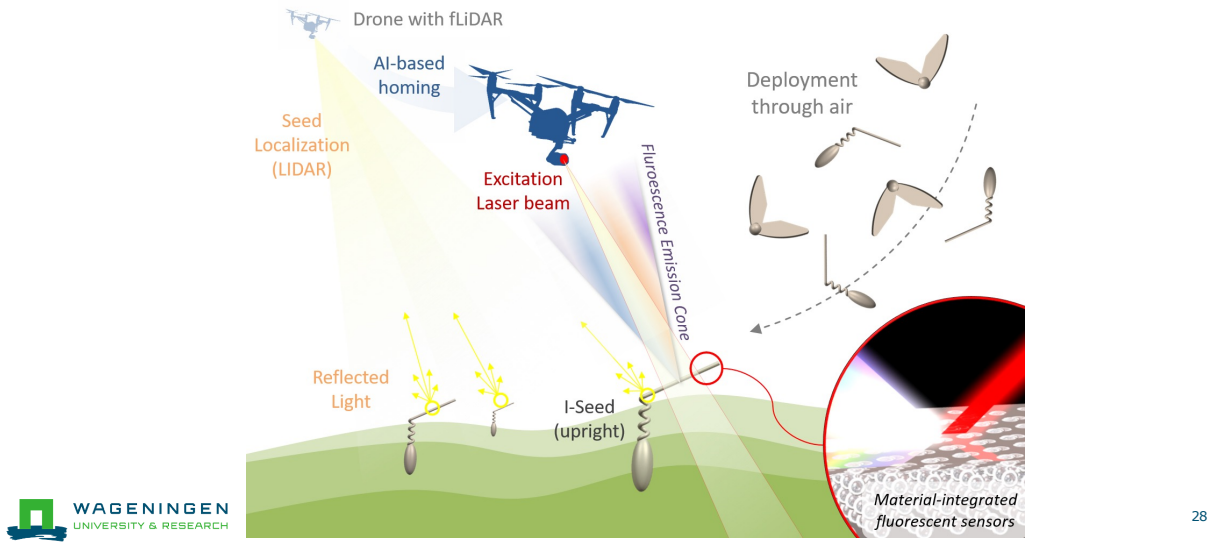
Fluorescence principle
Photon upconversion
Excitation: infrared
Emission: green



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The I-Seed project: environmental sensing

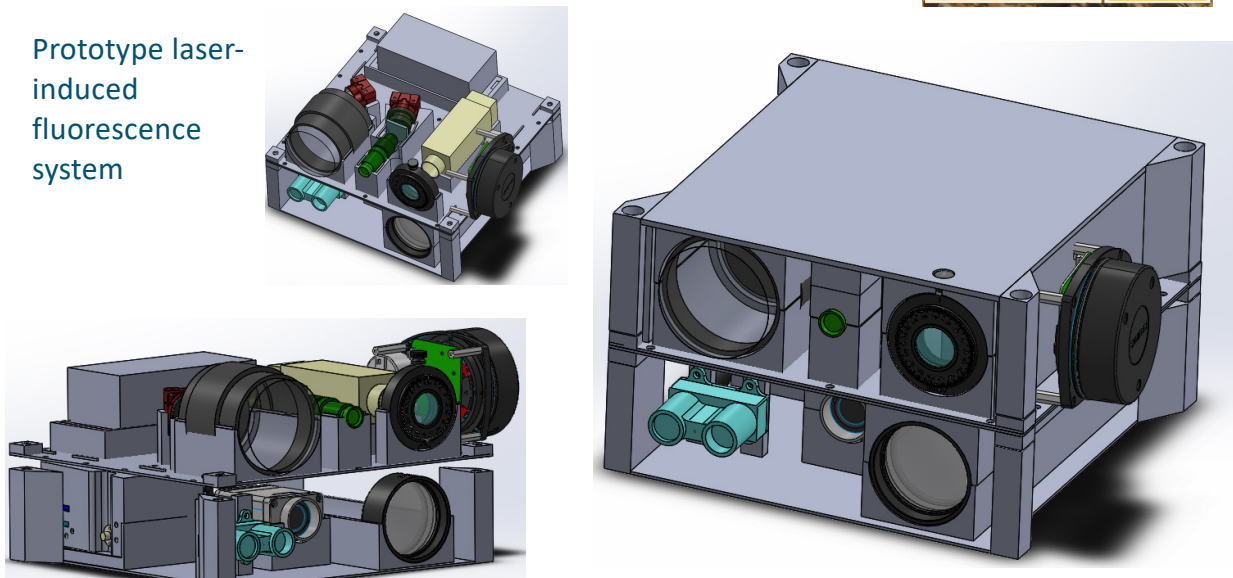


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The I-Seed project: environmental sensing



Prototype laser-induced fluorescence system



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Raman Spectroscopy



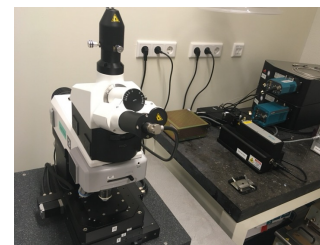
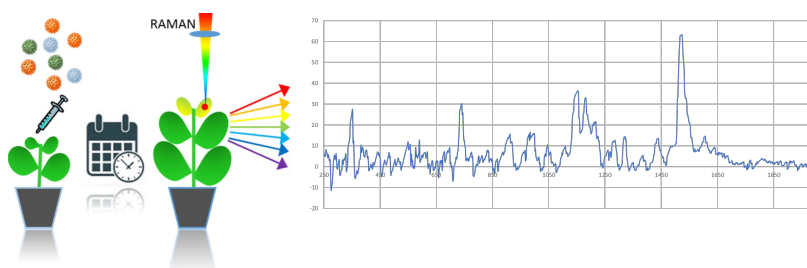
Corien Voorburg
Joseph Stoenner



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Early non-destructive detection of virus infection using Raman Spectroscopy (RS)

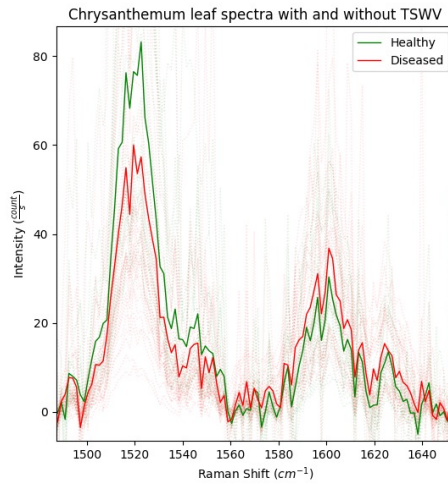
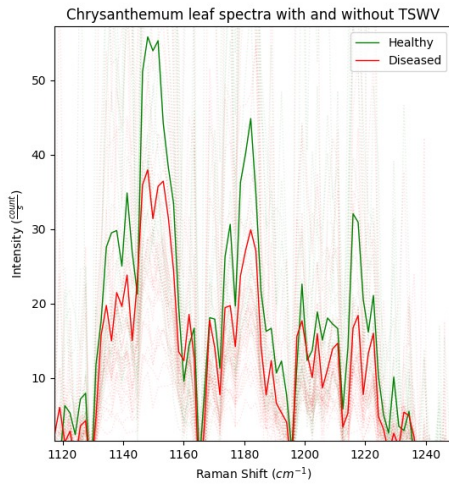
- Chrysanthemum with Tomato Spotted Wilt Virus (TSWV)
- Raman microscope
 - 5 healthy plants
 - 15 infected plants



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Spectral differences



Trained model
with random
forest
classifier:
Accuracy 0.78



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Laser Technology


Frits van Evert
Ard Nieuwenhuizen
Menno Sytsma
Anoek Leunissen
Estuardo Hernandez Olesinki




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Robot to control broad-leaved dock

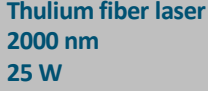




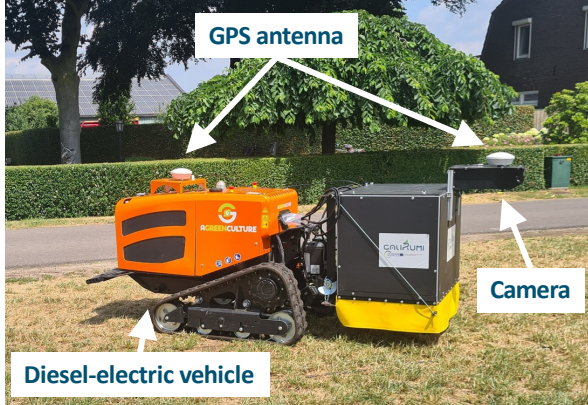
GPS antenna



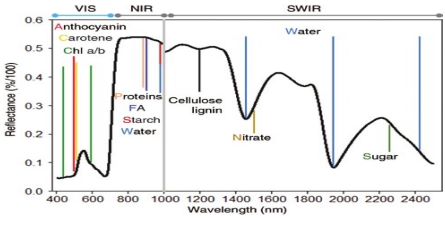
Camera







Thulium fiber laser
2000 nm
25 W




Diesel-electric vehicle




<https://galirumi-project.eu/>



European Union Agency for the Space Programme



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870258

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Laser technology for pest insect control!

- Absorption spectra of insects

Insects Spectras (Absorption Lines)

Wavelength(nm)

— Bemisia tabaci — Frankliniella occidentalis
— Echinothrips americanus — Aphidius ervi

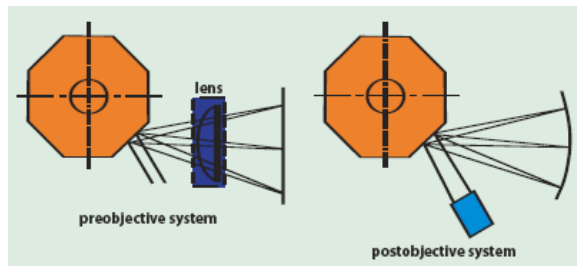
Wing
Wing Spot
Body

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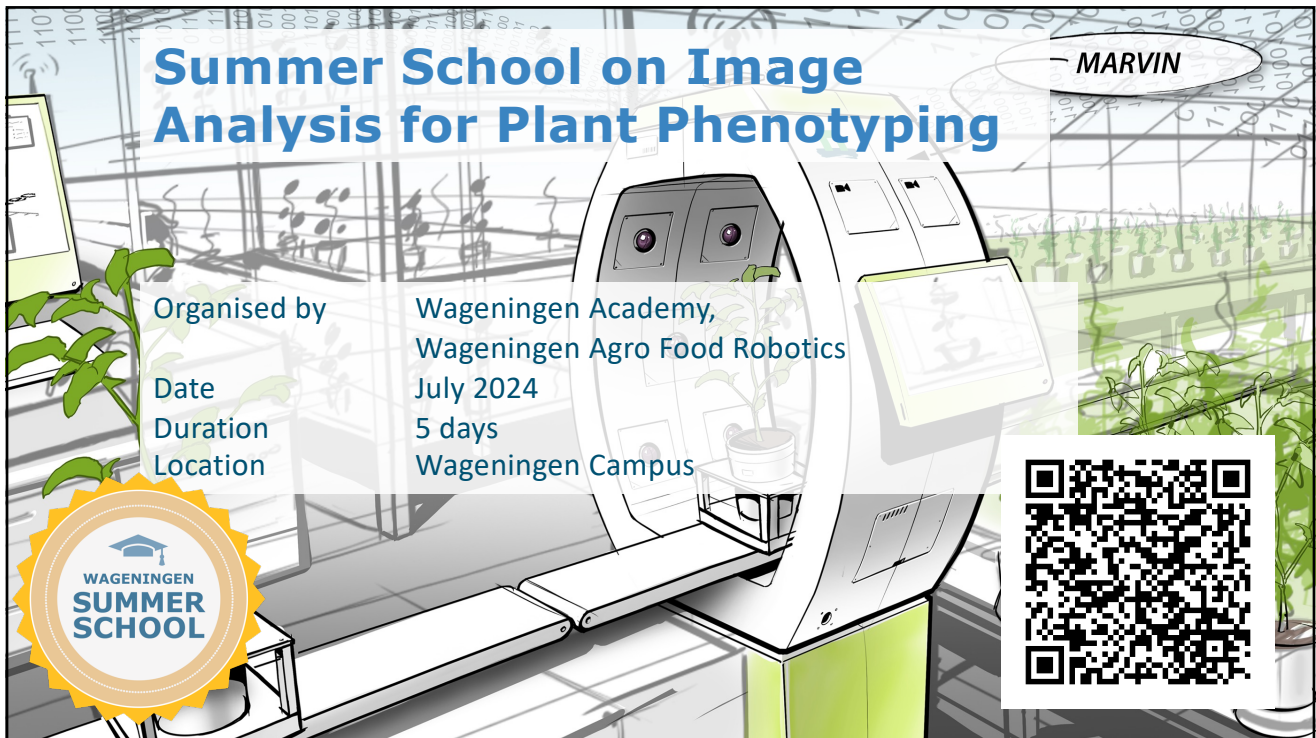
Two approaches

- Preventive
 - Laser mesh in front of ventilation
- Curative
 - Direct insect killing through leaf



Announcements





Summer School on Image Analysis for Plant Phenotyping

— MARVIN


Organised by Wageningen Academy,
Wageningen Agro Food Robotics

Date July 2024

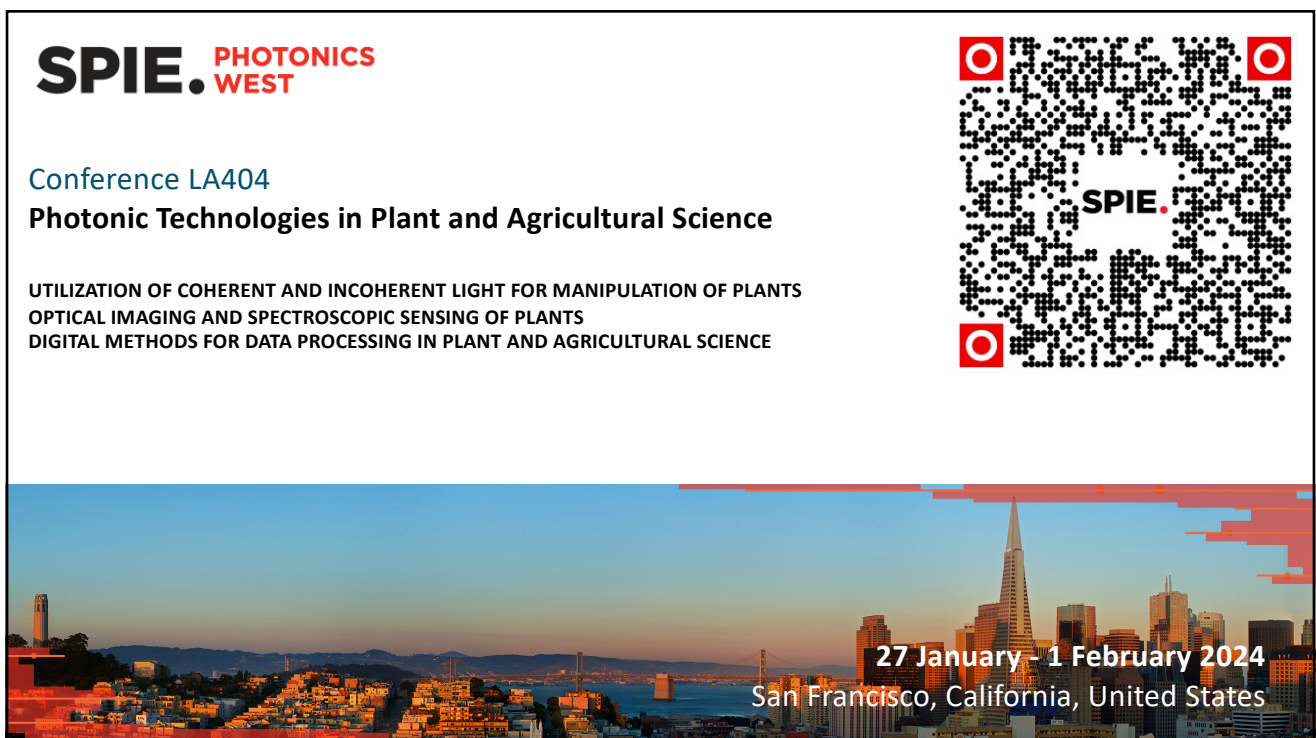
Duration 5 days

Location Wageningen Campus

WAGENINGEN SUMMER SCHOOL




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SPIE. PHOTONICS WEST

Conference LA404
Photonic Technologies in Plant and Agricultural Science

UTILIZATION OF COHERENT AND INCOHERENT LIGHT FOR MANIPULATION OF PLANTS
OPTICAL IMAGING AND SPECTROSCOPIC SENSING OF PLANTS
DIGITAL METHODS FOR DATA PROCESSING IN PLANT AND AGRICULTURAL SCIENCE



27 January - 1 February 2024
San Francisco, California, United States

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Take home message

- Sensors are key components in agricultural and food industry.
- Photonic technology is used in many of the sensors.
- Together with research and industrial partners we apply, test and validate photonic devices in the agro food domain.



<https://www.wur.nl/en/Research-Results/Projects-and-programmes/Agro-Food-Robotics.htm>