High-tech agrofood production - Robotics and mobile detection systems

Holland Innovation Network Brazil visit 2018-10-02

Ard Nieuwenhuizen and colleagues

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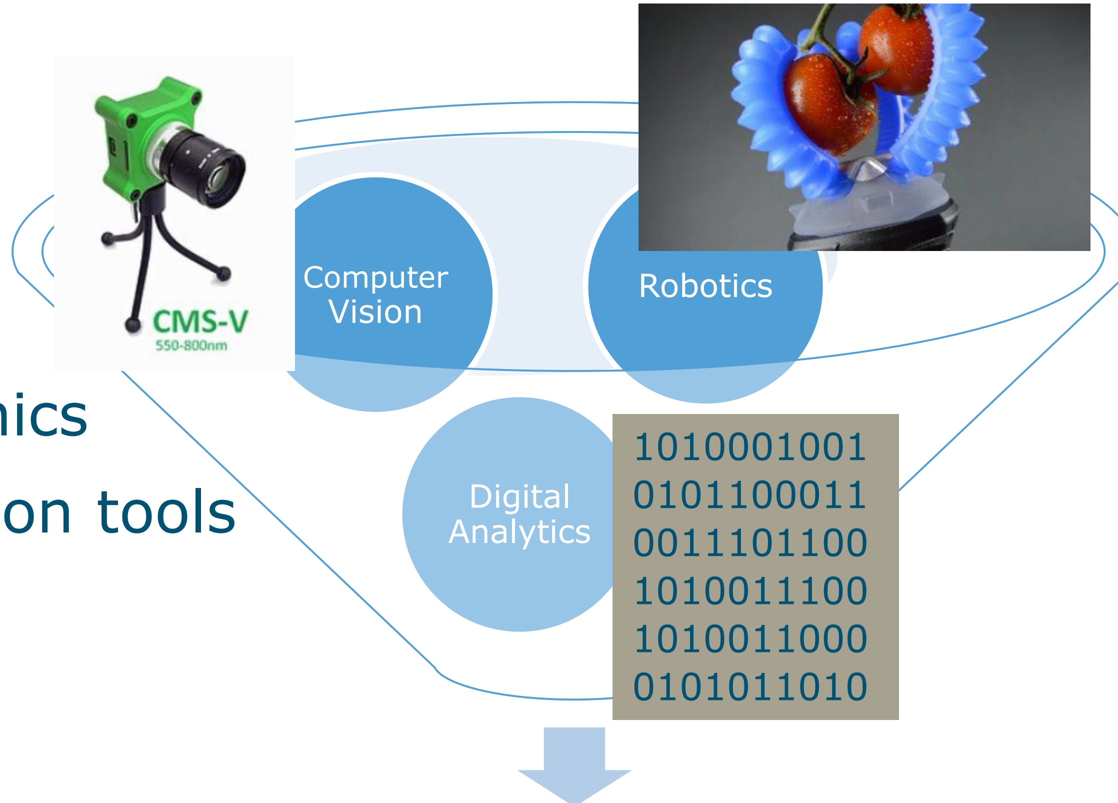
High-tech agrofood industry

Technology Trends ...

... to replace eyes, hands and brains of growers

- **Computer Vision**
  - 3D-cameras
  - Hyperspectral
- **Robotics**
  - Fine/soft mechanics
  - Advanced/precision tools
- **Digitalisation**
  - Big Data
  - Deep-learning



New Applications

Monitoring – Handling – Decision Support

Pictures from: Silios/Soft Robotics

Precision Horticulture and Robotics Opportunities

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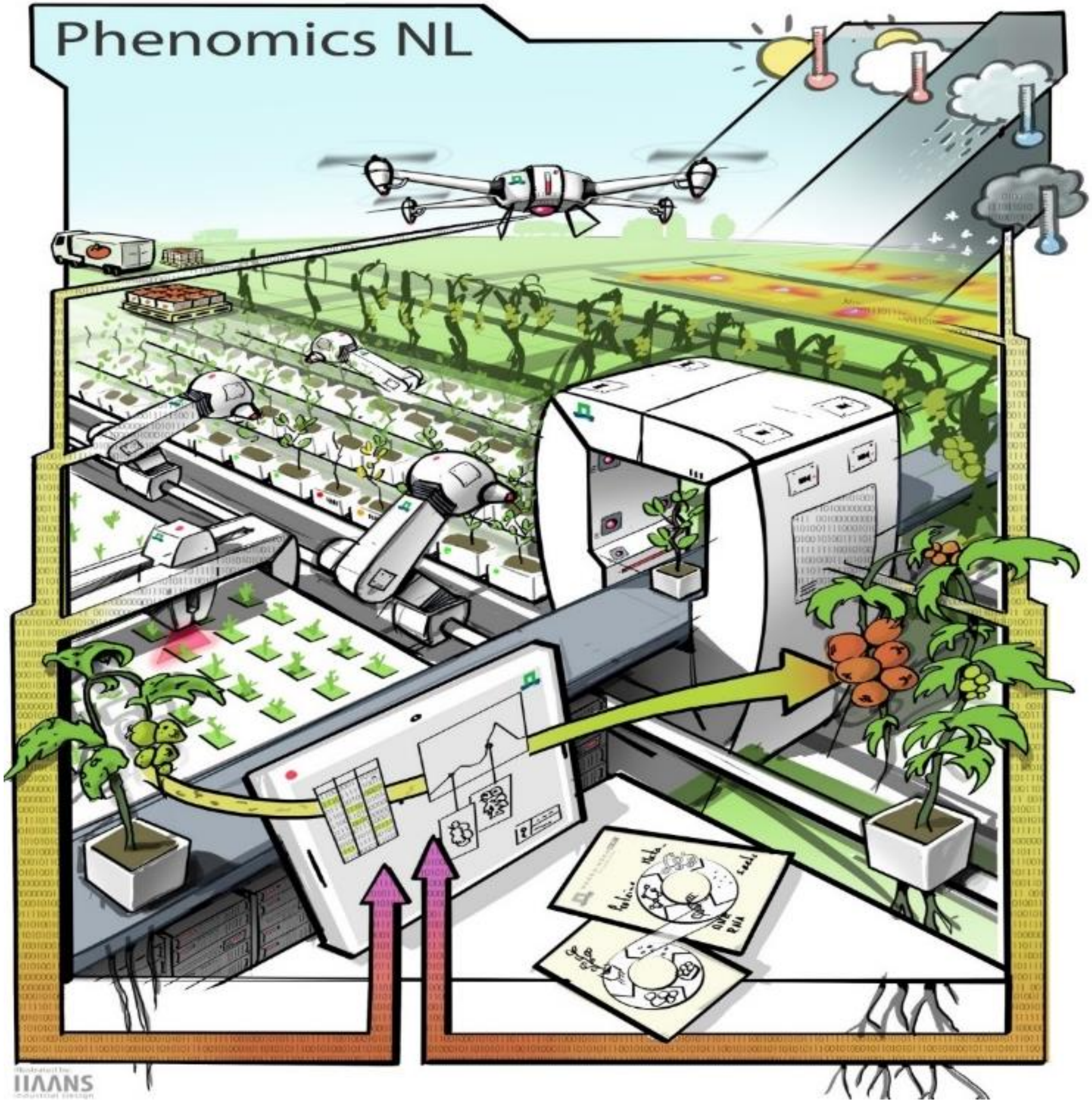
Future

Perspective

Crop Monitoring



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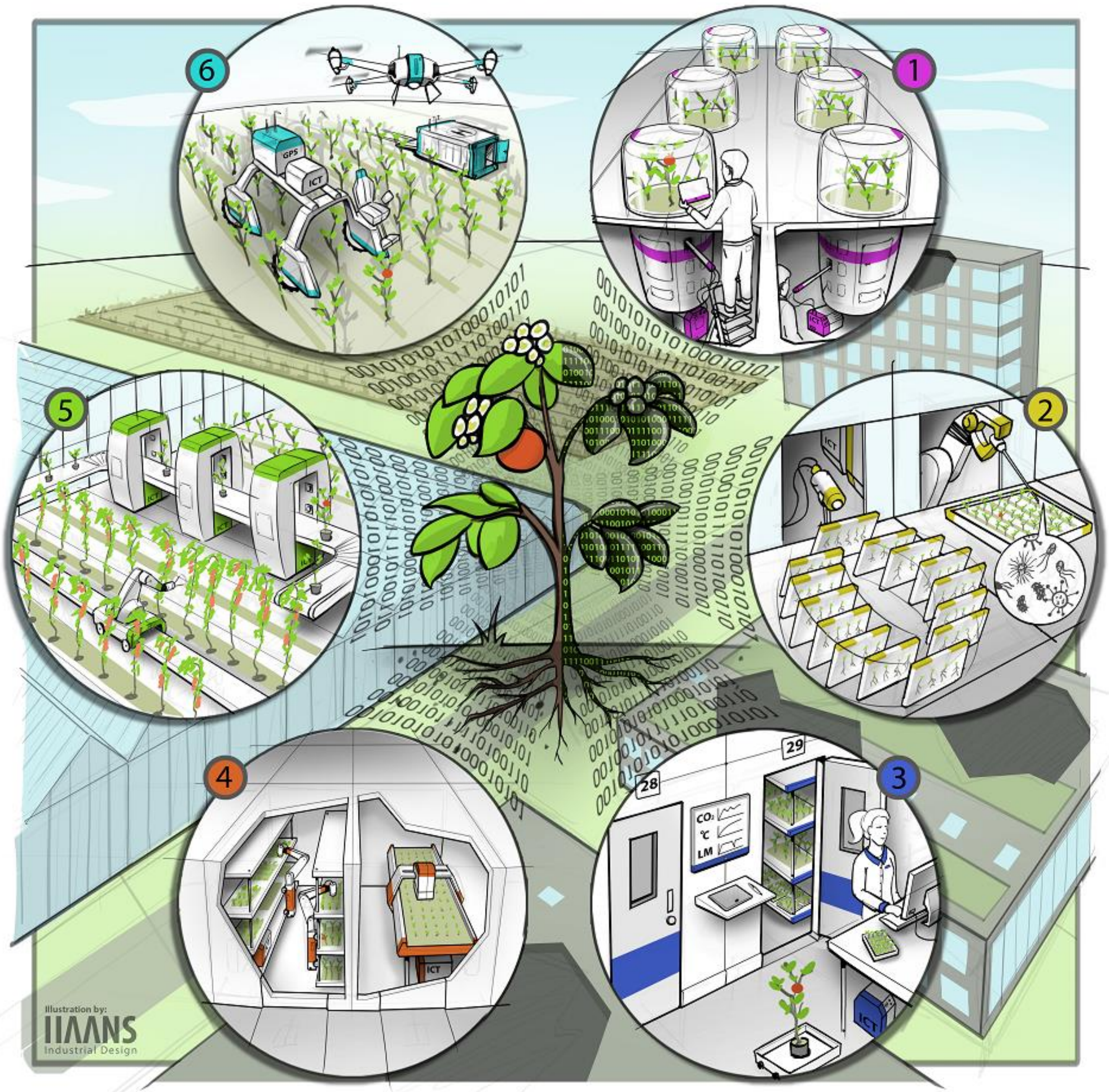


Netherlands

Plant

Eco-phenotyping

Centre

a large scale

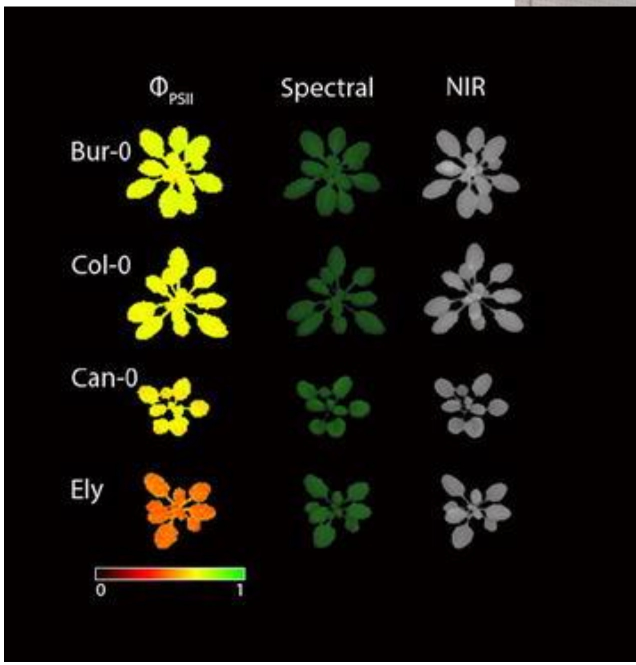
research facility

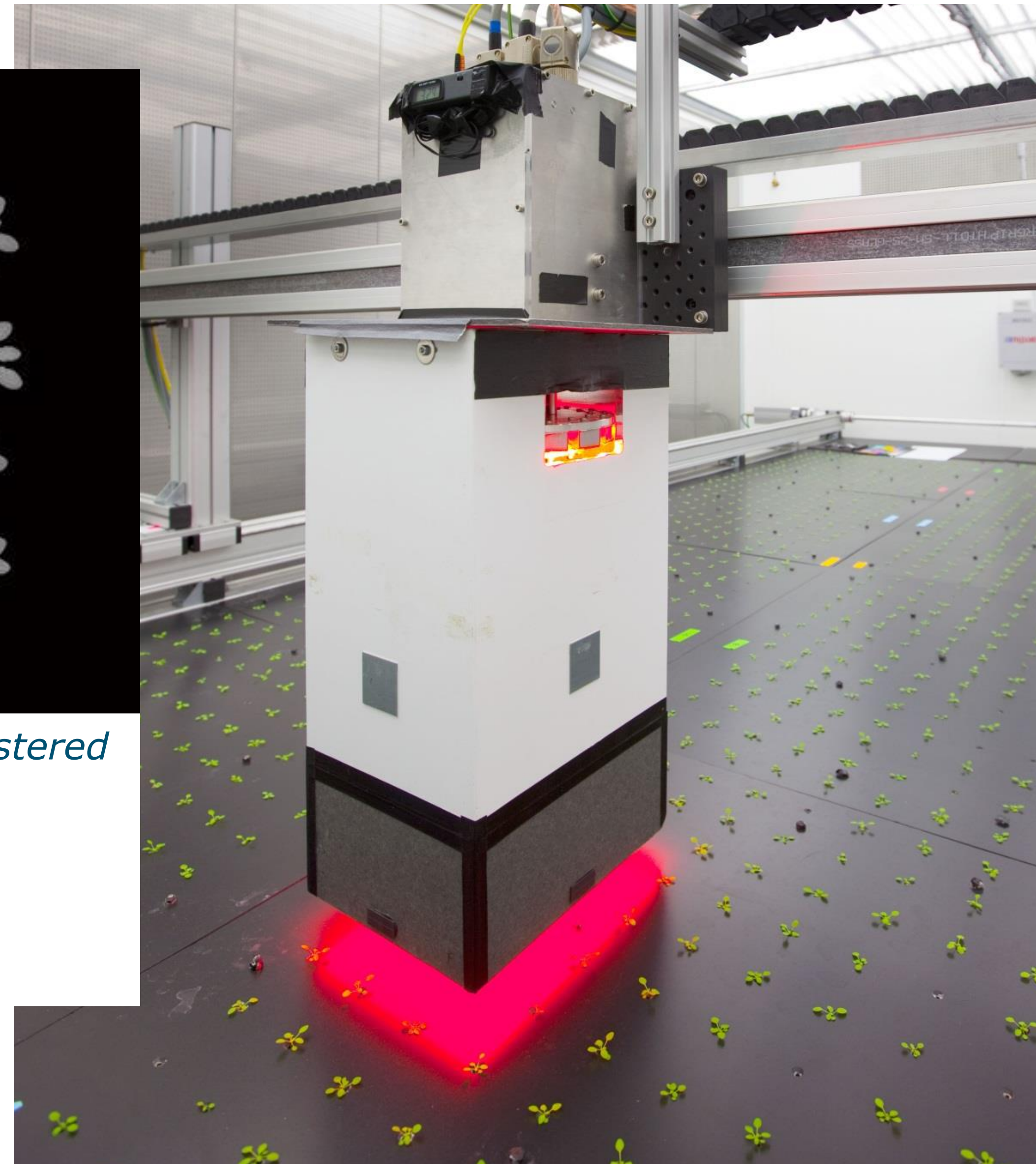
Starting: **2018**

Funding: **NWO**

Cost: **22 M€**

Rapid Phenotyping





1440 plants - Every plant is fixed and registered

60 Minutes to image every plant ΦPSII at growth irradiance

Typically 25 days per run (100 GB data)

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Phenomea – Phenotyping Labs

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Started: end 2017

Phenotyping (3D-Vision Technologies)

Sorting of seedlings

Rick vd Zedde (Wageningen UR)

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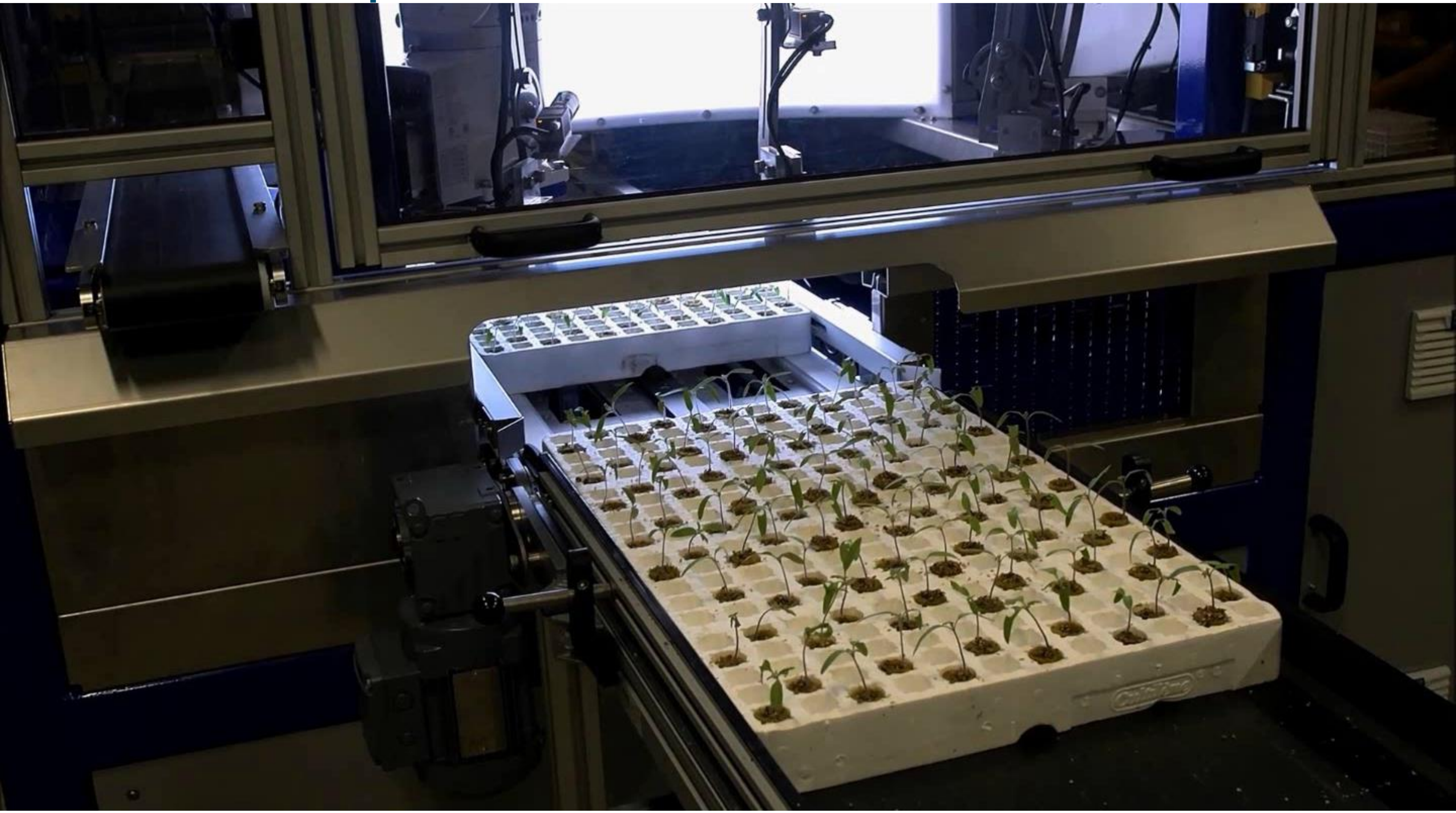
FlierSystems GROW YOUR FUTURE • SINCE 1931

PlantSampler robot



Video by: Piet Oomen (IsoGroup)/ Rick vd Zedde (Wageningen UR)

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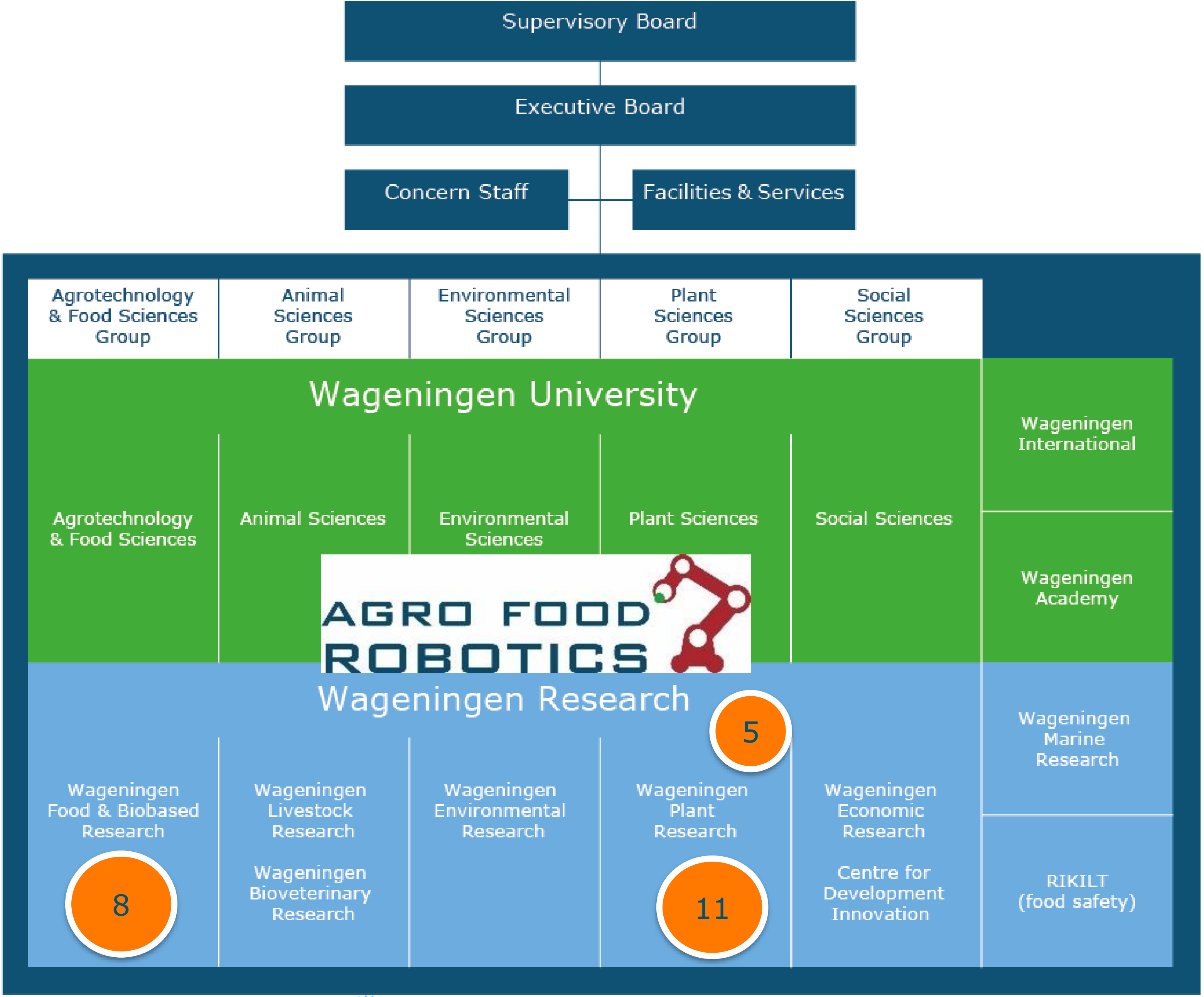
ISO GROUP



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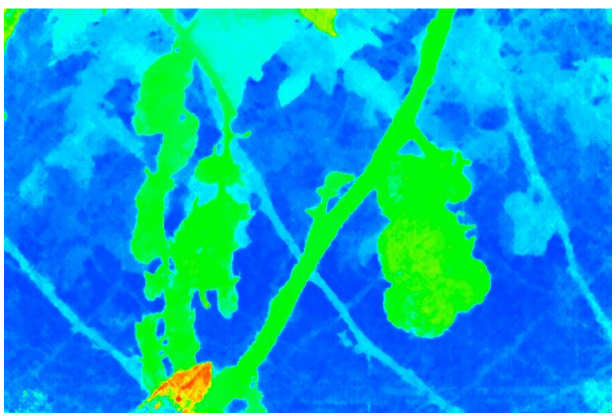
Started: 2017

PhenoBot – Greenhouse crop data

- No of internodes
- No of fruits per plant
- No of harvested fruits
- Weight harvested fruits
- Biomass partitioning
- Leaf area



3D Light Field Camera (Raytrix)
One camera, one lens
One shot for 3D and 2D data
7MP effective resolution

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ENZA ZADEN

Gerrit Polder (Wageningen UR)

Detectection Botrytis (Cyclamen)

Top Crop
Viewer

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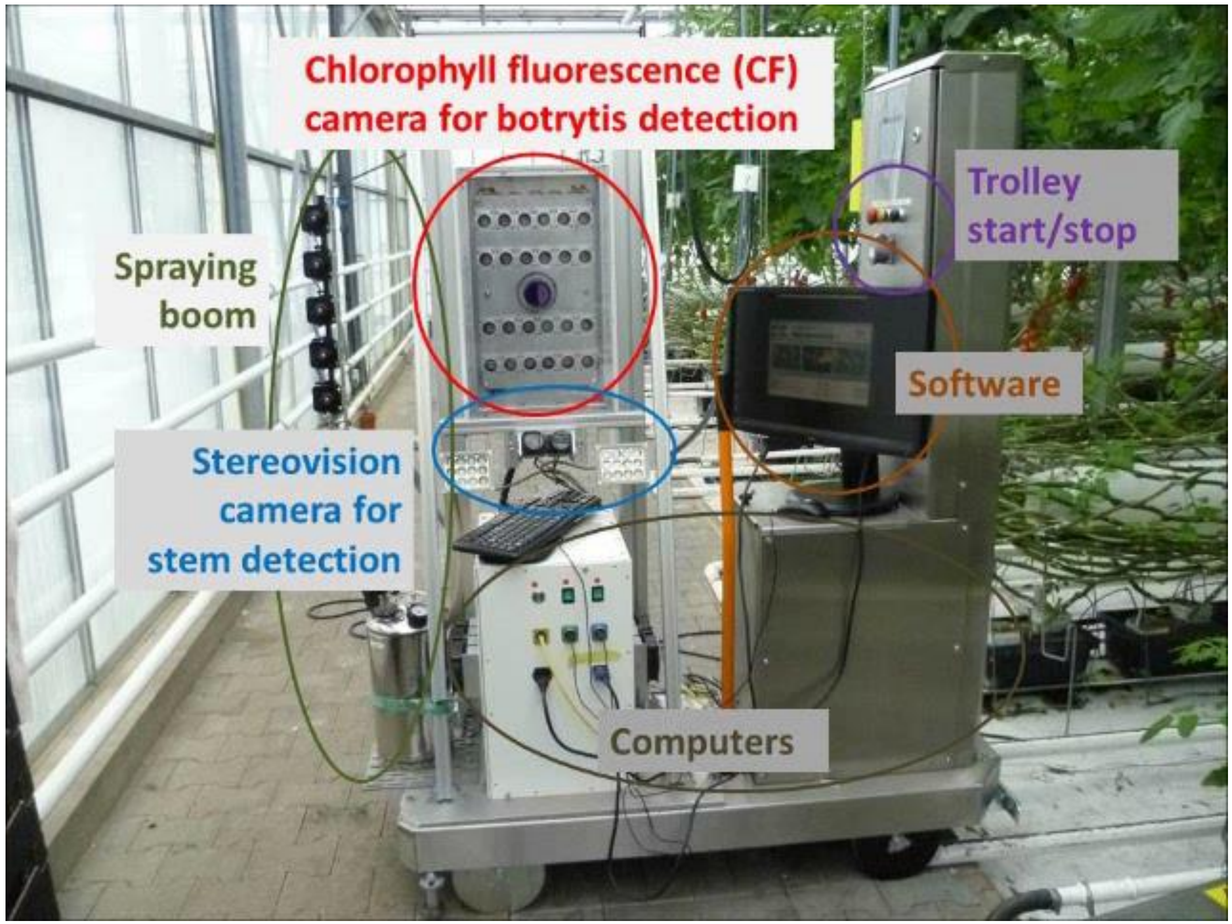
Erik Pekkeriet(Wageningen UR)

Selective spraying of Botrytis in tomato

Side Crop Viewer



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Erik Pekkeriet (Wageningen UR)

Monitoring gerbera

WAGENINGEN UR GLASTUINBOUW CLUB VAN 100 LEADING IN HORTICULTURAL INNOVATION

Targets:

- Spatial resolution: 1 m^2
- Plant load (yield prediction)
- Powdery mildew
- Stress
- Decision Support

Using:

- a.o. Hyperspectral camera

PRECISIETUINBOUW

TOPSECTOR TUINBOUW & UITGANGSMATERIALEN

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Automatic detection of spider mite damage

(PeMaTo-EuroPep)

- Use of light multi/hyper-spectral cameras
- Preliminary results from lab and greenhouse tests

RGB image

Damage detection with hyperspectral imaging

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PROEFSTATION VOOR DE GROENTETEELT

Universiteit Antwerpen

JUNTA DE ANDALUCIA

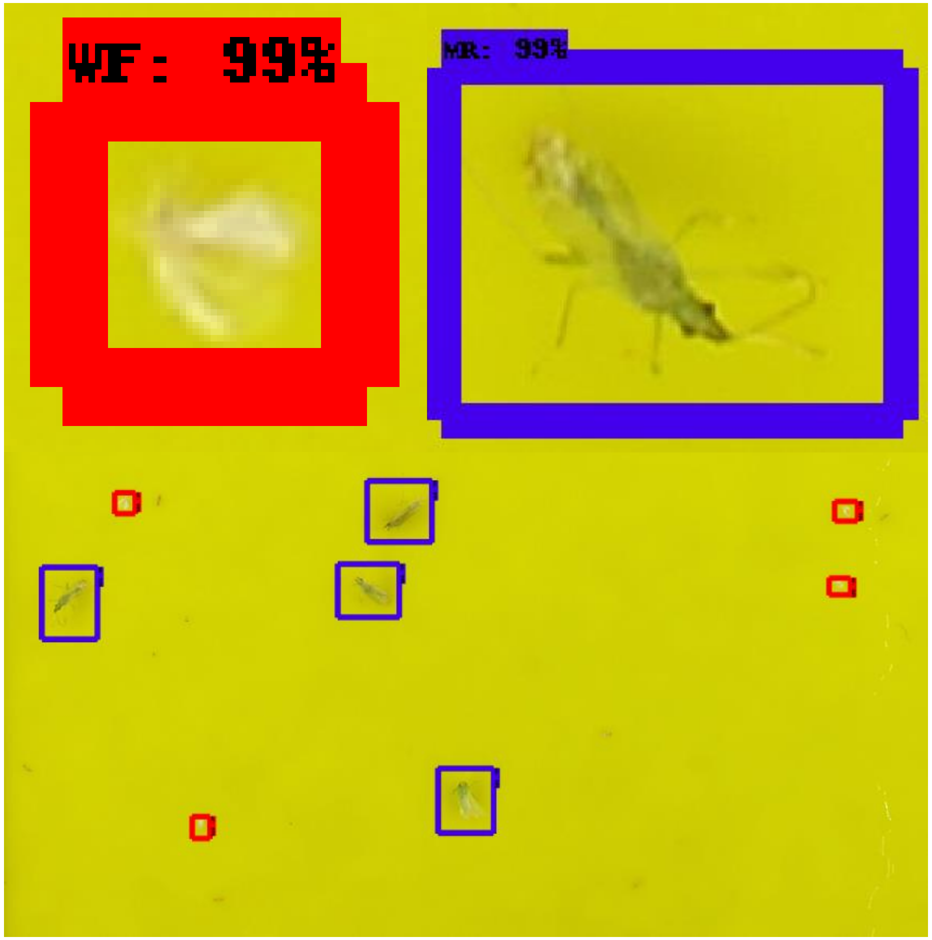
NWO Netherlands Organisation for Scientific Research

Automatic counting of white fly and beneficial insects trapped on yellow sticky

Use of a deep-learning image analysis network (F-RCNN, bounding boxes)

Photo: Wageningen University, Laboratory of Plant Breeding

PeMaTo-EuroPep
(2017–2019)



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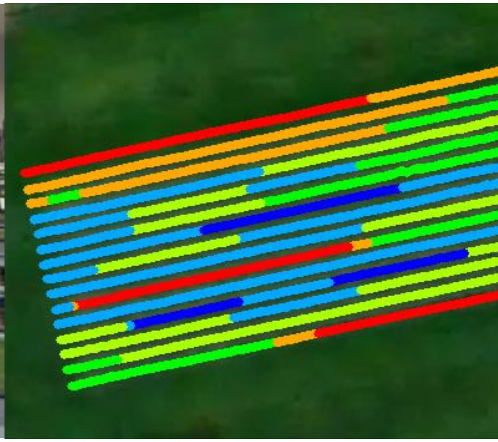
C-IPM Coordinated Integrated Pest Management in Europe

IoT in fruit growing

- Monitoring growth and quality
- Blossom detection and monitoring
- Feedback from sorting machine to harvest location

Internet of Food & Farm 2020 explores the potential of IoT-technologies for the European food and farming industry.



George Beers (Wageningen UR)

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Outdoor garden trimming robot

Mapping the garden

Trimming hedges and roses

Mapping the garden (point cloud)

http://trimbot2020.webhosting.rug.nl/

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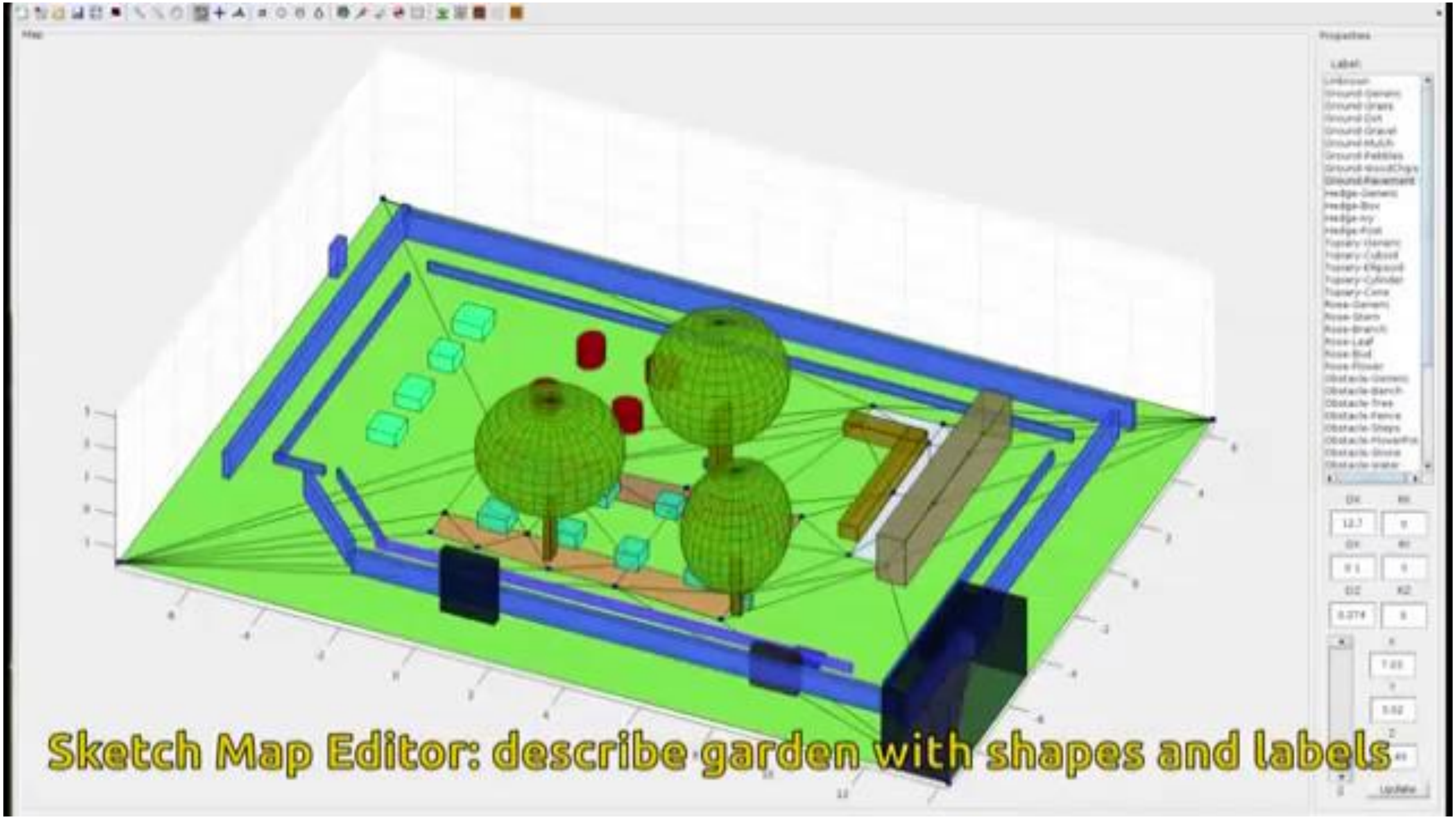
Matching garden design with measurements



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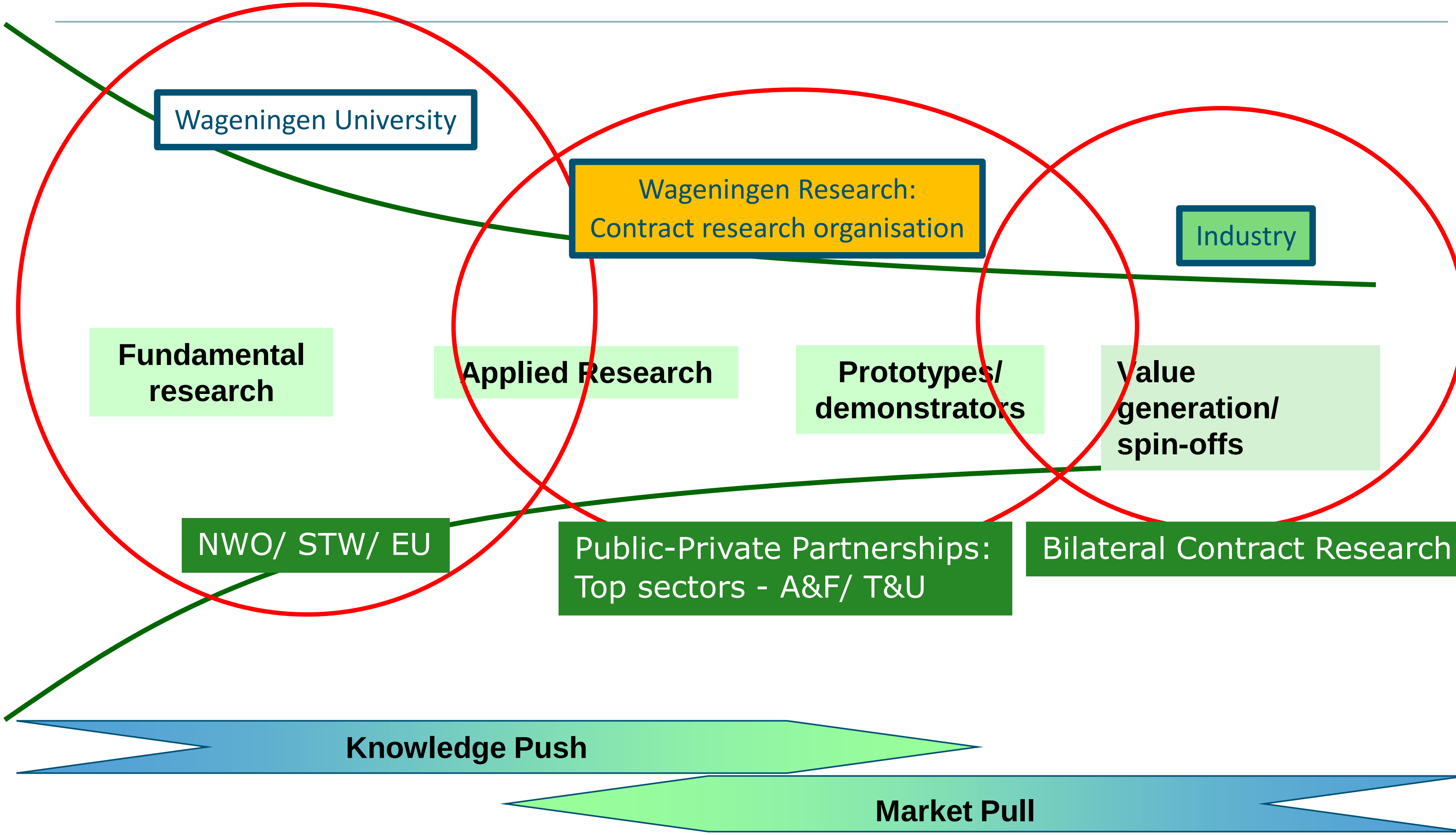
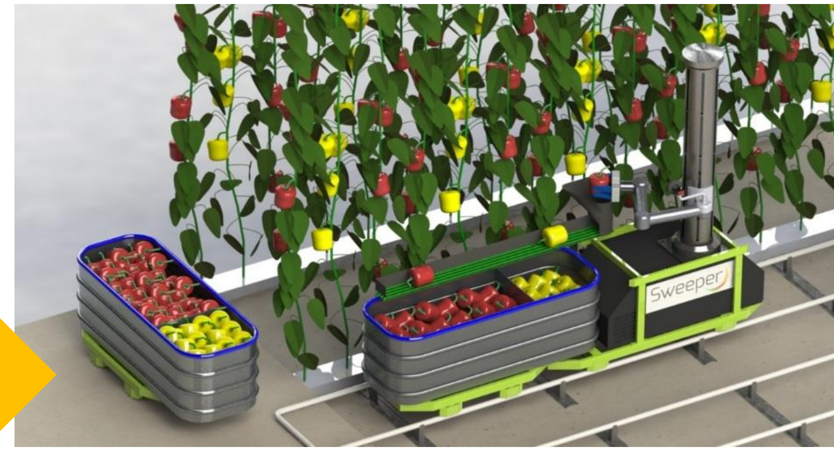
Trimming (lab testing)

WUR – Way of Working



Case: Sweet Pepper Harvesting



SWEEPER **aims** to put the **first generation greenhouse harvesting robots onto the market**.

Public-Private-Partnership

Main challenges for robotic harvesting

- Unstructured environment
  - Delicate product
  - Limited space
  - Occlusion
  - Fruit clustering

- Detection
  - Target and non-target
  - Ripeness and quality
  - 3D localization
- Economic feasibility
  - Harvesting success rate (no damage)
  - Cycle time

Lessons learned

- **Manipulator**
  - 6 DOF off the shelf robot arm
  - Robotic Operating System (ROS)
  - Mobile platform + post-harvest logistics
- **End-effector (grasp/cut)**
  - Smaller/light-weight
- **Camera system**
  - Ripeness and localization
  - 3D camera + illumination
- **Model based vision and control**
  - Deep learning, obstacle avoidance
  - Camera in-hand
  - Eye-hand coordination (visual servoing)
- **Economic evaluation**
  - Adapted crop morphology (crop management)

CROPS GA 246252

www.crops-robots.eu

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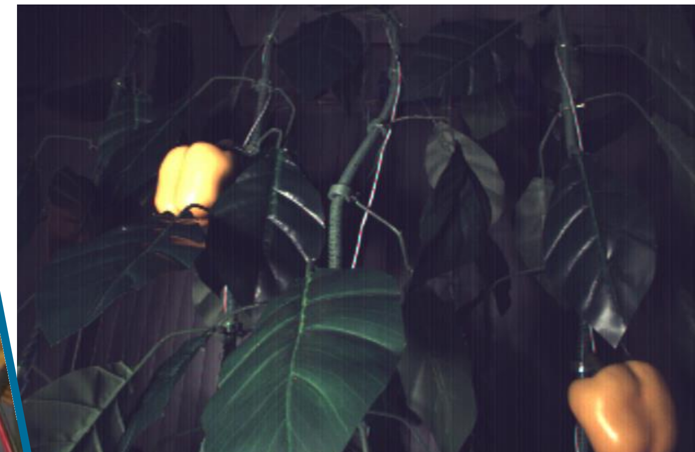
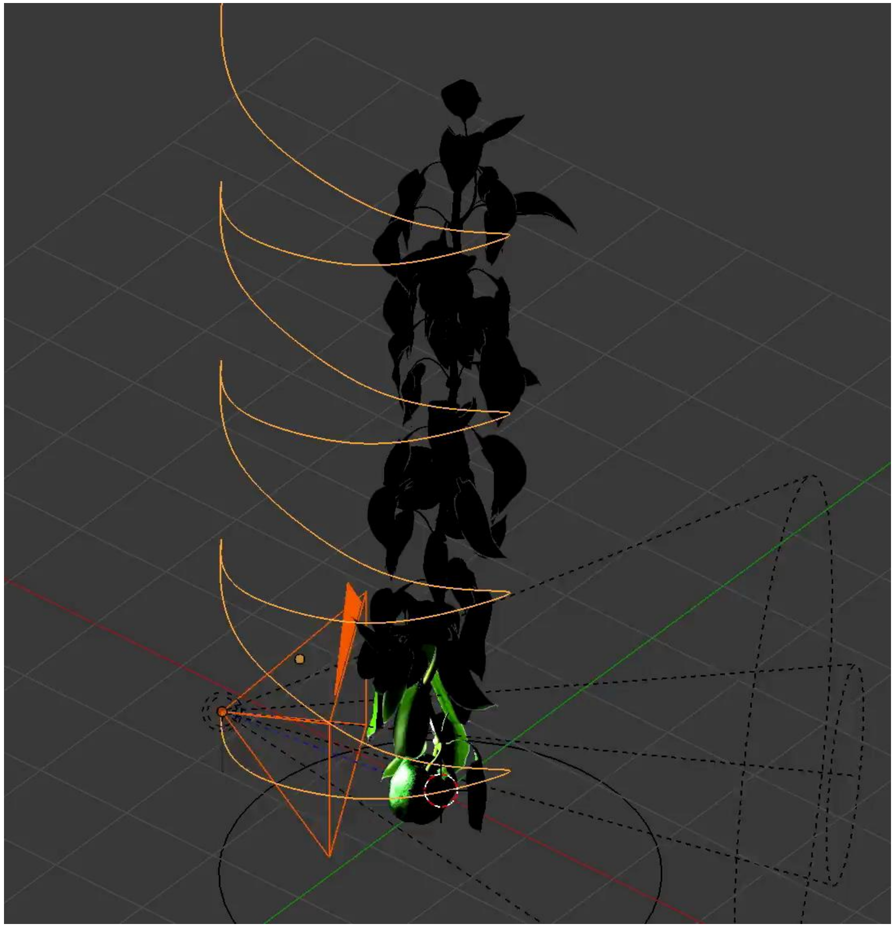
CROPbS "Clever Robots for Crops"

Advanced camera sensor

- One camera, placed in the end-effector
- Strobed active LED illumination
- Combined 3D data and colour image



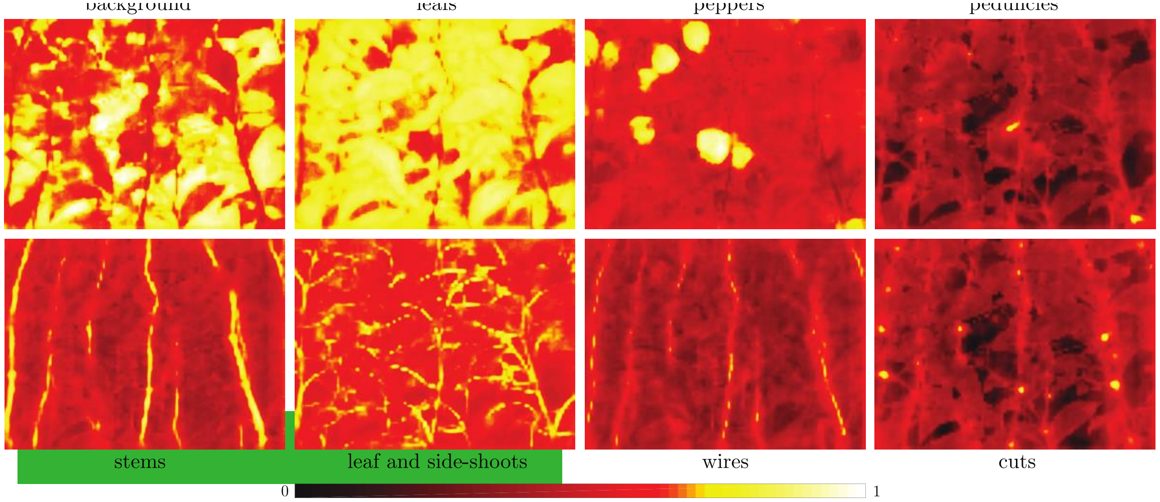
Plant modelling and visualisation

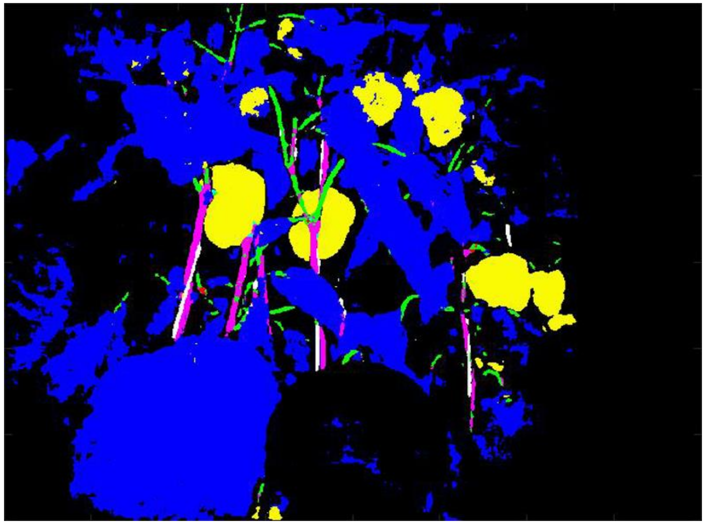


Use of professional 3D rendering software from animation and movie industries.

Deep-Learning for plant part localization

- **Need:** Large annotated datasets
- **Approach:** Synthetic dataset to bootstrap the model
- **Result:** Trained network for real-time obstacle detection and to determine best end-effector alignment





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Sweeper

Real-time target approach using visual servoing

Software framework for **eye-in-hand sensing** and robot motion control

Crops gripper

Movie: Umea University (Sweden)

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Sweeper

Questions

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