Visit Mid-Sweden University - November 2006

Autonomous Field Robots

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Overview

1. Sensor fusion meets GPS
2. Field robots

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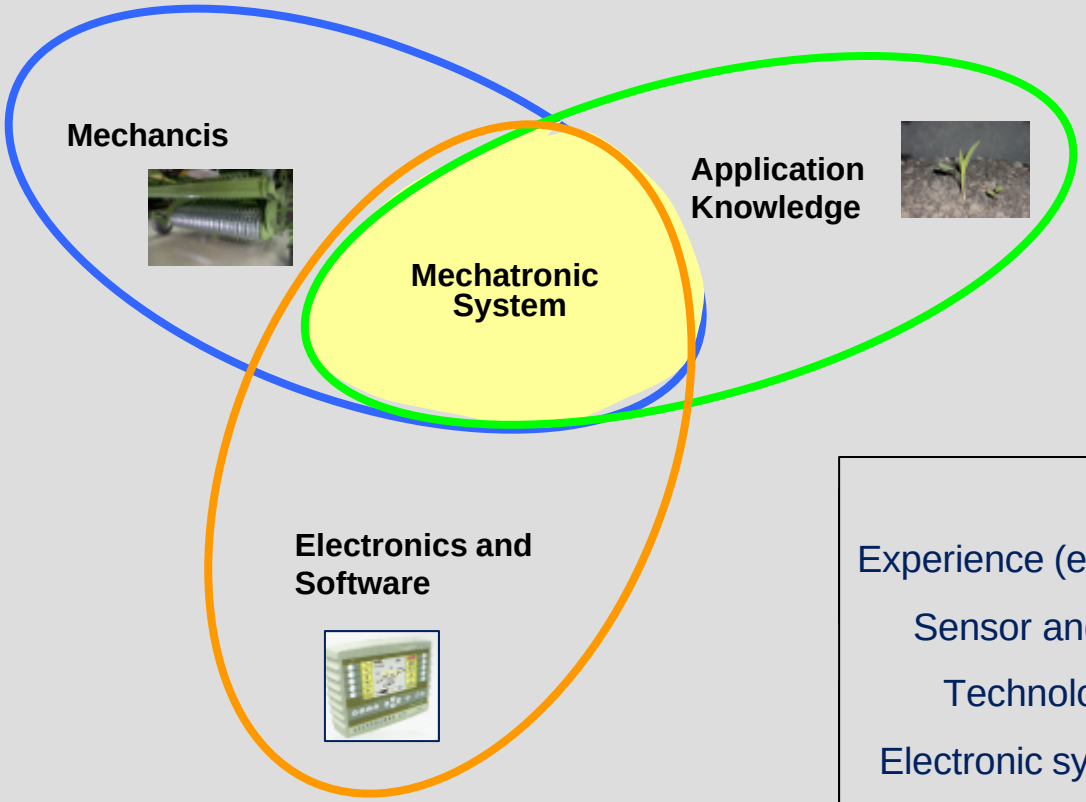
2. Field robots

Mechatronic agricultural engineering systems



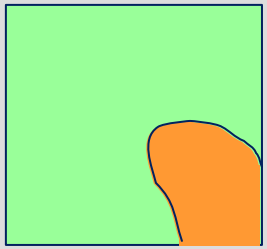
Experience (example: plant production)

Sensor and information systems

Technology push / challenge

Electronic systems, communications

Technology challenge in precision farming: sensor systems



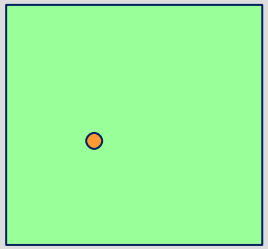
Precision Farming

GPS

Off-line sensors /

Averaging on-line sensors

Standard System Technology



Individual Plant Farming

High precise GPS

Non-averaging on-line sensors

Advanced System Technology

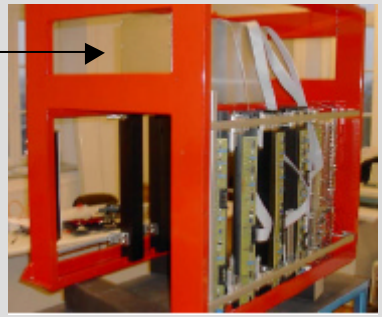
Technologies for individual plant detection

- System technology (real-time, embedded systems, CAN-bus)
- Sensors for crop detection (examples: photo diode arrays, spectral imaging)
- Positioning with GPS and other sensors (encoder)
- Power management
- Alarm unit (example: voltages, temperature, dust)
- User interface
- Software (examples: data acquisition, algorithms, testing)
- Mechanical mobile unit

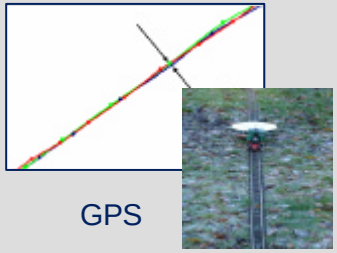
Technologies (examples/visualization)

User interface

Electronic systems



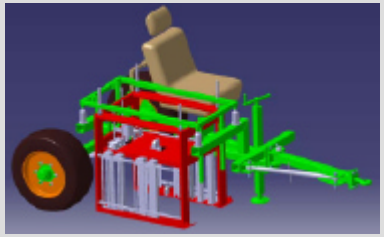
Mechanical sensor unit



GPS

Plant characterization

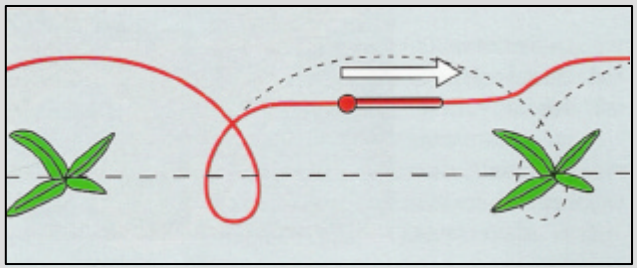
Testing in greenhous/field

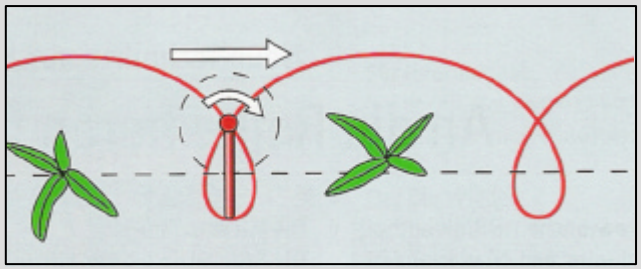


Test vehicle

First application of sensor fusion in weed control (1998)

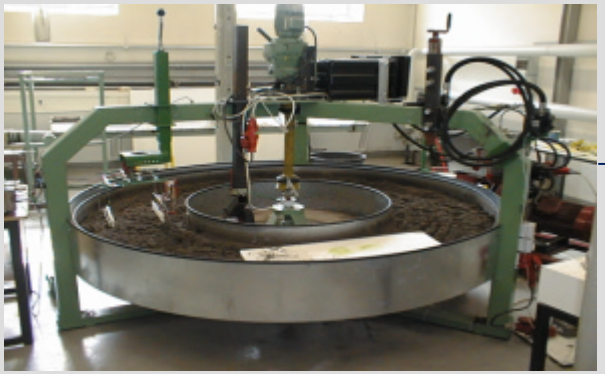
- Application: Mechanical intra-row weed control
- Multi-sensor system / microcontroller-based architecture
- Transversal cycloide hoe („Querhacke“)
- Plant database





"Microcontroller-based multi-sensor system for online crop/weed detection“ , A.Ruckelshausen, T.Dzinaj, F.Gelze, S.Kleine Hörstkamp, A.Linz, J.Marquering, Proceedings of the

Test setups: Carousel – greenhouse - field

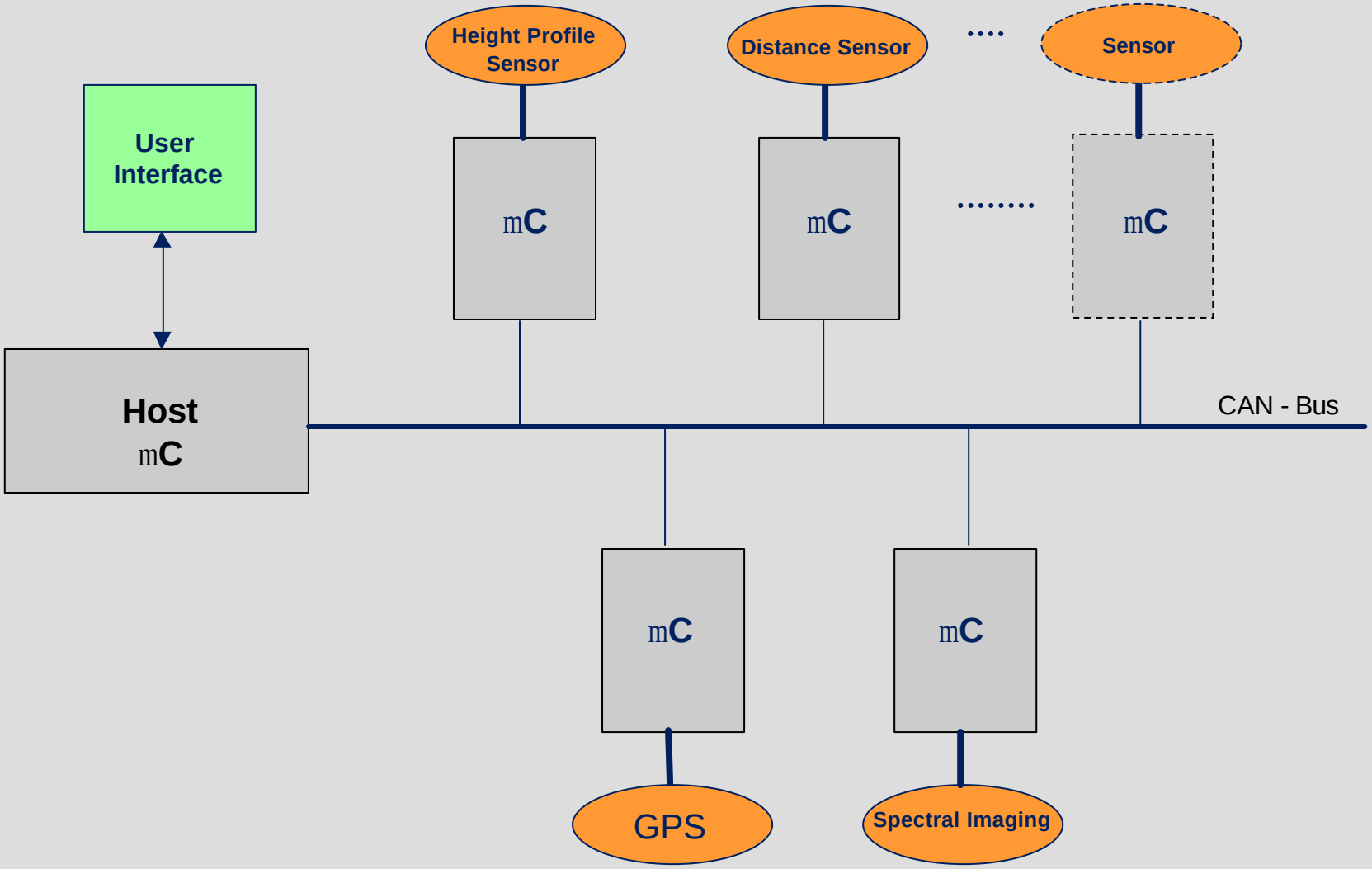


Hacke

mit

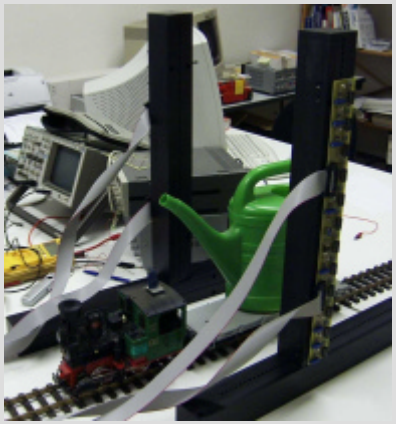
Messerwerkzeugen

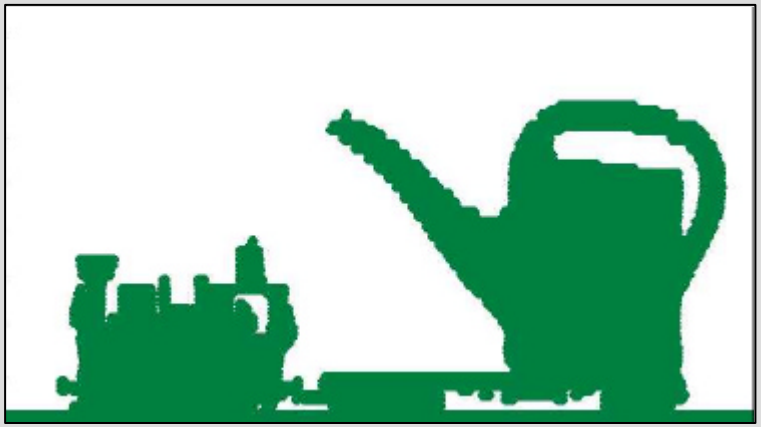
System architecture for individual plant detection



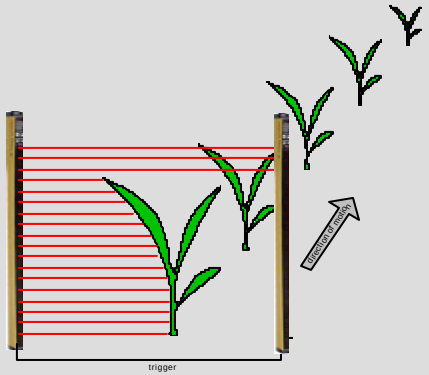
Advanced sensor technology: 1 bit imaging/height profile detector

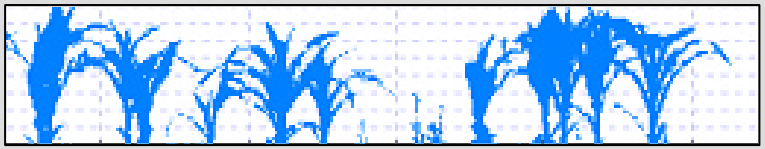
Test setup (laboratory)





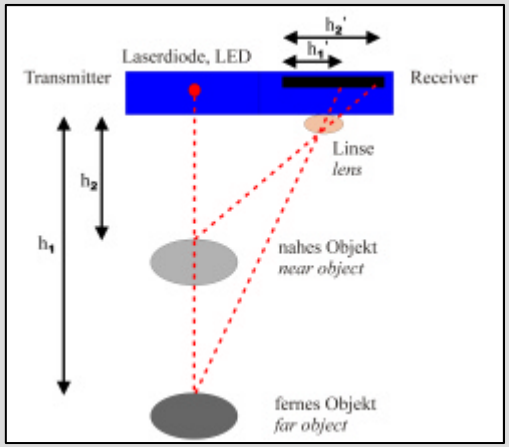
Maize plants (field)



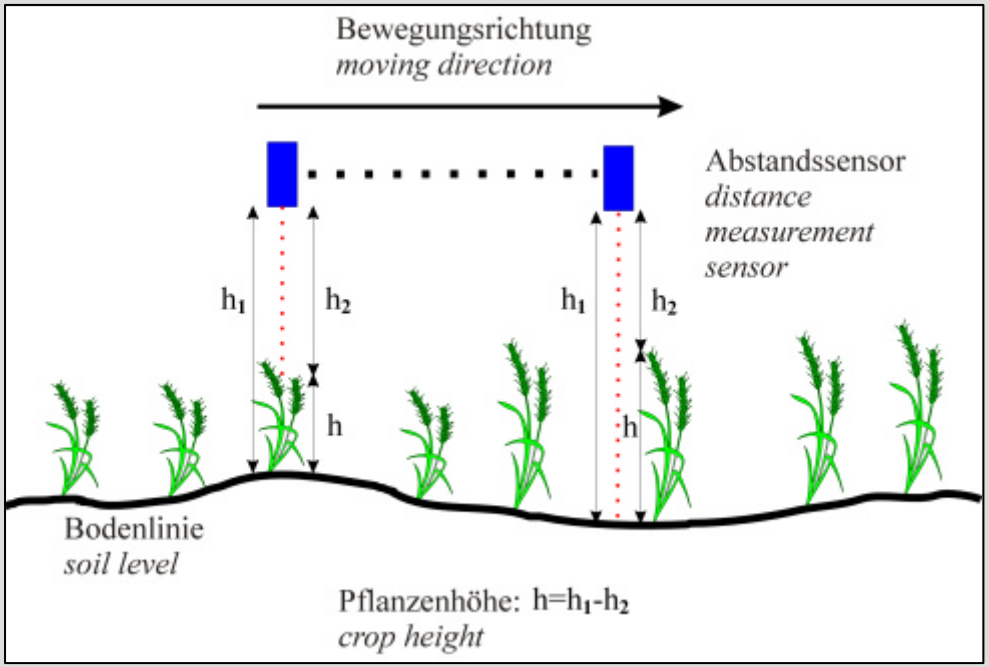


Advanced sensor technology: optoelectronic distance measurement

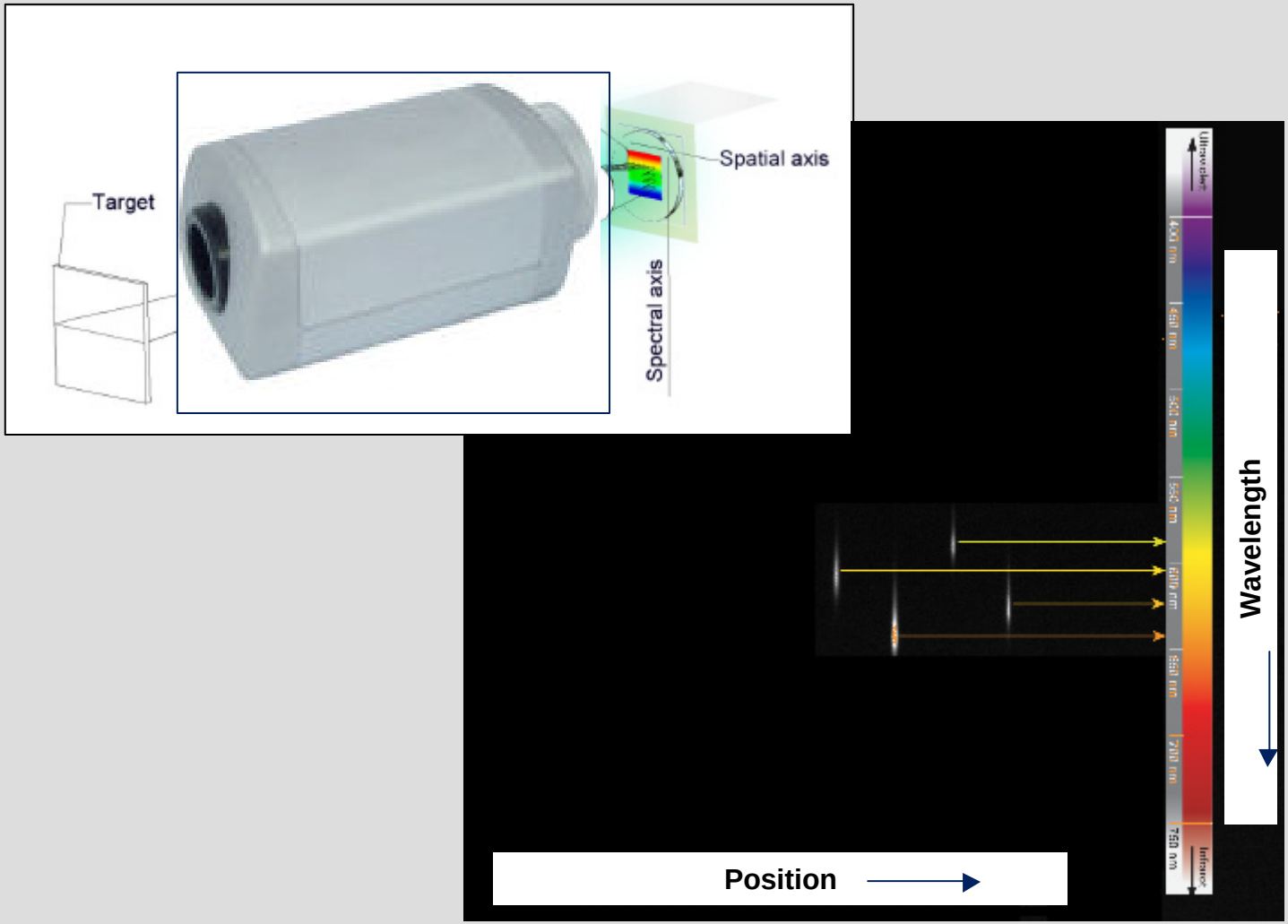
Applications: Measurement of crop height and densitiy, stalk detection



Triangulation sensor

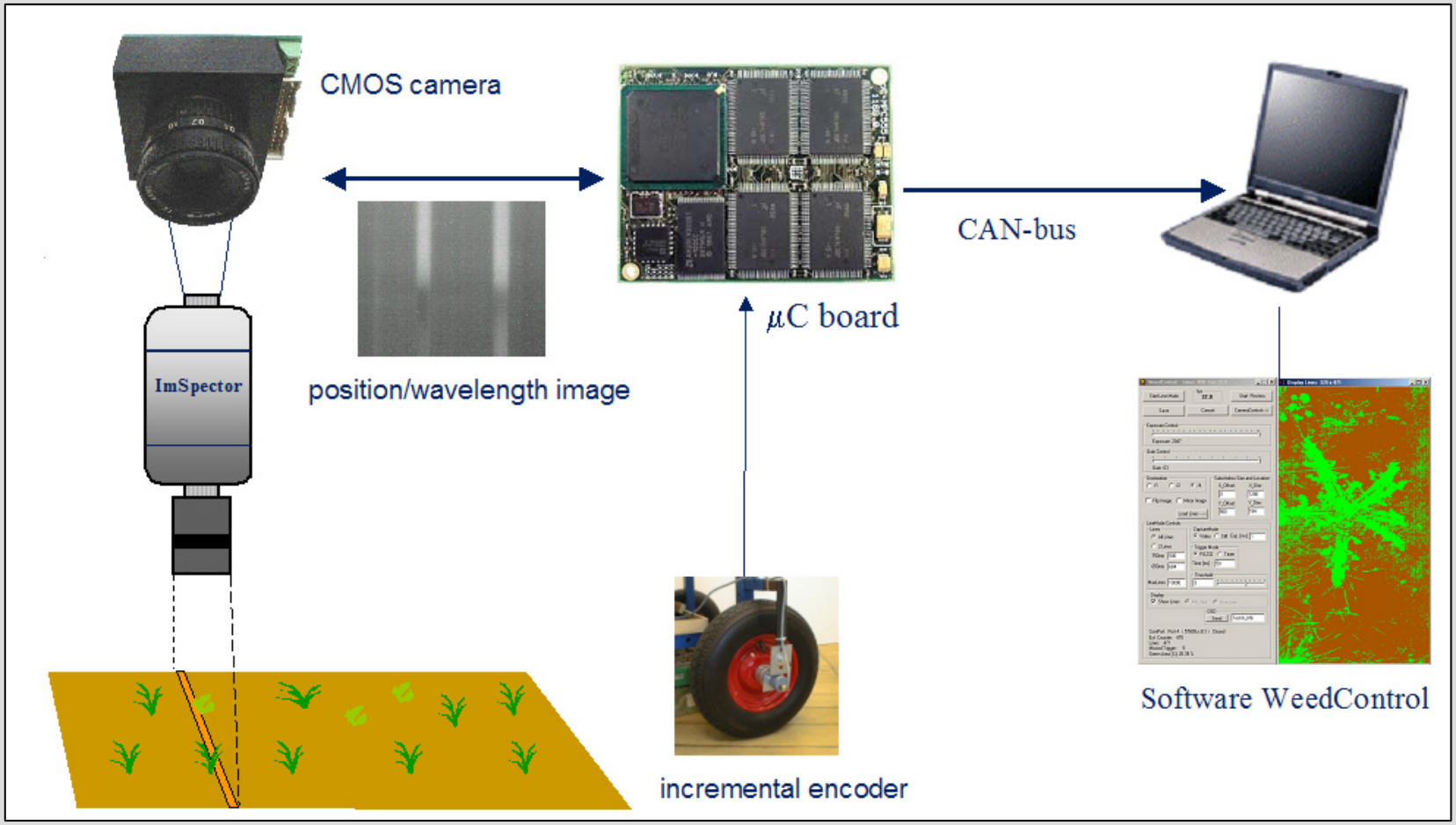


Advanced sensor technology: spectral imaging



Example: 4 LEDs with different wavelengths

System integration: spectral imaging with ImSpector/CMOS-camera



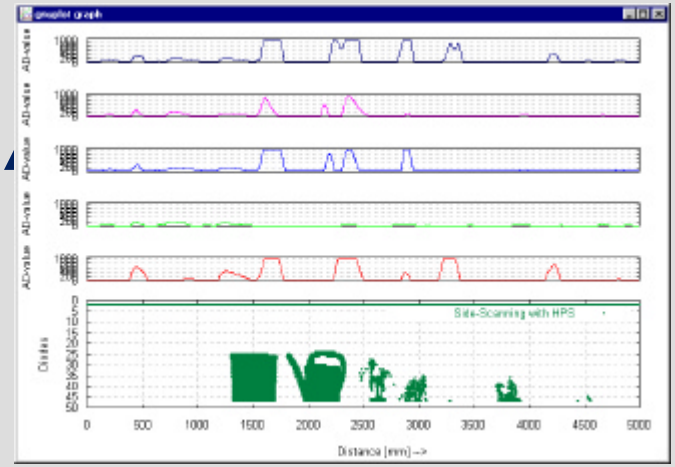
Sensor fusion (principle)

Objects with different properties

(spectral, geometrical, mechanical)

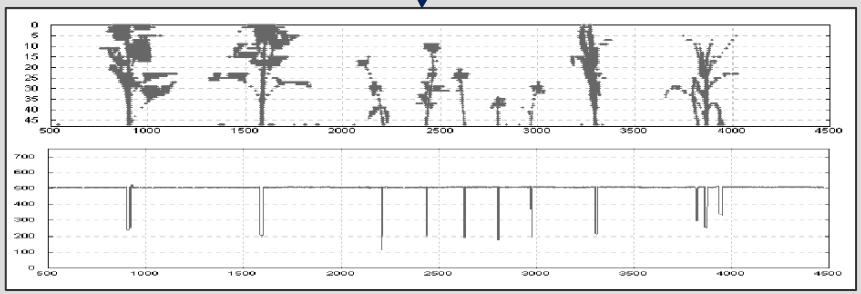
Measurement with sensors

of different selectivites

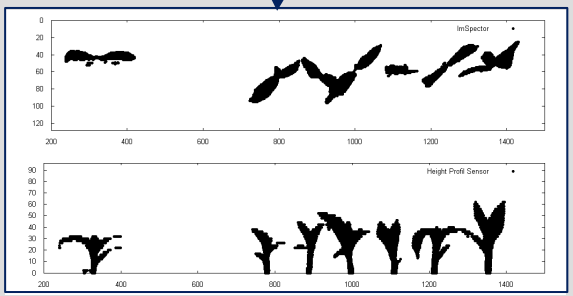


Sensor fusion for crop detection (examples)

Height profile measurement



Spectral Imaging (top view)

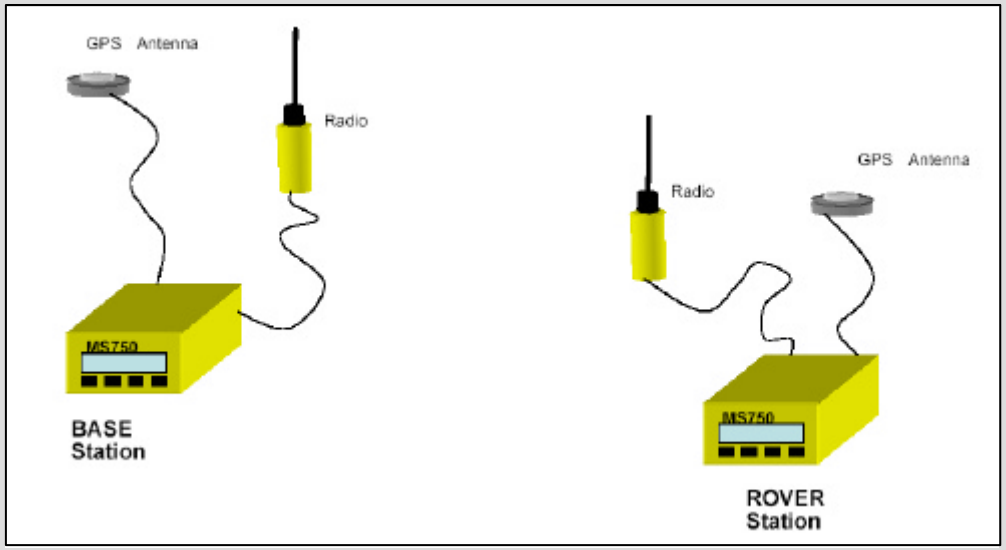


Distance measurements (horizontal)

Height profile measurement (side view)

GPS technologies

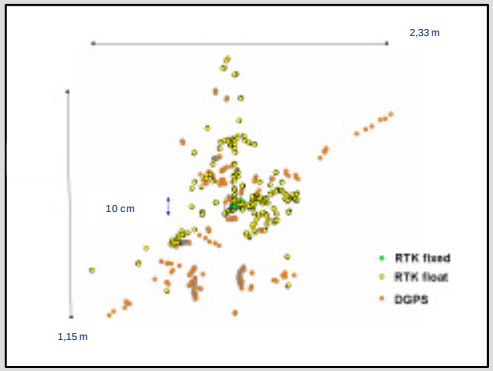
- Application in maize fields: typical distance of 2 maize plants is 8 to 12 cm
- ⇒ GPS accuracy better than 5 cm
- ⇒ Differential GPS with real-time kinematic (RTK/DGPS)
- Interpolation of two GPS signals with encoder information
- GIS-tool OpenJUMP (open-source application)

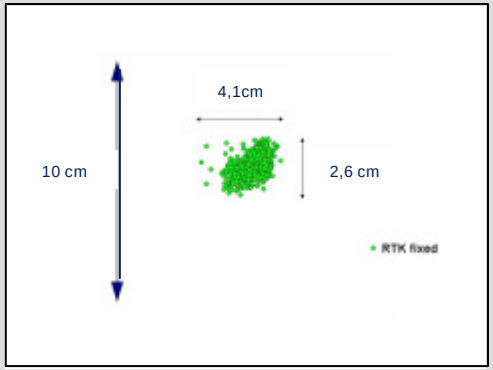


RTK/DGPS system MS750 from Trimble

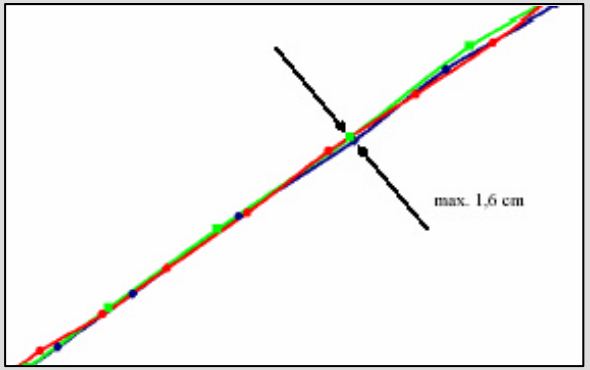
Characterization of the GPS-system

Point measurements





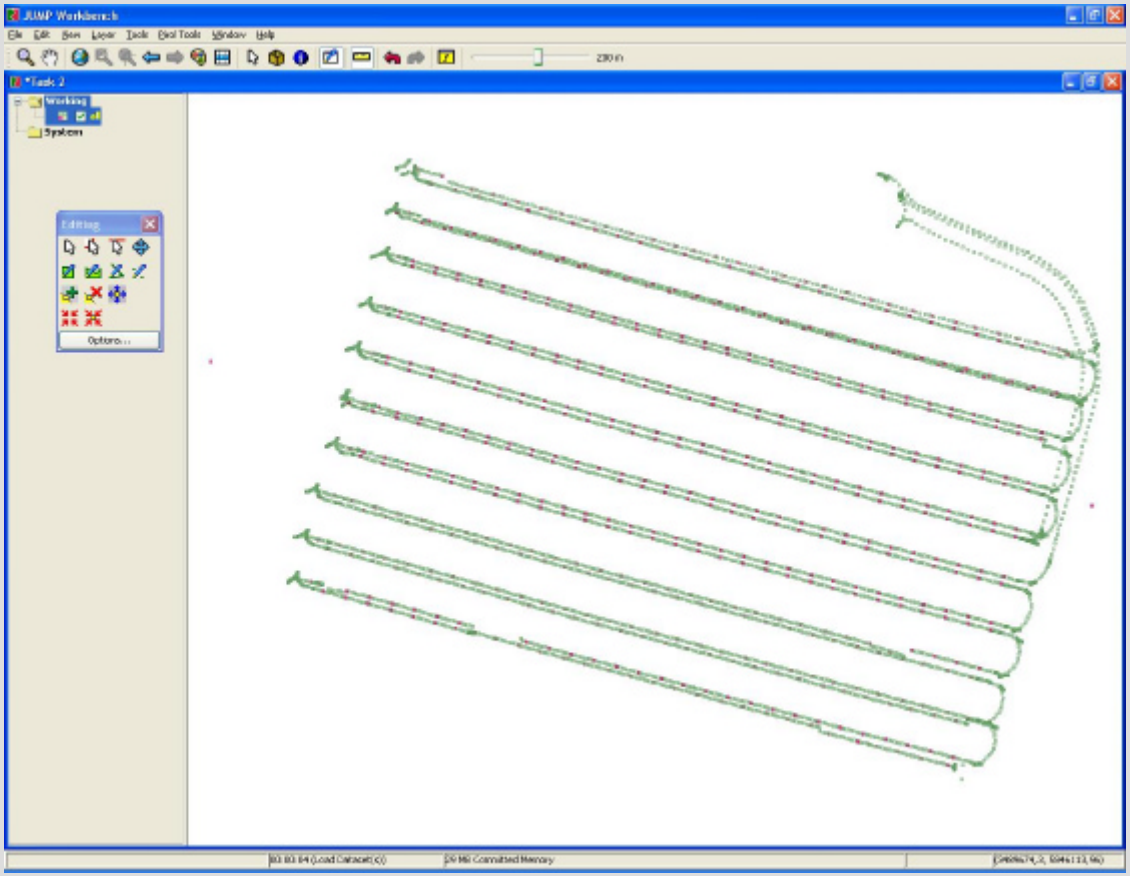
Line measurements



⇒ Typical measured RTK/DGPS accuracy: ± 2 cm

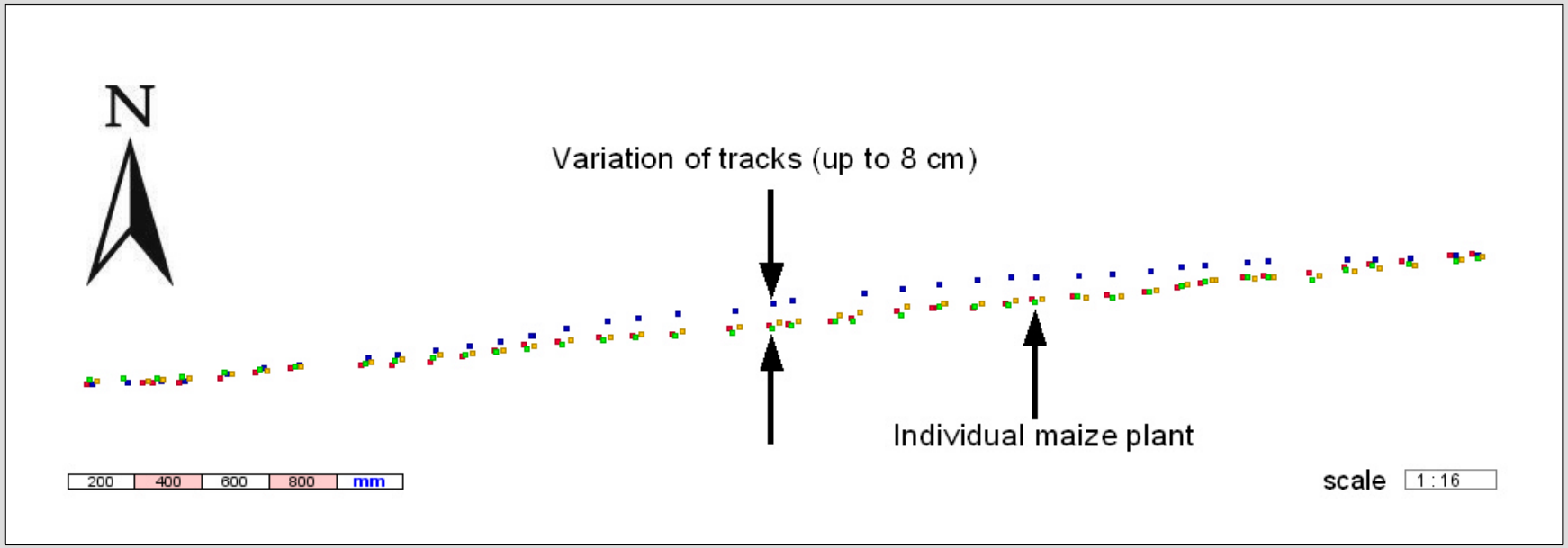
Mobile sensor unit in a maize field

Visualization of data with the GIS-tool OpenJUMP



Results

- 4 different runs in the same maize row
- Vertical variations due to different tracks of the mobile unit

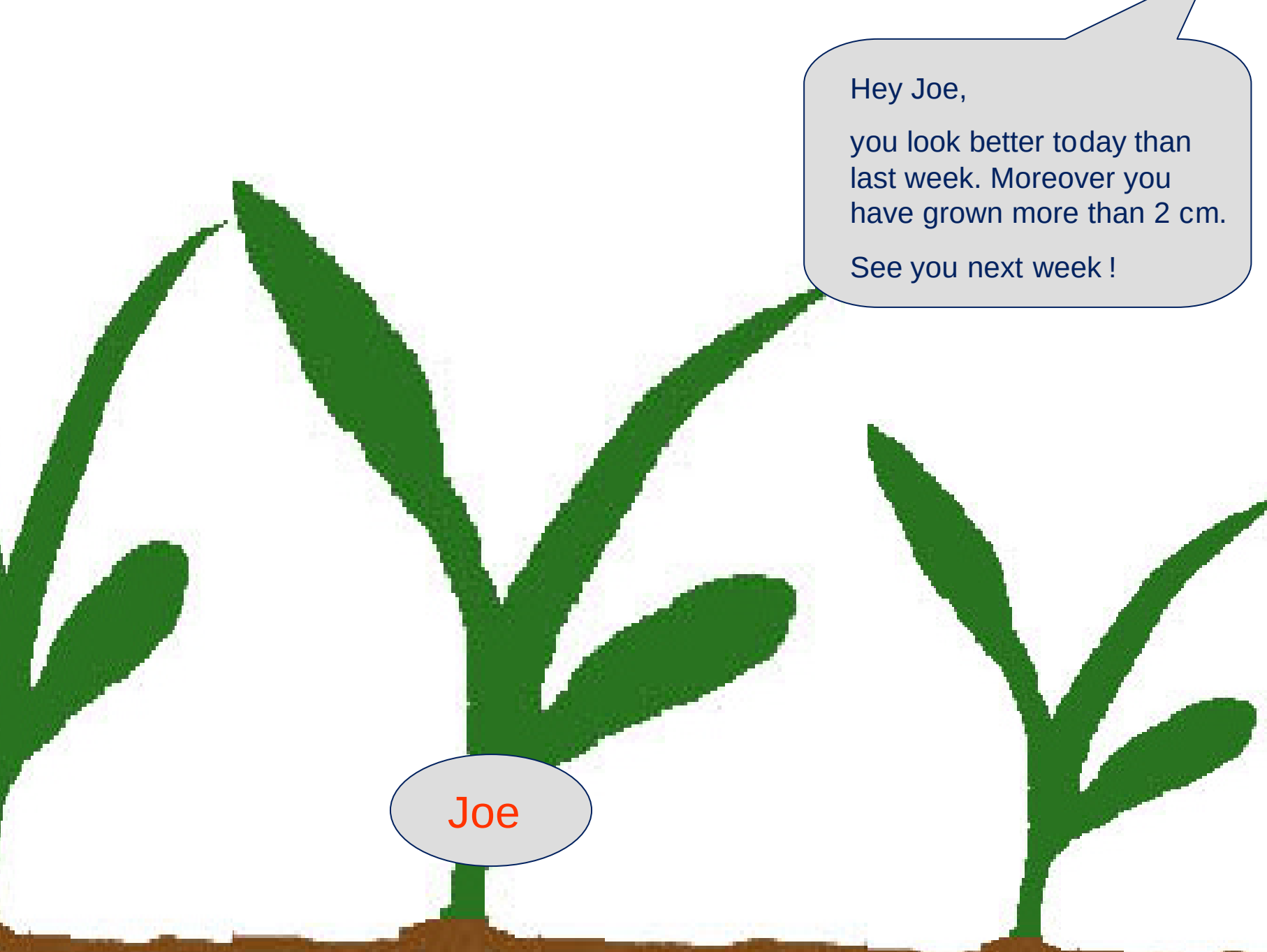


⇒ Identification of an individual plant

⇒ Reidentification of an individual plant

Conclusions

- Advanced sensor fusion concept for crop detection has been developed
- System technology is based on real-time processing and flexibility
- RTK/DGPS system has been tested resulting in sufficient accuracy
- Individual plant detection based on sensor-fusion and GPS has been realized
- Future options for characterization of plants in the plant production process
- Future options for individual plant treatments
- Future support by improved technologies and lower prices
- Future options for combining individual plant treatment with autonomous robots


Hey Joe,
you look better today than last week. Moreover you have grown more than 2 cm.
See you next week !
Joe

Overview

1. Sensor fusion meets GPS
2. Field robots

Autonomous Service Robots: Field Robots

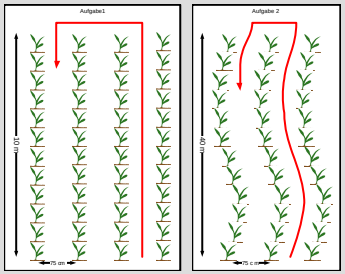
- Cost reduction, environmental protection, jobs
- Technologies: Sensors, actuators, system technology, vehicles, safety, algorithms, application related aspects, user interface
- ☺ Fun, as for example: Field Robot Event in Wageningen/Netherlands, Hohenheim/Germany (2006)

International „Field Robot Event“

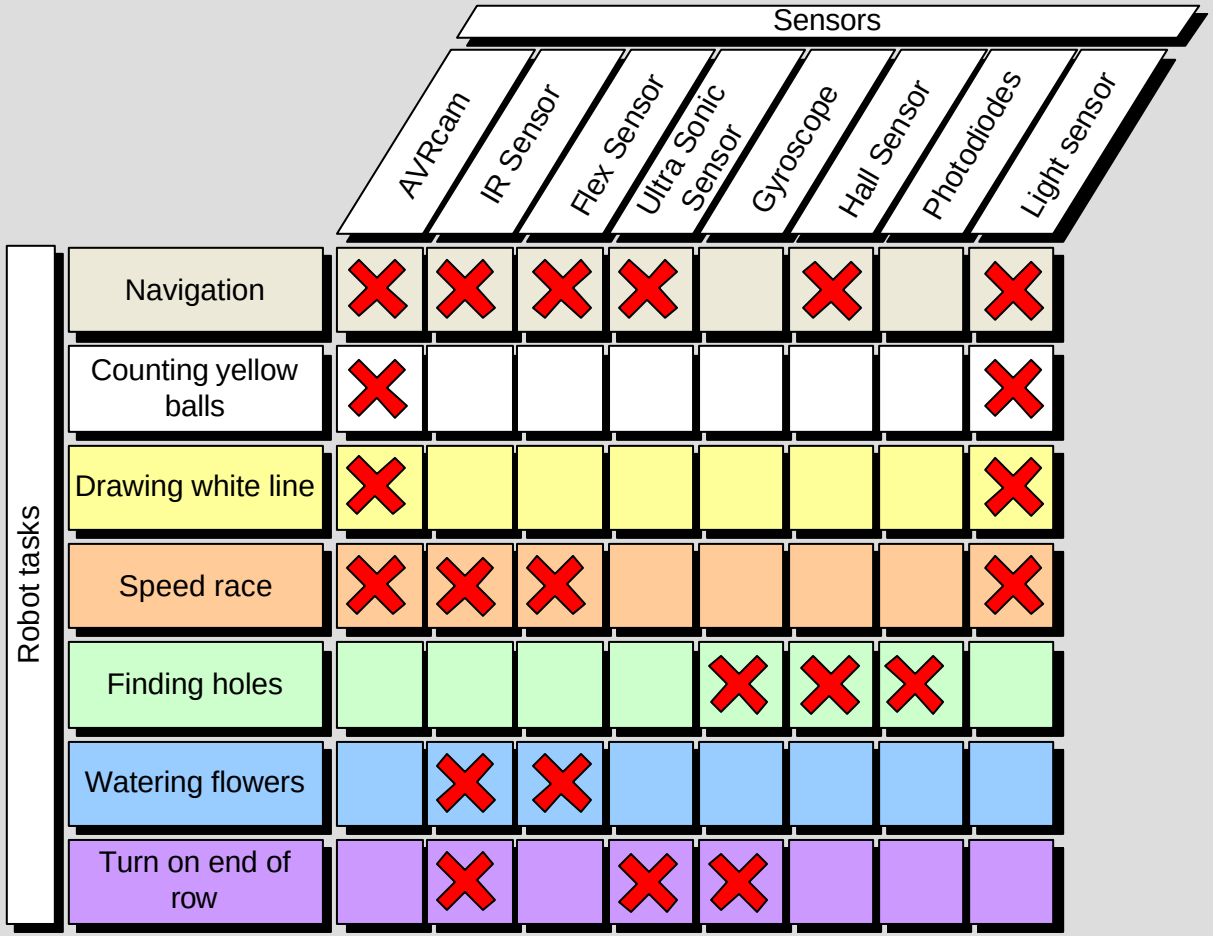
- Initialized by Wageningen University.
- Interdisciplinary teams from all over the world compete.

The tasks:

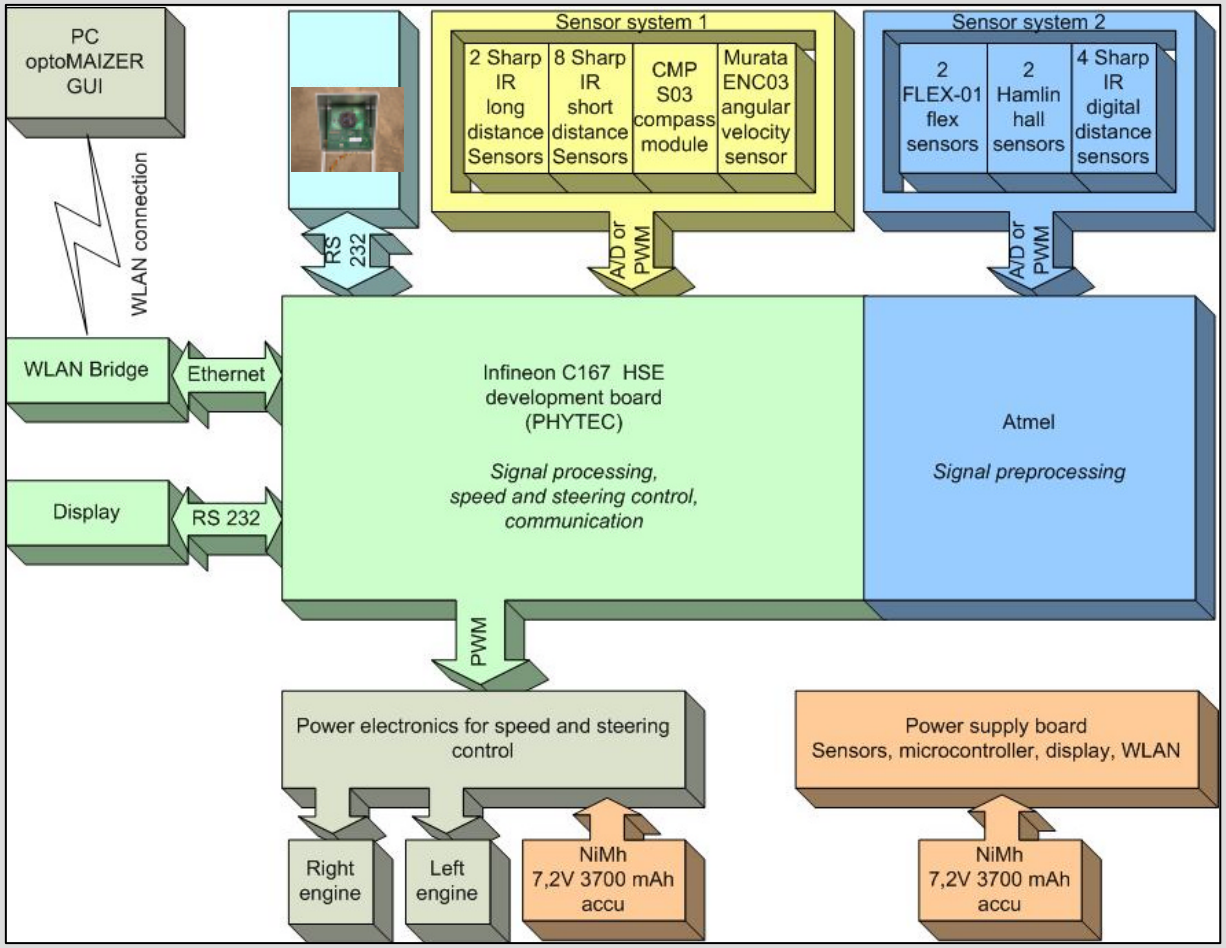
- Navigation through straight and curved maize rows.
- Make a turn at the end of the row into the next or second row.
- Counting of the plants.
- Detection of holes in a lawn area.



Sensor fusion concept

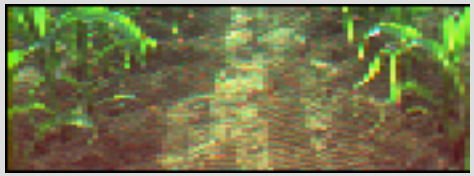


Architecture of an autonomous field robot (*optoMAIZER*)

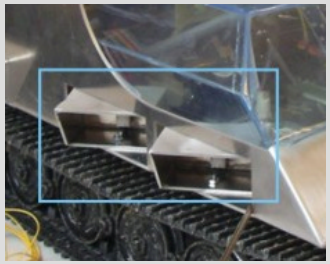


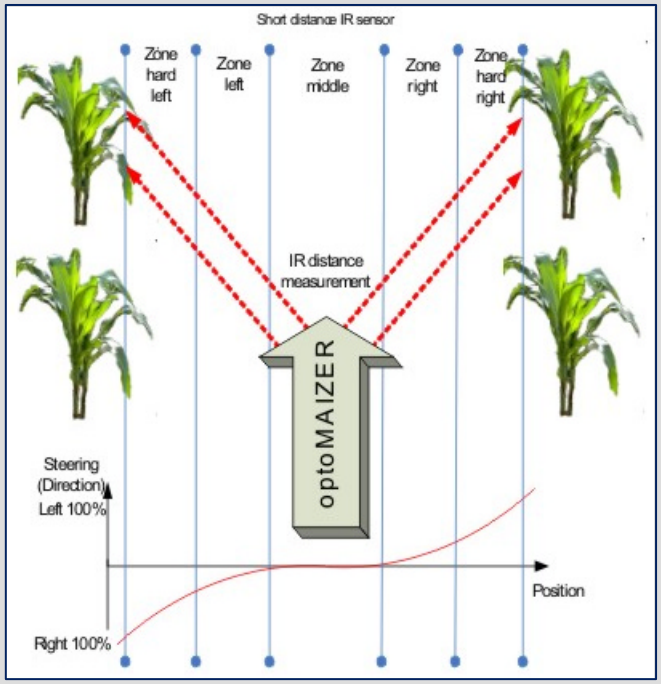
Navigation: intelligent low-cost camera “CMUCam“ for navigation

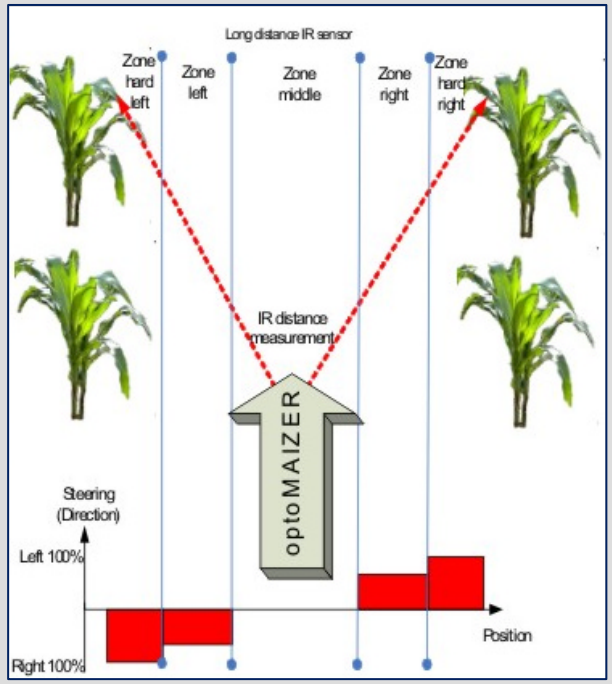
- Integrated microcontroller for image processing
- Options for reduced data (example: windowing)
- Tracking options (example: color tracking)
- Resolution up to 160 x 255 Pixel
- Low cost solution (ca. 140 €)



Sensors (example): distance sensors for navigation

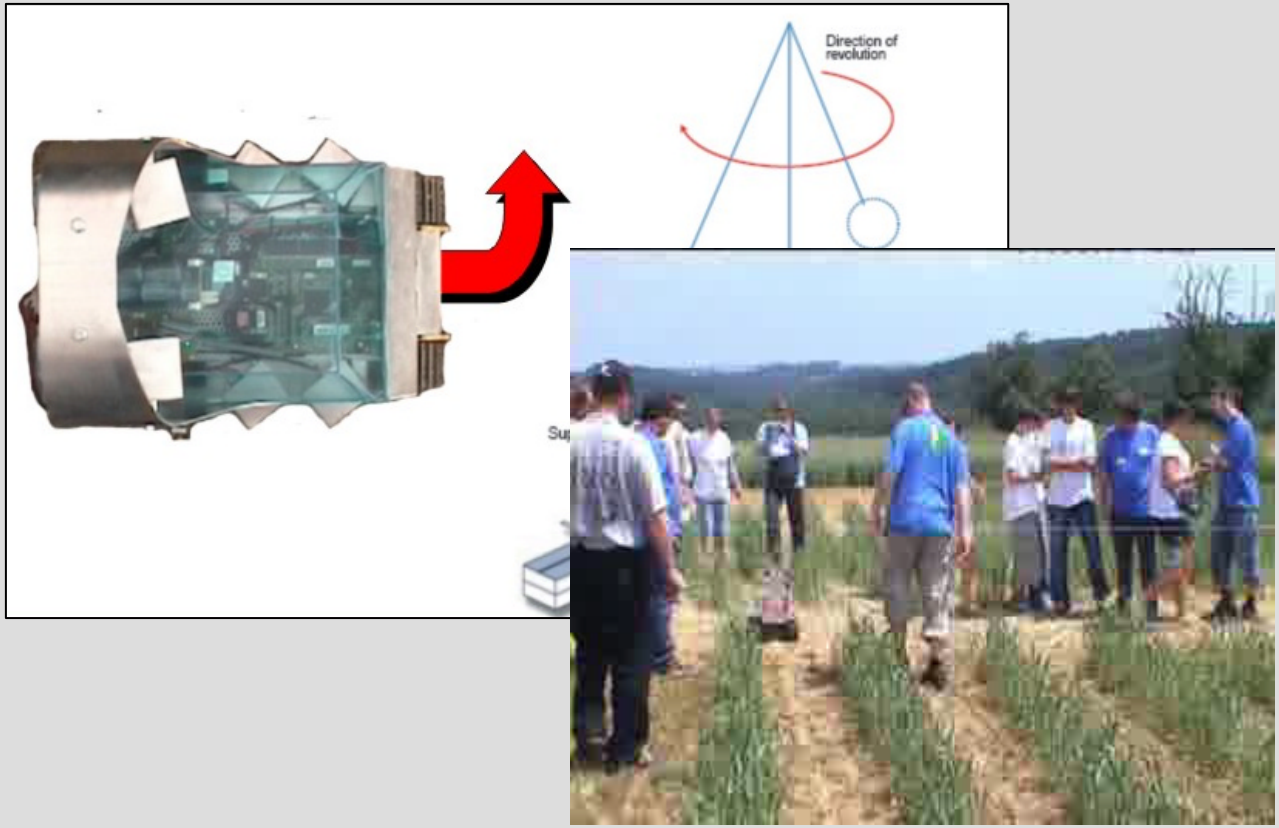






Navigation: Simulation and realization

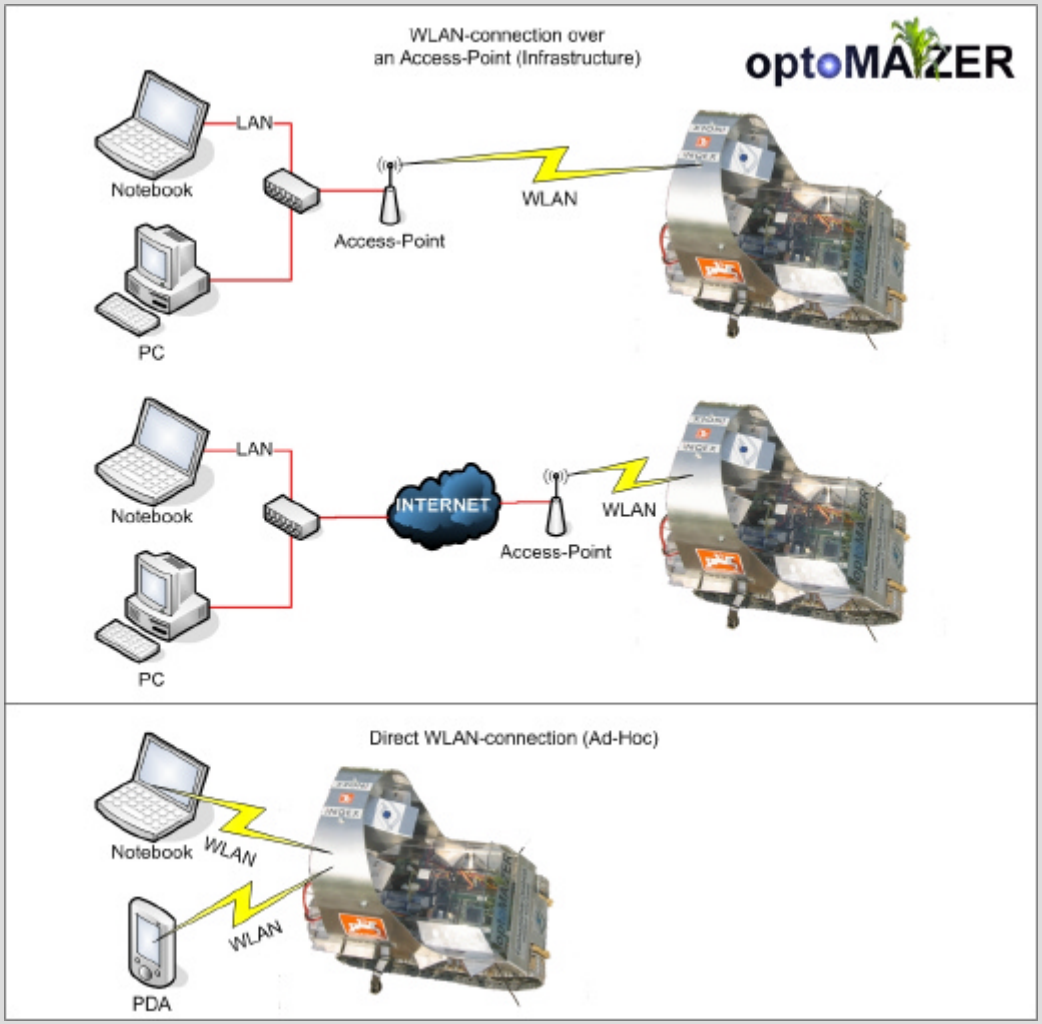
Sensors (example): angular sensors for turnaround



User Interface

- System tests
- Test of sensors
- WLAN
- Strategies (software)
- Algorithms
- Parameter settings
- …

Robotic platform: Learning mode and teleservice



Autonomous field robot Eye Maize : Navigation and turnaround

ield Robot Event 2006
www.maizerati.de

Autonomous robotic platform Weedy

- Modular concept
- Usage of single technologies with own experiences
- Complexity: system integration and application
- Status: Prototyp of vehicle tested
- Ongoing work …