Towards sustainable agriculture by robotics technologies
By Amos Albert, CEO of Bosch Deepfield Robotics
Bosch Deepfield Robotics

Content of this talk

➤ Why?

➤ How?

➤ Now?
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World demands for a sustainable green revolution

Shortage of resources

- increasing world population
- changing eating habits
- vulnerable to and cause of climate changes

- arable land
- water
- plant protection
- workforce
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Transfer barriers (from research to production)

3 dimensions of uncertainty:

- **New** technology
- **New** customers
- **New** busin. model

≥2 dimensions **new** ➞ no transfer!

- Domestic robots: comfort, quality of life
- Personal mobility: comfort and safety
- Human-robot collaboration: Productivity

What about agricultural robotics?

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How to bridge the gap?
DEEPFIELD Robotics

Bosch Start-up for Agricultural Robotics
Bosch Deepfield Robotics

Bosch Start-up Platform (BOSP) and its Services

BOSP = detached legal entity featuring small and agile teams, running an explorative market development
## Strategic Alignment

<table>
<thead>
<tr>
<th>Keep competitive</th>
<th>grow</th>
<th>create</th>
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<tbody>
<tr>
<td><strong>Evolution</strong></td>
<td><strong>Revolution</strong></td>
<td><strong>M&amp;A</strong></td>
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<tr>
<td>Product Development: Improve performance reduce cost</td>
<td>Technology diversification, new products in existing markets</td>
<td>Acquire access to new markets, competence, resources</td>
</tr>
<tr>
<td><strong>Sustain</strong></td>
<td><strong>Extend</strong></td>
<td><strong>Build</strong></td>
</tr>
<tr>
<td>existing business</td>
<td>existing business</td>
<td>new business</td>
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- **Uncertainty**
- **Bosch Start-up Platform**

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*Bosch Deepfield Robotics*
Phases in Bosch Start-up Platform
(from Robert Bosch GmbH, via Start-up, to Robert Bosch GmbH)
Deepfield Robotics @ Agritechnica (hall 9, booth F02)

- Mechanical weed control
- Connectivity solutions (intelligent sensor network)
- Automated field testing
- Multi-functional platform BoniRob
The start of all: Evolution of BoniRob

2008-2011

Single use case: phenotyping

2011-2014

Multi-purpose agricultural robot

2015-

Rugged design version available for customers
Acknowledgements to much more co-workers
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The BoniRob: A Multi-Purpose Agricultural Robot

- Powered by batteries and a fuel-based range extender
- Slot for Application Module (electrical & data-link to robot)
- Reconfigurable joints (adaptive trackwidth)
- Easy exchange of application modules
- High connectivity (5GHz Wi-Fi, 2.4 GHz Wi-Fi, GSM/UMTS/LTE optional)
- 3D sensing for autonomous navigation in row-based cultivations (optionally navigation based on GPS)
- Total of 12 degrees of freedom

BoniRob Quick Facts:

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<table>
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<tbody>
<tr>
<td>Chassis</td>
<td>2.2 m x 1.3-2.4 m x 1.8-2.8 m (height x width x length) (dep. on track width)</td>
</tr>
<tr>
<td>Clear height / Tare weight</td>
<td>Approx 0.85 m / approx 1090 kg</td>
</tr>
<tr>
<td>Track width</td>
<td>1.0 – 1.9 m (electrically driven)</td>
</tr>
<tr>
<td>Wheels, Speed</td>
<td>0.55 m / 0.2 m (diameter / width), speed: up to 150 cm/sec</td>
</tr>
<tr>
<td>Power</td>
<td>24V, 230 AH Batteries, 2.6kW Generator, up to 24h operation without refueling</td>
</tr>
<tr>
<td>Payload</td>
<td>150 kg for customized application module</td>
</tr>
<tr>
<td>On-Board PC</td>
<td>i7-based Industrial PC running Linux. Robot is fully integrated into ROS + Gazebo</td>
</tr>
</tbody>
</table>
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The BoniRob: Basic Modules

Robot sensors:

Different Apps

App A

sensors / actuators / functions

Drive ECU

Remote control and safety circuit

High Level Navigation ECU

App B

sensors / actuators / functions

High Level Navigation and Control
(Industrial PC, ROS); Simulation in Gazebo

Low-Level Control, Safety
(embedded real-time system)

Low Level Control, Safety

Propulsion
Steering
Track width

Remote technol.

Drive ECU

High Level

Hilux

Remote control and safety circuit

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High Level Navigation ECU

App C

Customized Application Modules
(Communication via ROS)

High-Level Navigation and Control
(Industrial PC, ROS); Simulation in Gazebo

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App C

Customized Application Modules
(Communication via ROS)
Autonomous Navigation, Semantic Localization, and Mapping

U. WEISS et.al., “Semantic Place Classification and Mapping for Autonomous Agricultural Robots”, IROS 2010
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Autonomous Machines
Precision/Smart Farming
Monitor Environment and Plants
Reduce Costs / Enable Organic Farming

We need a “Sustainable Green Revolution”

Navigation
Phenotyping
Soil Monitoring
Pres. Spraying
Weeding
Nursing

Weed Monitoring and Plants Reduce Costs / Enable Organic Farming

16
Pictures from then and now: manufacturing BoniRob V3
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Mechanical in-row Weed Control

watch videos www.deepfield-robotics.com
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Source: Langsenkamp et al., *Tube stamp for mechanical intra-row individual plant weed control*, 18th World Congress CIGR (2014)
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Deepfield Connect – Asparagus Monitoring

watch videos www.deepfield-robotics.com

Conventional asparagus cultivation

Best growth at 20°C
Best profit from asparagus season

Control via cover sheet

Consider weather forecast

▼ BETTER YIELD ▼ BETTER QUALITY ▼ BETTER DECISIONS ▼

The Bosch innovation project

Temperature tracking with connected sensors

Asparagus farmer

Sensor kit

FUTURE
- Foil placement recommendation
- Temperature prediction
- Yield prediction
- Dashboard for consultants
- Other crops
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Automated field testing for plant breeding

Plant Breeding
- Increases yield
- Robustifies plants
- ……

… is the key to feed and fuel the world

Hypothesis
Breeders are desperate to automate their (outdoor) business

Today Plant Breeders
- Manually **screen large amounts** of plants
- Need **10+ years** to create a new sort
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Seed Quality Field Trials
for Seed Production

watch videos www.deepfield-robotics.com

Conventional Seed quality field trials

TODAY

Every year from March till June

Weather dependent

Much of manual work

TOMORROW

High Throughput Field Screening

Day-to-Day Germination Rate + Plant-by-Plant 3D Leaf Area + Related Weather Conditions

Automated Workflow

High Quality Data

Improved Seed Treatment based on better decisions

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Field Trial Automation – 4D Sensing

The same emerging plant detected and reidentified over several days (4th dimension)

Emerging Plants Counting and Leaf Area estimation

- Point Cloud construction
- 3D Leaf area computation
- Reproducable measurements (1 h/d)
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One team – many experts

Talk to us
visit our website

www.deepfield-robotics.com