DIGITALISIERUNG IN DER LANDWIRTSCHAFT: CHANCEN UND RISIKEN

DRESDEN, GERMANY, 30.09.2016

AUF DEM WEG ZUM INTERNET DER FELDER UND PFLANZEN

AMOS ALBERT, PROF. DR.-ING.
CEO DEEPFIELD ROBOTICS
Outline of talk

- Motivation
- Digitalization, helping to close feedback loops
- Role of robotics (potential and barriers)
- Case study: Robot for automated field testing (Deepfield 4D-scan)
- Summary
Motivation

Future Agriculture  (Farming 4.0, Smart Farming, Data-driven agriculture, Cyber Physical System,...)

- **Trends/Drivers**: Shortage of resources (arable land, fertilizers, water, skilled labor), growing population, changing eating habits, climate change, herbicide resistances, ...

- **Agriculture** = Repetitive tasks w/ sequential, logical processes under uncertain & changing environ. conditions [prime example for era of industry 4.0, i.e. (sensor-/actuator) networks and automation]

- **Solution**: “Closing feedback loops” to increase/ensure quality and/or yield
Many sources for data

... online acquisition, lab & field tests, from experience/history, ...
Data analytics and interpretation
... from simple heuristics to state-of-the-art AI techniques ...
Acting and reacting

... from long-term scheduling to individual plant treatment ...

- **Examples for short-term actions**
  - Irrigation, pollination, selective harvesting / weed control / plant protection, ...

- **Examples for mid-term actions**
  - Forecasting harvest time, scheduling of seasonal workers
  - Optimizing the entire value chain (incl. post harvesting, sales, ...) and profit

- **Examples for long-term actions**
  - Optimizing seed breeding and production process, plant protection products, ...
Digitalisierung in der Landwirtschaft
Deepfield Robotics in a nut-shell

**Deepfield® Connect**: Connectivity solutions (IoT)

Stationary sensor networks as entry point, robots emerging to serve as mobile sensors and/or actuators.

**Deepfield® 4D-scan**: Automated field trials

Beehive Monitoring

Robotic Field Mobile

Tractor implement
Digitalisierung in der Landwirtschaft
Example Deepfield Connect – Asparagus Monitoring

10% more "category I" = 3000 €/ha higher profit.

Average soil temperature, depth 20 cm

Data acquisition
System / environment
Data analytics / interpretation
acting/reacting

Deepfield Robotics
A Bosch Start-Up Company

Sensors measure the temperatures in the soil mound. The sensor box relays the data via the cloud to the asparagus grower's smartphone.
Digitalisierung in der Landwirtschaft

Example Deepfield Connect – Strawberry Monitoring

Functions:
- Frost warning
- Overheating warning
- Water supply management
- Disease warning
Digitalisierung in der Landwirtschaft
Robotics enable transition from the “internet of fields” to the “internet of plants”

- Expected early adopters for individual plant treatment
  - Seed breeding, seed production resp. general field trials, first example: *Deepfield® 4D-scan*
  - Fruit and vegetable production: Scouting, individual treatment/optimization, selective harvesting etc.
  - Selective weed control
Proof of concepts by means of BoniRob

BoniRob V1, 2010
BoniRob V2, 2013
BoniRob V3, 2015

Precision-Spraying-App
Phenotyping-App
Penetrometer-App
Weeding-App

Field mobile for 4D-scan:
Differential drive

BoniRob:
Omnidirectional, 12 dof

Weeding mobile:
Differential drive
Barriers in market adoption of robotics
Huge potential but technology gaps are not the only barriers:

- **Cost-efficiency:**
  - Robots either cost competitive or provide complete new quality in specific use-cases. Induced costs to be considered (logistics, infrastructure, maintenance, operation)

- **Safety and reliability:**
  - Risks and uncertainties can not be projected to system alone (classical engineering methods for safety fail)

- **Robustness:**
  - suitability for daily use, dependability, availability

- **Other limiting factors:**
  - Short period of time in which applications are required (development and testing challenges)
  - ...

**Key during introduction:** Definition / implementation of the “right” degree of autonomy, i.e. handling / supervision concept
Increasing autonomy level over time.

Degree of autonomy depends on:
- Who makes decision?
- How is decision executed?

Autonomous System = Automation \* Complexity (unstructured, dynamic)

Automation = replacement of manual operations by computerized methods

Remote Control
Operator in line of sight

Tele-Presence, semi-autonomous
supervisor/user from remote

Autonomous

Shared Autonomy reduces complexity / downtime

Definition and implementation of the right degree of autonomy resp. the handling and supervision concept

Basic Idea: Robotic system considers explicitly human in the loop

or catchy speaking “Let robots do what they are good at, let humans do what they are good at”

100% remote control
- Tedious, labor intensive
- Limited capability

100% autonomy
- Difficult and expensive to implement

Optimization:
- Reduce complexity, costs, time to market
- Increase capability, performance, safety

Remote Control | Shared Autonomy | Autonomous

Feasible System?
Motivation for Deepfield 4D-scan
Challenges in Seed Breeding and Production
Motivation for Deepfield 4D-scan

Picture of the future in automated field testing

Picture of the future: Automated Field Testing

Field trials May, 2016
Field trials for improving seed quality (sugar beet)

Conventional Seed quality field trials

TODAY

Every year from March till June

Weather dependent

Much manual work

TOMORROW

High Throughput Field Screening

Plant Counting

Plant Growth Measurement

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

Result: Optimized seed quality for increased yield and stress tolerance
Field trial campaign with Strube, Germany, 2016

Envisaged and implemented HMI design guidelines

► One-man-operation:
  – Ease-of-use and intuitive operation to keep the operator as master of process.

► Making use of smart end-devices (tablet/phone):
  – Less need for training and adaptation of well-known handling.

► No overburden operator while keeping focused:
  – Control the attention of the operator to the relevant information and to user interaction / intervention needed.
Field trials for improving seed quality (sugar beet)
Patient’s record provides disruptive new insights

Benefits of 4D-scan

- Field emergence counts
- Dynamic of field emergence
- Rate of mortality
- Leaf area in the time domain
- Uniformity of the population
- Visualized documentation

and additionally

- Ground coverage / closing of rows
- Reaction on temperature, soil preparation, herbicides, etc.
- Plant distance (sowing precision)
- Weed counting and leaf area
- Mortality rate of weeds
- ….
New Insights gained in field trials
Machine based individual plant counting outperforms human

Task: Counting of emerging plants over time

Emerging Plants

EP [%]

0 10 20 30 40 50 60 70 80 90 100

Days after sowing

10 12 14 16 18 20 22 24 26

Bosch = 4D-scan

Strube = human expert

7% deviation; significant; obviously some plants emerge and then disappear (frost, animals, diseases)

→ Not detectable by human expert, but 4D-scan
  • even knows which plant,
  • knows when the plant disappeared, and
  • potentially why?

→ disease, frost, animal, herbicides, ...

Technology provides complete new insights into dependencies between growth, yield, quality <-> treatments / environmental conditions

Deviation, because of def. threshold for plant: >0.1 cm²
New Insights gained in field trials
Qualitative and quantitative effects\(^1\) of herbicide\(^2\) treatments

![Graph showing plant count, emerged weeds per day, and average temperature over days after sowing.]

- **Emerged weeds per day** (field of 0.1 ha; about 10,000 sugar beets)
- **“Killed” weeds per day**
- **Average temperature**

\(^1\) Smoothed curves
\(^2\) Herbicide mechanism via leaf and soil agent
New Insights gained in field trials
Dynamics of field emergence for different varieties

- Final emergence rate
- Time shift
- Curve gradient

Gradient curve:
- Max. emergence rate
- Time shift
- Bell curve width
Reflexion

- **USP: Was ist das Innovative/Besondere am Vortrag für den Zuhörer?** - AHA-Effekt
  - Digitalisierung ermöglicht komplett neue Einsichten in Wirkzusammenhänge (qualitativ/quantitativ) ... und damit Potenzial zur Erhöhung/Sicherstellung des Ertrages und der Qualität
  - Robotik mit Potenzial bis hin zur Einzelpflanzenbehandlung (ökonomische & ökologische Vorteile)

- **ToDo: Welche Information ist wichtig für Verständnis und Nutzen für den Zuhörer?** - Lerneffekt
  - Messen kann man viel; aber ohne die richtige Interpretation und das Schließen von „Regelkreises“ wertlos
  - Die Digitalisierung auf Feldebene ist in vollem Gang
  - Weiteres Potenzial lässt sich erst durch eine höhere Auflösung heben (trade-off Kosten/Nutzen)

- **Kontext: Wie hängt der Vortrag mit der Agenda der Veranstaltung zusammen?** - Wert der Veranstaltung (Networking der Referenten)
  - Digitalisierung ist das A und O, um das Potenzial vollends zu schöpfen
  - Eine erfolgreiche Transformation (neue Technologien, Geschäftsmodelle, Anbaumethoden, Infrastrukturen, etc.) erfordert das Zusammenspiel aller Akteure (z.B. Interoperabilität, Standards, Offene Pflanzendatenbanken, ...)
THANK YOU!

ONE TEAM – MANY EXPERTS

Visit our website:
www.deepfield-robotics.com