Combining intercropping and robotics

A symbiotic design approach

8 March 2017, Joris IJsselmuiden,
with support from Tjeerd Jan Stomph et al.

WAGENINGEN
UNIVERSITY & RESEARCH

Images from: ecorobotix.com | rowbot.com | naio-technologies.com | Li Long / Wopke van der Werf

OVERVIEW

Combining intercropping and robotics: a symbiotic design approach

- Introduction
- Definitions
- Benefits
- Inspiration from robotics
- First design steps
- Discussion

Denk nog even aan
Van Bekkem (Greenpeace),
en andere presentaties vandaag ->

laten we deze (multidisciplinaire)
uitdaging aangaan!

Introduction

Combining intercropping and robotics: the "elevator pitch"

- In China and other countries, intercropping is relatively common
- These farmers, and literature, show that intercropping can be more sustainable and more productive than sole crop systems
- But intercropping is not widely adopted in most countries, because of its high labor requirements
- With robotics, these labor requirements can be reduced, facilitating widespread adoption of intercropping!

Definitions

- Intercropping (in any form of plant production)
  The cultivation of multiple crops in beneficial spatiotemporal configurations
  - Strips, rows, cells, patches (e.g. soil dependent), fully mixed
  - Temporal niche differentiation; advanced crop rotation
- Robotics (vs. current mechanization)
  The development and study of (mobile) machines that possess autonomy and intelligence
  - Varying sensing modalities
  - Varying locomotion types
  - Varying actuation and decision support types
  - Varying scale and numbers

- Symbiotic design
  The application of systematic and open-minded design methodologies, in which intercropping and robotics are used as key enablers. Ecological and technical components are designed hand-in-hand, to avoid local optima

Benefits,

of intercropping

- Biodiversity
- Temporal niche differentiation, advanced crop rotation:
  use whole growing season | only young plants use a lot of nutrients from the soil
- Less biocides needed because pathogens and predators spread less easily
- Positive interactions between different crops
  nitrogen binders between non-nitrogen-binders | natural deterrent
- Insects can migrate from harvested areas
  natural allies | “bestuivingscrisis”
- Efficient light use through height differences
  species & cultivars | temporal niche differentiaton

-> more and more varied yields!

-> using less resources!

Benefits,

of robotics

- Go beyond what current mechanization can do:
  selective harvesting, targeted spraying, etc.
- Replace (or support) human labor:
  soil/substrate preparation, sowing/planting, crop monitoring, irrigation, nutrition, crop protection, crop maintenance, and harvesting
- Do things more precisely and more often:
  robotics is an enabler for precision agriculture; better location and time specific actions
- Remove human operator -> reduce scale / increase numbers ->
- Less soil compaction
  - More productivity and sustainability!
  - Climate is getting wetter, this issue more urgent
  - All year land access (longer growing seasons),
  - Soil health; higher nitrogen efficiency, less greenhouse gas emissions, less erosion and leeching, less propagation of soil pathogens(?)
- Inherent safety, added benefits of multi-agent systems / swarms

-> produce more with less!

Images: Wageningen Plant Research Lelystad

Benefits,

of intercropping + robotics

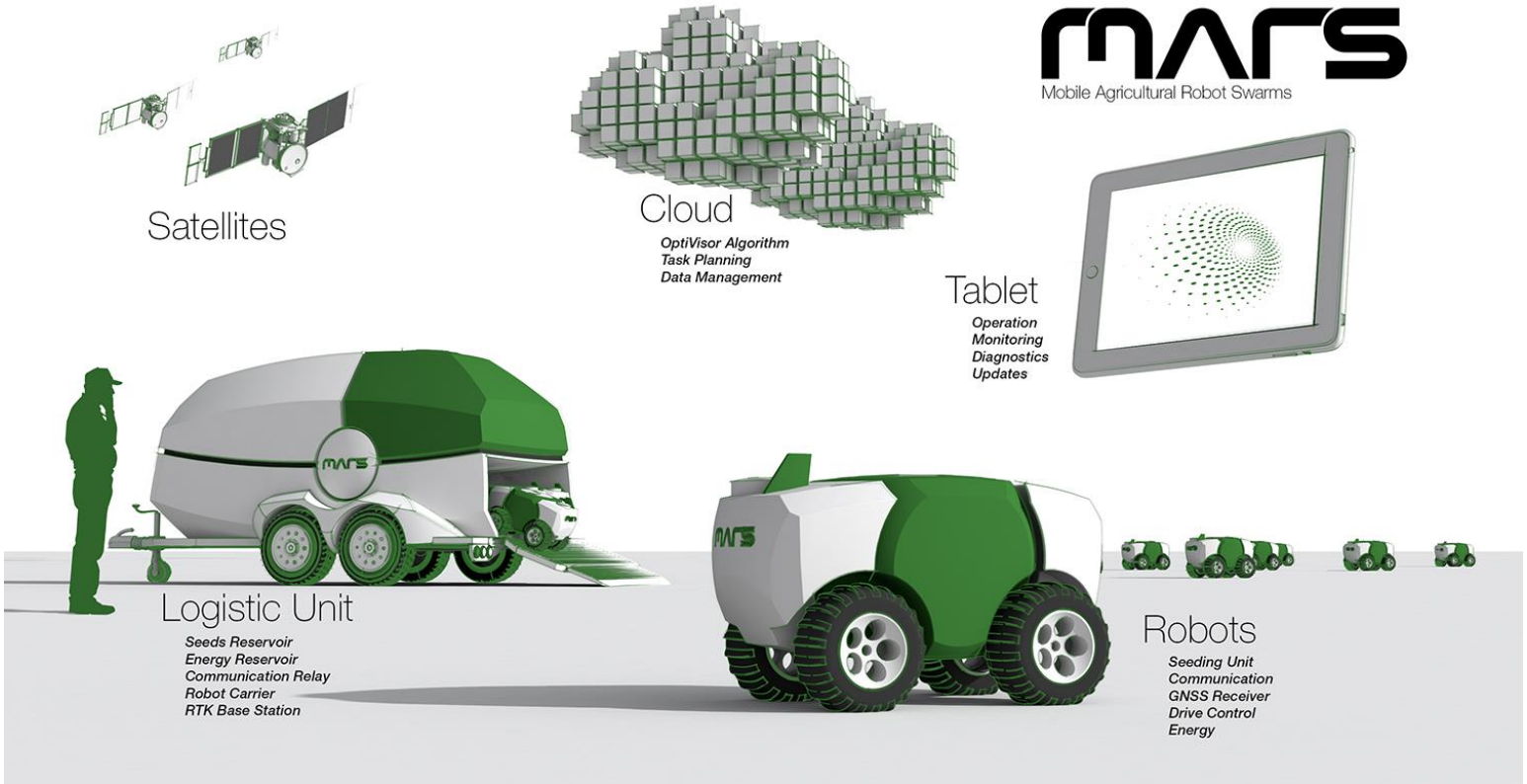
- Achieve economically feasible intercropping, through reduced labor requirements!
- Both, combined, allow us to use more of the growing season (temporal niche differentiation, light vehicles)
- etc., etc.

- **Problem: capacity!**

WAGENINGEN
UNIVERSITY & RESEARCH

Inspiration from robotics: MARS ECHORD++

Swarm of robots seeding a corn field (by Agco Fendt and others)



Inspiration from robotics: Volvo CE

This one is not that small though...

"The concept HX1 represents a new approach to a sustainable future concept, one based on electro-mobility and autonomous vehicles. Rather than having a few, large, versatile machines (as is common on construction and mining sites today), the HX1 demonstrates the emergence of smaller and more numerous, specialist machines. This 'elephants to ants' concept is a new way of meeting customer needs, combining intelligent machines, automation and electromobility."

http://www.heavyequipmentguide.ca/article/24925/volvos-electric-load-carrier-wins-quality-innovation-award

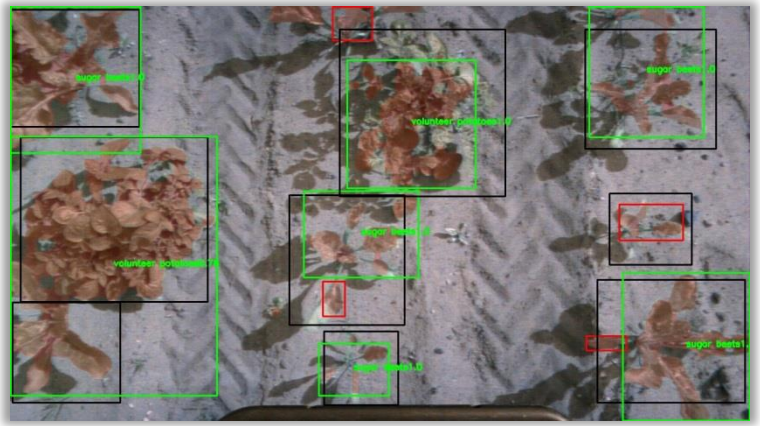
Inspiration from robotics: Ecorobotix, Rowbot, Naïo Oz

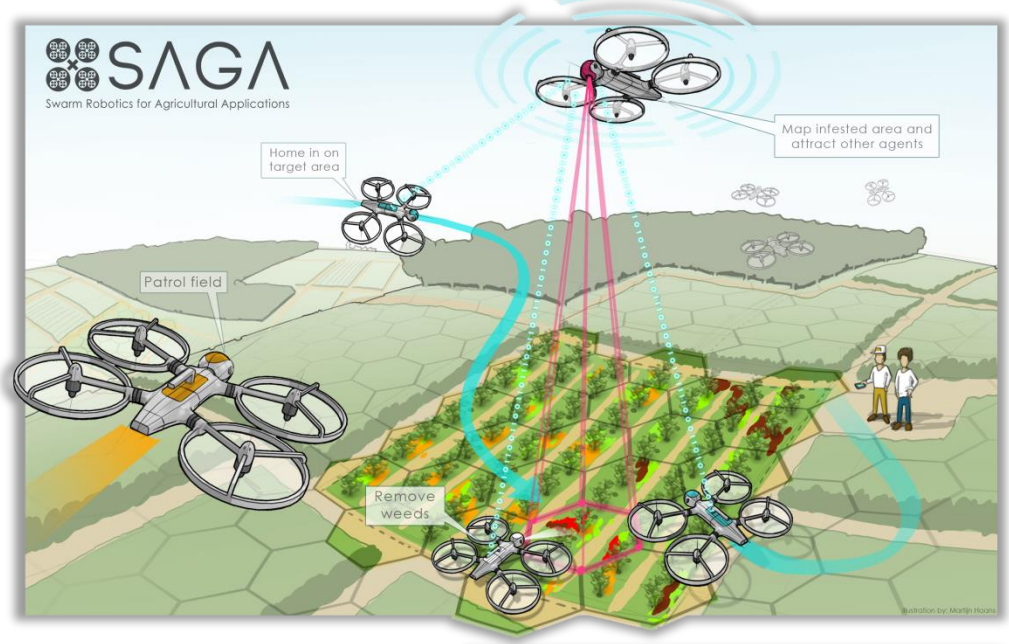
- Ecorobotix: weeding
- Rowbot: in-season nitrogen, seeding cover crops into tall corn
- Naïo Oz: weeding, harvesting?!

Inspiration from robotics:
Wageningen University; Farm Technology Group and partners

- Precision weeding
- Sweet pepper harvesting

Precision weeding





Left: automatic detection of volunteer potatoes in sugar beet

Right: drones for automatic weed detection and mapping

Sweet pepper harvesting

Partners: Wageningen U&R Greenhouse Horticulture, and others
Funding: EU FP7 (project CROPS), EU H2020 (project SWEEPER)

First design steps: what should be automated?

- soil/substrate preparation
- sowing/planting
- irrigation
- nutrition
- crop protection
- crop maintenance
- harvesting
- *crop monitoring / modeling -> predictions / decision support / optimal control*

Miniaturization
(esp. tillage, seeding, harvesting)

Beyond 3^{+}m strips, or mixtures of simultaneously harvested crops

First design steps: characteristics of our methodology

- Open-minded
  - Not limited by 20st century technology and tradition
  - Ecology is leading, technology should “follow suit”
  - Possibility of highly dynamic/chaotic cultivation systems
- Symbiotic: find synergies between ecology and technology
- Functional structural plant modeling (FSPM, endless configurations)
- Modeling the technological systems (same reason)
- Multi-agent systems / swarming compulsory. Many advantages, separation of concerns

Images: Wageningen Plant Research Lelystad

First design steps: some key ideas

- Form factor
  - Zwerm van kleine robots?
  - Lopen? Hoveren? Vliegen?
  - Gantry op diep verankerde rails, voor “0 bodemdruk”, maar hoge capaciteit
    - Inspiratie: http://farmbot.io
    - Lastig in Griekenland, maar niet in Nederland
- Task distribution
  - Specialized machines, or multipurpose?
  - Tractor + implements metaphor?

First design steps: some key ideas

- Improve genetics for intercropping, or reduced tillage
    - e.g. wider rooting pattern to improve underground interaction effects
- Economische analyse van intercropping + robotica systemen (modeling & simulation)
- Bodemdruk studies (simulatie <-> echte wereld, eea al gedaan)
- Modeling & control challenges
    - Farm management and optimal control is much more complicated in intercropping
    - Success of intercropping is weather dependent etc. You need a vigorous crop, to achieve positive effects
    - -> many mixed cropping experiments fail because conditions are not (made) optimal. Modeling & control needed! FSPM

Dank U!

Kansen?

Uitdagingen?

ECHORD++ MARS

joris.ijsselmuiden@wur.nl
0317 - 481258

WAGENINGEN
UNIVERSITY & RESEARCH