Smartfarming kennisdag 2022

Kennissessie - Synergia

Synergia - Ecologisch gebaseerde systeemverandering met hulp van High Tech in de landbouw

Simon van Mourik – Farm Technology Group Wageningen University

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Modern Farming

Farm industrialization 2nd half of 20th century

Goal: optimize labour and financial efficiency

Monocultures, large scale systems

'Mono' populations in optimized environments

'Lock-in' for change

Cheap and predictable food

Simple 'ruling' technology - high inputs – high overall losses

Precision Farming

High Tech Farm industrialization beginning of 21th century

Goal: optimize labour, financial, and resource efficiency

Monocultures, large scale systems, but with precise management and actions

Examples of Precision Farming

milking robot

field task mapping

egg transport

climate control

Domains:

- Precision Livestock Farming
- Precision Agriculture (arable farming)
- Precision Horticulture (greenhouse, orchard)
- Postharvest (monitoring, packaging, transport)
- Other: farming of fish, algae, mealworms

Automation

High tech actuators, sensors, drones, robots

Machine intelligence, ideal situation: not all processes are fully automated

Gripper
Conveyor
Heating
Lighting

Sensor
Camera
Electronic nose

Computer
Drone, robot

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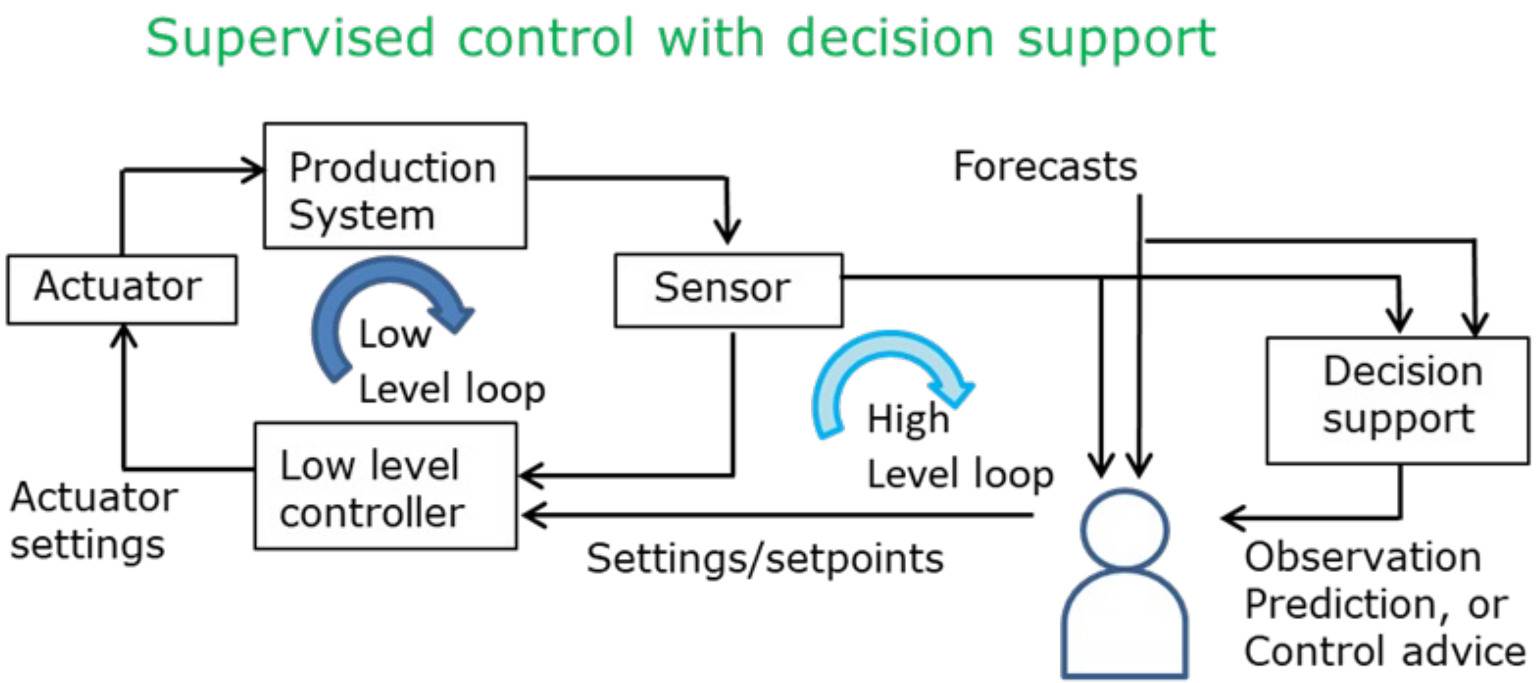
Decision support

Large demand from industry for decision support systems

Machine intelligence is big bottleneck



Observation : indoor climate

Prediction : effect of change in climate on crop yield

Control : optimal climate regarding crop yield, energy use

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Machine intelligence

Work at FTE

Task	Required skills	Methods
Prediction	Knowledge on system response Learn/adapt Knowledge on uncertainty	Input-state-output model Adaptive modelling Uncertainty modelling
Observation	State estimation	Sensor based state estimation Data assimilation
Control	Performance objective Respond to changes in state Plan ahead Mitigate uncertainty/risks	Performance criterion Feedback control Model predictive control Robust/risk sensitive control

Van Mourik et al (2021). Introductory overview: Systems and control methods for operational management support in agricultural production systems. Environmental Modelling and Control 139, 105031.

Challenges machine intelligence

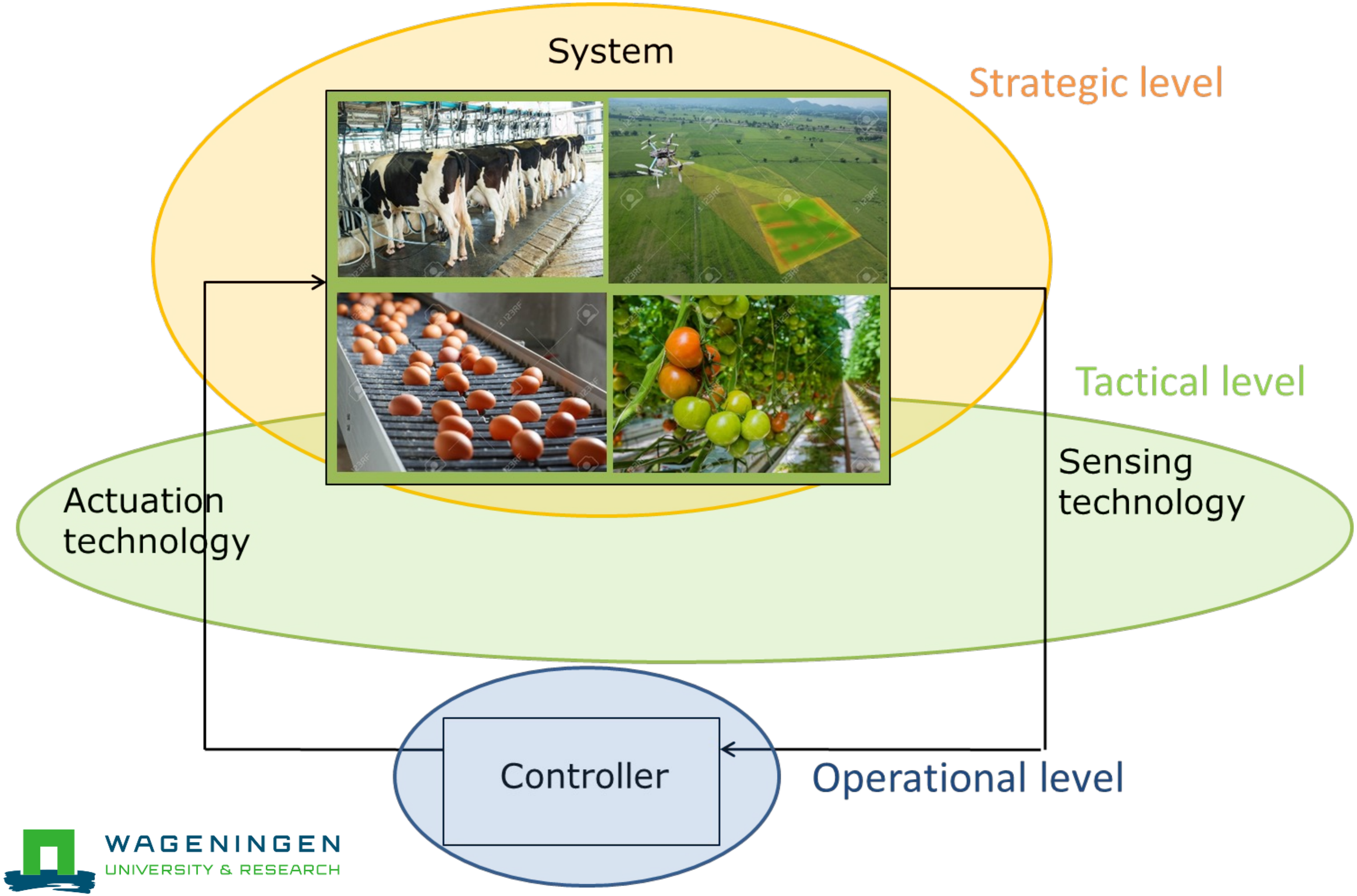
- System complexity
  - Biological and physical processes
  - Multiple time scales
  - Nonlinearity, uncertainty
  - Many parameters and state variables to estimate and monitor
- Variability
  - External uncontrollable input (weather, disease load, market prices, demand)
  - Internal unpredicted variations (biological, spatial variation)

Challenges machine intelligence

- Monitoring limitations
  - Sensor inaccuracies (noise, offset)
  - Limited observability: internal crop status, occlusion
- Actuation limitations
  - Limited capacity (passive cooling, only positive input, kabels in robots).
  - Interacting actuators (cooling and dehumidification)
  - Crop/animal fragility (limited range of input and actions allowed).

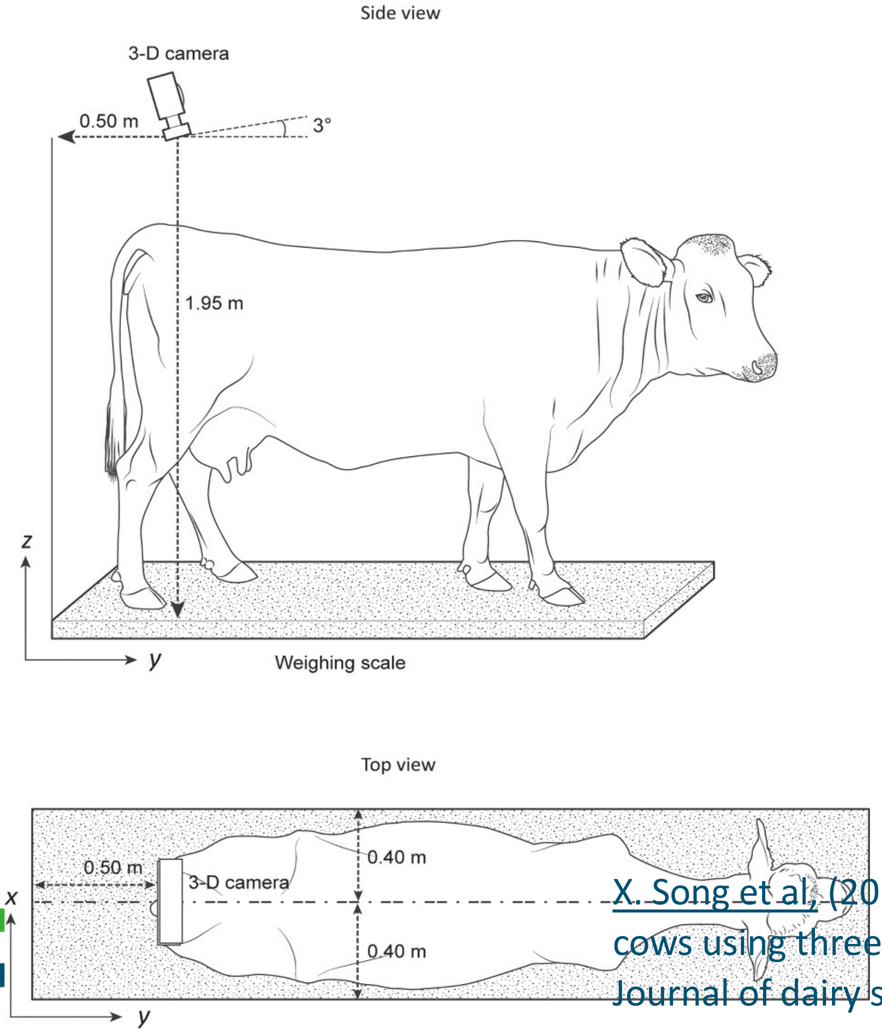
→ This is a research line at Farm Technology group

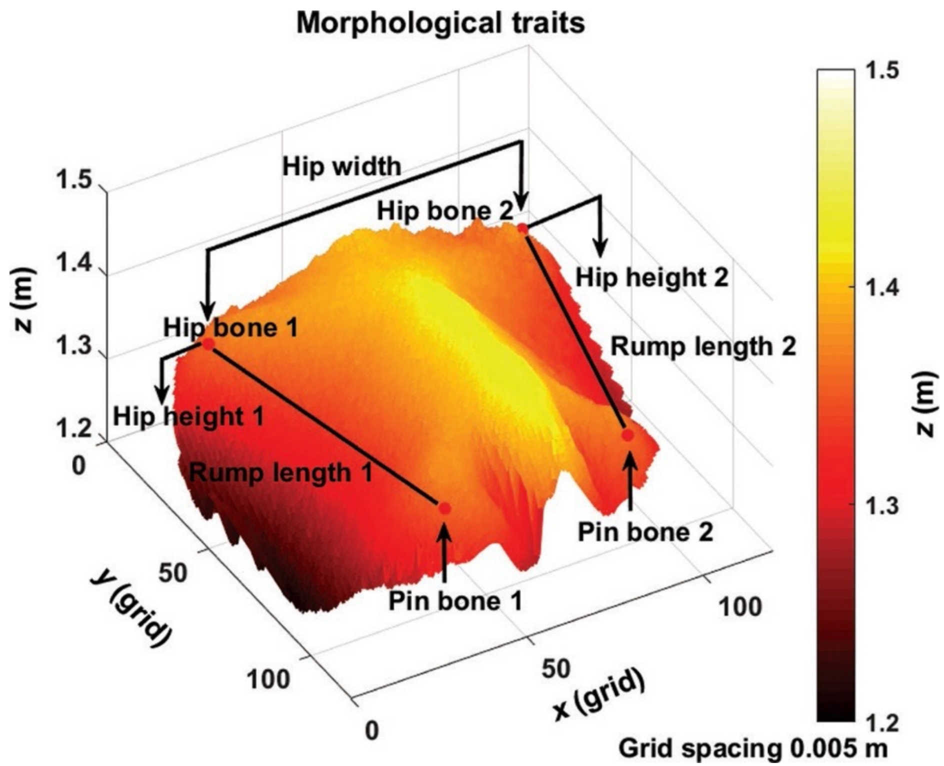
Operation, tactics, and strategy



Example: tactical improvement

3D Camera system to identify cow morphology (Xiangyu Song)





X. Song et al, (2019). Automated body condition scoring of dairy cows using three-dimensional feature extraction from multiple body regions. Journal of dairy science 102 (5), 4294-4308.

Societal Impact

Societal/economical trade-off: larger impact requires larger investment

Investment	**Improvement**
Operational	
• Risk sensitive irrigation	no less drainage
Tactical	
• Soil property sensors	60% less drainage
Strategic	
• Intercropping	Less use of fertilizer, pesticides, water. Control largely substituted by ecological processes

Future: Technology and Ecology

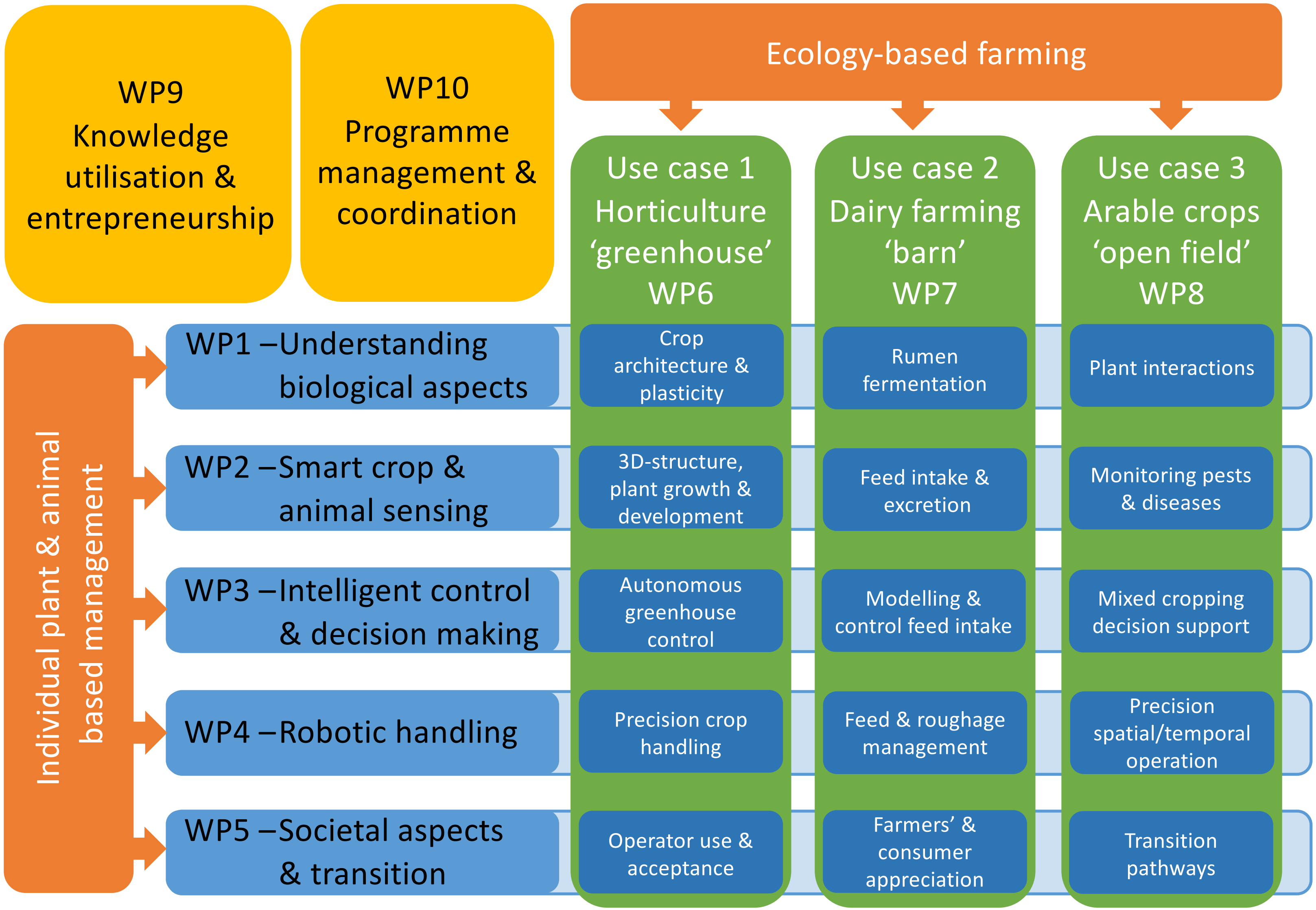
Precisely managing inputs and actions via precision technology

Optimize resource efficiency, such as energy, water, labour

Extra: synergy between biology and technology (SYNERGIA)

- Examples: intercropping, biological pest control, animal based management
- Enabled by small scale and flexible machines with high intelligence
- Challenges:
  - Understanding biological aspects (complexity)
  - Sensing/monitoring of crops and animals
  - Control and decision making
  - Robotic handling
  - Societal aspects

Synergia



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Synergia

5 NL universities

Wageningen University, TU/e, TUD, UTwente, Radboud

Management & coordination

WU & Top institute Food & Nutrition (TiFN)

Training of 27 young researchers

21 PhD, 3 PdEng, 2 PostDoc

Industry partners

Avular, Connecterra, Greenport NHN, **IMEC**, **Oneplanet**, Kverneland / Kubota (Japan), Leafteasers, Lely Industries NV, NanoPHAB, NXP semiconductors, Province Flevoland, Sensor Sense, Settels Savenije van Amelsfoort, Signify Netherlands

Supporting partners

Ministry of LNV, FrieslandCampina, FME, Luke (Finland)

Discussion and conclusion

- Realistic? Feasible?
- Challenges like complexity, variability will become larger in ecology based systems
- System changes (robots, intercropping etc) require large investments, and may bring (financial) risks
- What do you think?

End

Thanks!

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More information on SYNERGIA:

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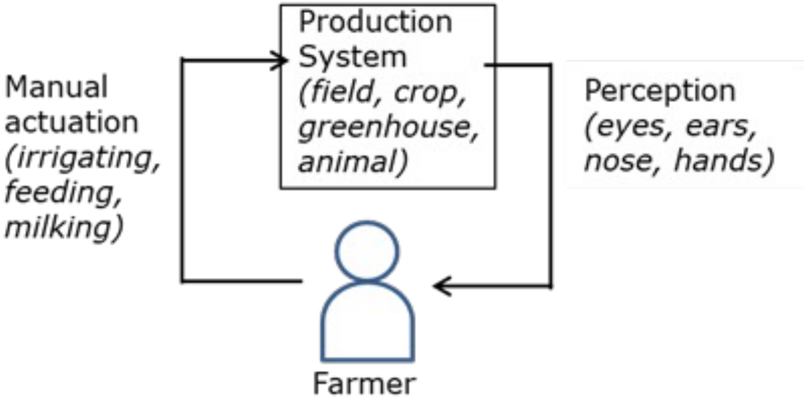
Wouter Jan Schouten MSc (schouten@tifn.nl)

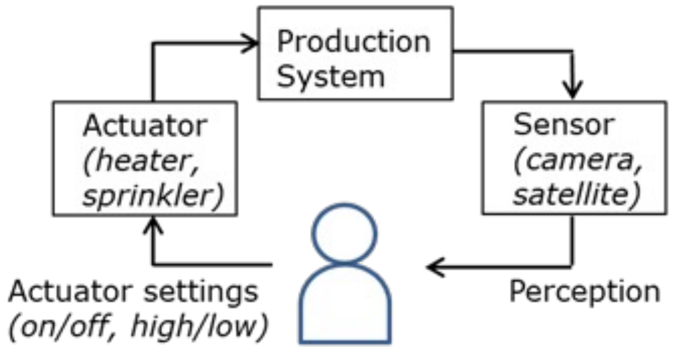
Management support

4 stages of automation

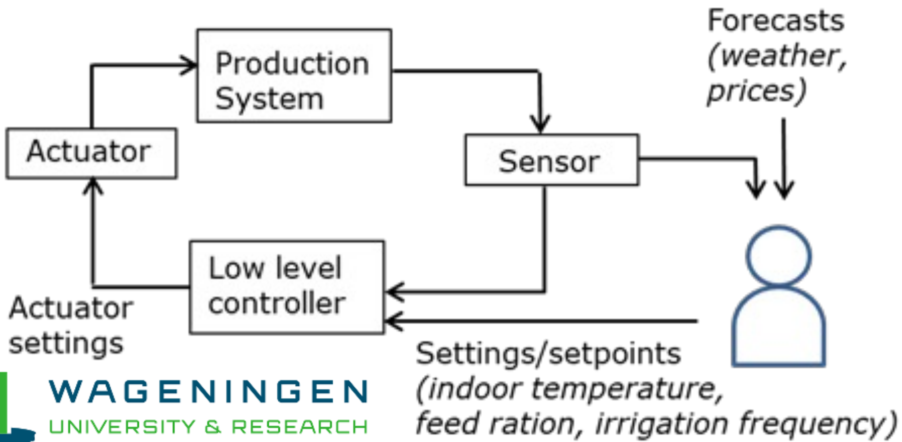
Traditional farming



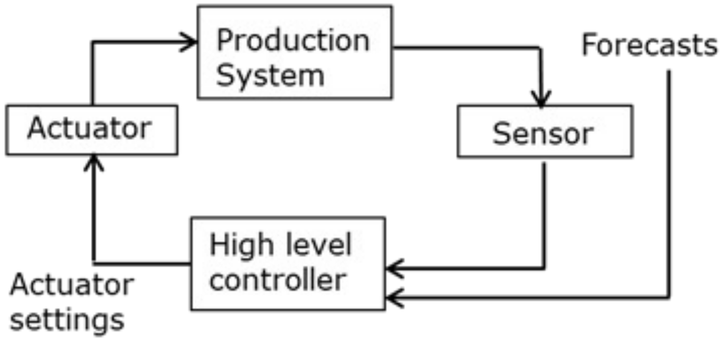
Manual control



Supervised control

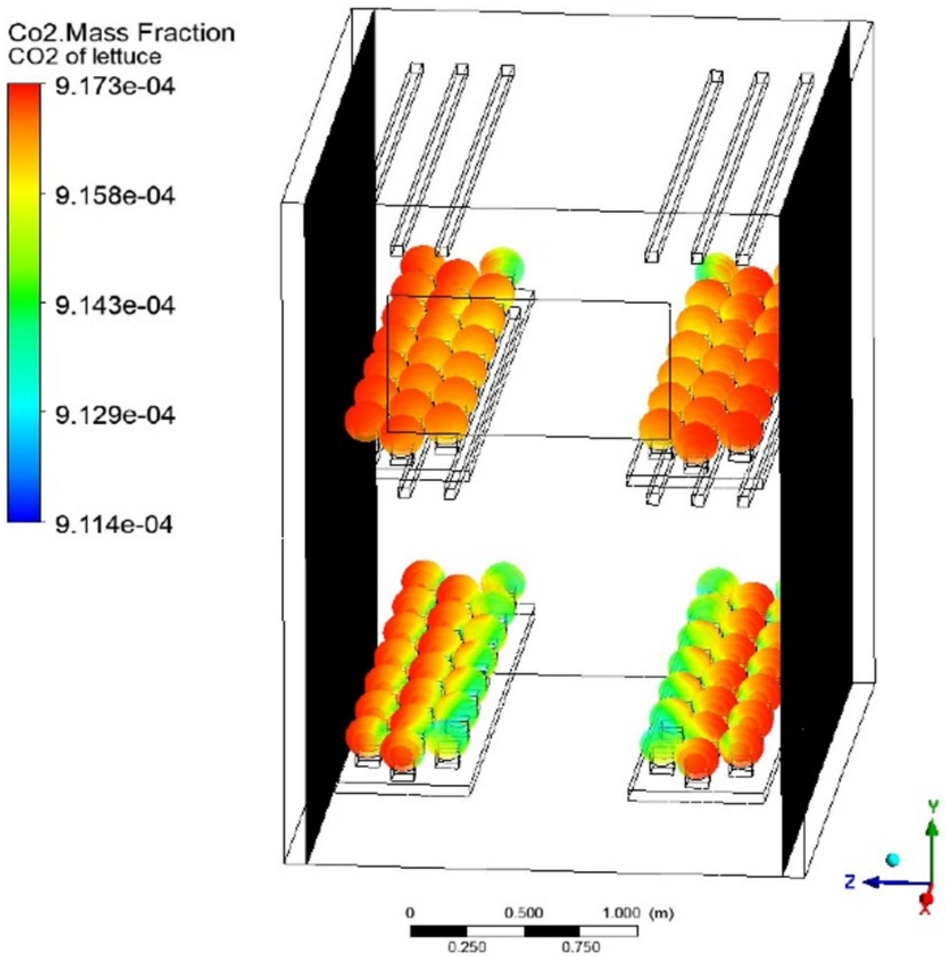


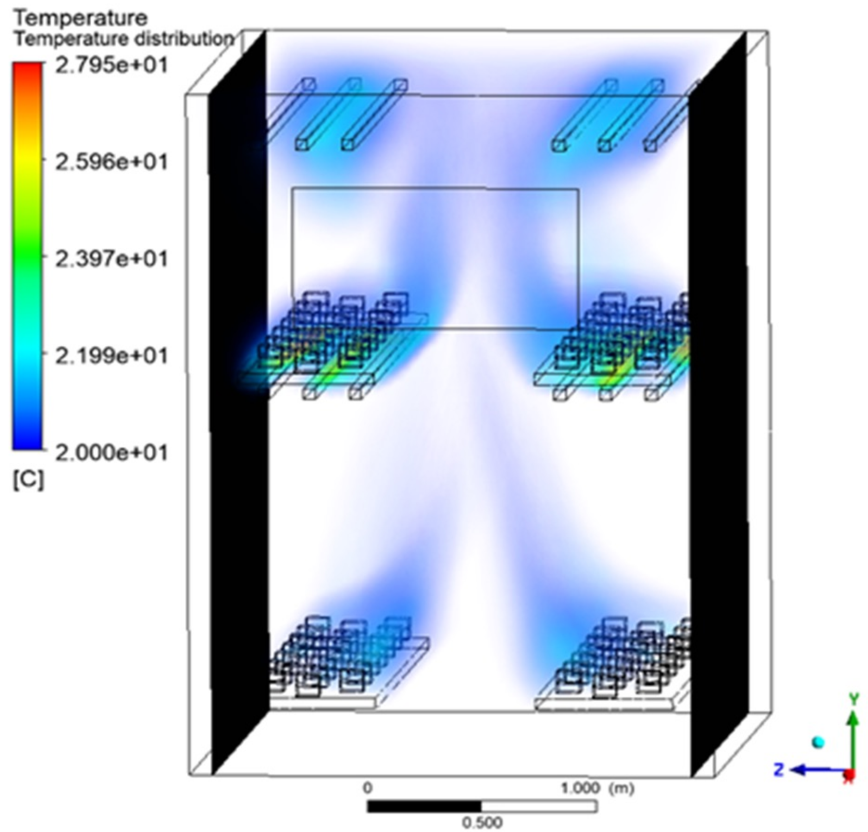
Automatic control



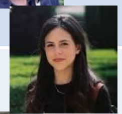
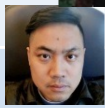
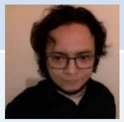
Example: strategic level

Indoor vertical farming system for precise climate control (Yuexiang Chen)





Current research topics

Topic	PhD/PD	Management level
Greenhouse LED light modelling	David Katzin 	Tactics
Greenhouse LED light control	Wouter Kuijpers (TUe) 	Operation
Climate control of Chinese solar greenhouse	Weituo Sun 	Operation
Vertical farm design	Yuexiang Chen 	Strategy
Greenhouse energy management	Henry Payne 	Operation
Crop flexibility	Cristina Zepeda (HPP) 	Operation
Monitoring of cow health status	Xiangyu Song 	Tactics
Resilience of livestock animals	Ingrid van Dixhoorn 	Tactics
Irrigation under uncertainty	Francisco Mondaca 	Operation
Circular farming systems	Daniel Reyes-Lastiri 	Strategy

Societal Impact

Societal/economical trade-off: larger impact requires larger investment

Investment	Improvement
Operational	
• Flexible climate	30-50% less energy consumption
• Risk sensitive irrigation	no less drainage
Tactical	
• LED lights in greenhouse	30-40% energy reduction
• Soil property sensors	60% less drainage
Strategic	
• Vertical farming	No pesticides, less land use, less transport
• Intercropping	Less use of fertilizer, pesticides, water

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Impact vs investment

Operational (moderate improvements, small investment)

- Flexible climate → 10-30% less energy consumption
- Timing of grass harvest → 10% more yield
- Risk sensitive irrigation → no less drainage

Tactical (larger improvements, larger investment)

- LED lights in greenhouse → 30-40% energy reduction
- Egg transport chain → 90% less fractures
- Soil property sensors → 60% less drainage

Strategic (multiple simultaneous improvements, huge investment)

- Vertical farming → No pesticides, less land use, less transport
- Intercropping → Less use of fertilizer, pesticides, water
- Circular farming → Waste stream reduction (reduce output instead of input)

Deze kennissessie is mede mogelijk gemaakt door een bijdrage van:

Provincie Noord-Holland