Transferring AI&Robotics Technology into the Agri-Food Domain

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1. Brief background: my view on AI (ANI)

2. Transfer AI ⇔ agri-food, currently and potentially

Wikimedia Commons Clip art - lupe Symbol PNG

https://www.nlmtd.com/inspiratie/be-smart-be-transparent-partner-and-innovate-in-the-agri-food-value-chain/

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OECD AI systems(!) definition

- machine-based system

- capable of influencing the environment by producing an output (predictions, recommendations or decisions) for a given set of objectives

- uses machine and/or human-based data and inputs to
  i. perceive real and/or virtual environments;
  ii. abstract these perceptions into models through analysis in an automated manner (e.g., with machine learning), or manually; and
  iii. use model inference to formulate options for outcomes.

- AI systems are designed to operate with varying levels of autonomy.

https://oecd.ai/en/ai-principles

Take home: AI fits well with agri-food!

- **goal-oriented action** in agri processes

- **environment denying full control**
  - weather, soil, plants, animals, market prices, pests, …

- **environment dynamics**
  - humans and animals present, weather, prices, …

- **incomplete observability**
  - sensing constraints, sensor noise, soil conditions, …

- **data-intensive and knowledge-intensive**
  - machine telemetry, satellite data, agri-food chain, …
    farmers' experience; knowledge re soil, plants, chem, …

- **demand for AI-tech** by ag-tech users

… and others appear to share that view:

PHENOROB
Robotics and Phenotyping for Sustainable Crop Production

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AI is around. Today. In agri-food, too.

- ... in current ag tech
  - plant breeding, driver/process assistance in farm machines, animal husbandry, milking robots/carrousels, logistics, Farm Management Information Systems, ...

- ... in not yet quite current ag tech
  - weeding robots, autonomous tractors, ...

3 pervasive "boring" topics …

… whenever aiming at real-life application of ag-tech:

1. legal status of systems with AI modules
    (incl. functional safety, "certifiability", liability, IP)

2. runtime scalability of AI algorithms on edge hardware
    ("0-5G fitness") – deployed AI models need no cloud computing!

3. availability and quality of data for pre-training, training and
    validation for data-based methods (incl. simulation data)

Project: AI-Testfield (2021-2023)

With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

- Experimental environment for industry-grade development of semantic perception

- our focus: systematic variation of environment conditions for capturing multi-modal field data sets (test case: human detection)

- DFKI partners: UAS Osnabrück, KRONE, LEMKEN

- AI topics/transfer areas:

  – methodology for testing/certifying "sensor boxes" for autonomous operation

 – functional safety in harsh environments (detect humans under all circumstances)

... to be exploited in agrifoodTEF

Krause & al., ASABE-2023
https://www.dfki.de/web/forschung/projekte-publikationen/projekt/ai-test-field

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

DFKI

Project: Agri-Gaia (2021-2023)

- AI ecosystem for the agricultural and food industry based on Gaia-X https://www.agri-gaia.de

- our focus (one of several): develop methodology and data sets for pre-training plant classifiers from synthetic plant models and field scenes

- DFKI+UOS partners: UAS Osnabrück + 9 industry partners from agri-food

- AI topics/transfer areas in this regard:

  – provide geometric plant models plus hybrid appearance models (RGB, hyperspectral), varying plant conditions (water/nutrition stress)

  – supply systematic pre-training data

... to be exploited in agrifoodTEF

Iqbal & al., GIL-2023
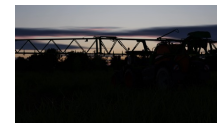
- Selective management of harmful and non-harmful weeds using AI

- our focus: decide to treat (weeding robot) single plants based on plant species determination from sensor data plus symbolic context knowledge (rule-based)

- DFKI+UOS partners: UAS Osnabrück, Amazonen-Werke, Farming revolution

- AI topics/transfer areas:
  - hybrid (data-based + knowledge-based) robot control
 - closed-loop mobile manipulation
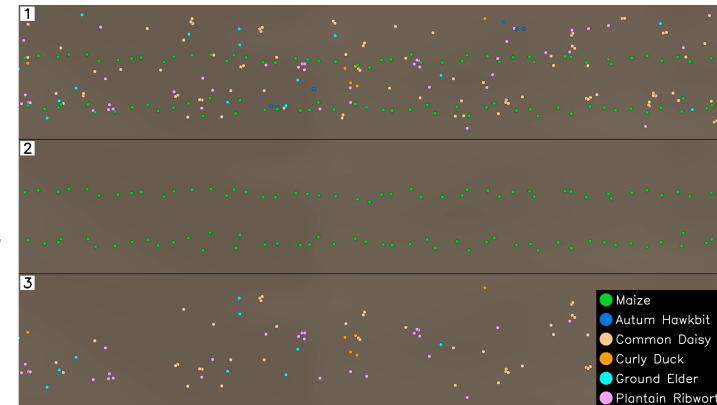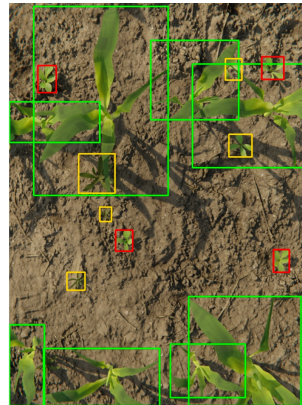
Renz & al., GIL-2023, Nimeyer & al., KI-2023
https://cognitive-weeding.de/

Project: agrifoodTEF

European Testing and Experimentation Facility Network for AI and Robotics in Agriculture

- agrifoodTEF is the European Testing and Experimentation Facility Network for AI and Robotics in Agriculture, which supports agri-food companies in product-related development (>TRL6)
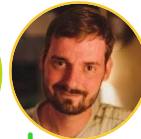
- National test lab or German node:

- Duration: 01/2023 – 12/2027

- Budget: approx. 60 million € (DE-node: approx. 9.5 million €)

- EU: DIGITAL EUROPE Programme (Digital Europe Work Programme 2021-2022)
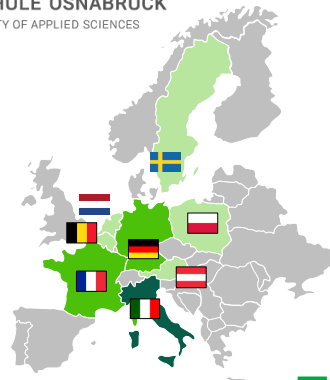
Node Leaders

Satellite Leaders

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- National test lab or German node:

  AGROTECH VALLEY   DFKI Deutsches Forschungszentrum für Künstliche Intelligenz GmbH   HOCHSCHULE OSNABRÜCK UNIVERSITY OF APPLIED SCIENCES
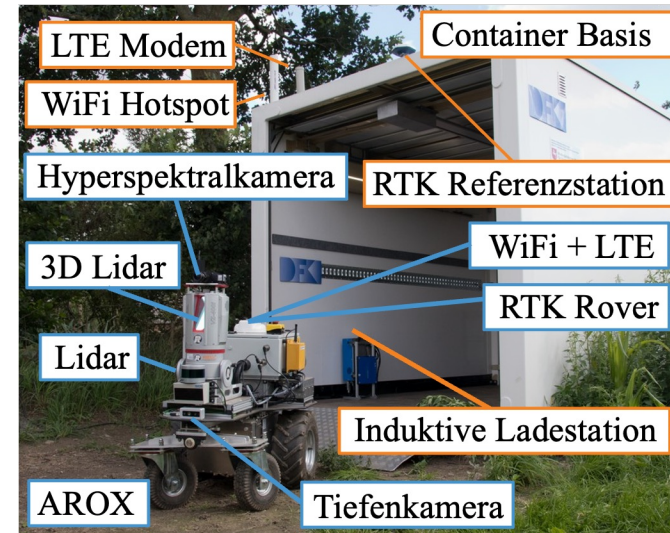
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Project: Zukunftslabor Agrar (2020-2024)

- Future Lab agriculture (TP2, agricultural robotics)

- our focus in TP2: long-term autonomy (LTA) in ag robots

- DFKI+UOS partners: UAS Osnabrück, TU Braunschweig, U Göttingen, U Vechta, Thünen Institut, Julius-Kühn Institut

- AI topics/transfer areas:
  - what exactly is LTA in ag robotics? (timing, resource supply, process-dependence)
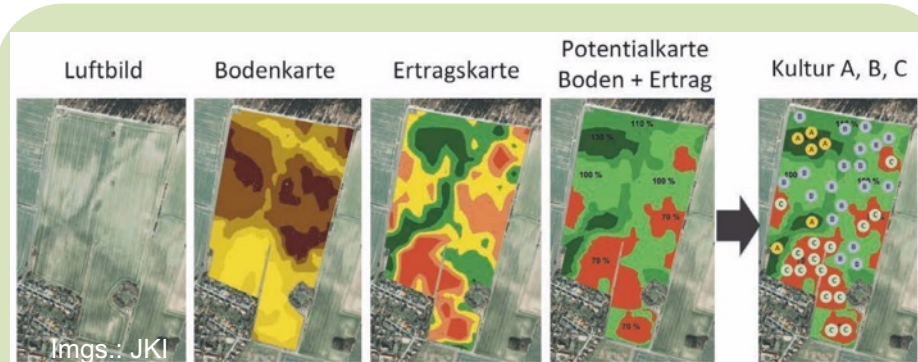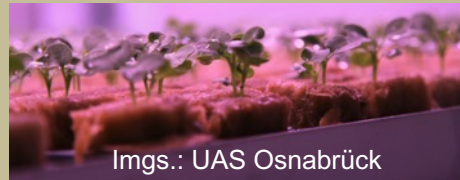 - semantic maps in LTA ag robots
  - empirical work

https://www.zdin.de/zukunftslabore/agrar

LTE Modem
WiFi Hotspot
Hyperspektralkamera
3D Lidar
Lidar
AROX
Tiefenkamera
Container Basis
RTK Referenzstation
WiFi + LTE
RTK Rover
Induktive Ladestation

Future: AI tech will enable <u>other</u> agri-food systems!

AI & robotics solutions for

- high labor intensity,
- low machine weights,
- small machine sizes,
- high data intensity ,
- single plant treatment, …

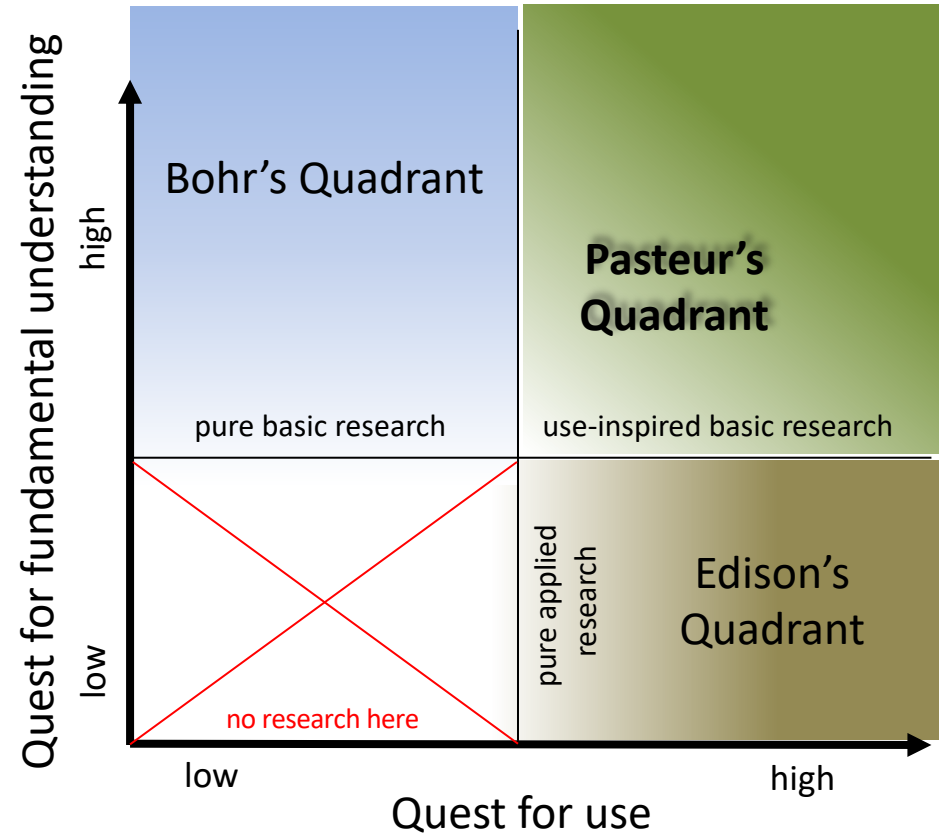➢ Indoor/Vertical farming,
➢ Spot Farming,
➢ Micro Farming, …

Imgs.: UAS Osnabrück

FZ „Agrarsysteme der Zukunft", UAS OS

Luftbild   Bodenkarte   Ertragskarte   Potentialkarte Boden + Ertrag   Kultur A, B, C

Imgs.: JKI

Spot Farming   Wegener et al. 2017, doi.org/10.15150/lt.2017.3156

Fadeout: my take on research transfer

- à la Donald E. Stokes (1997):
  Pasteur's Quadrant – Basic Science and Technological Innovation

- **serious AI transfer would generate serious basic research questions**, and vice versa

- you need
  - transfer domain knowledge (e.g., agri)
  - target domain "customers"
    (e.g., machine manufacturers, farmers)
  - research infrastructure
  - nerves (e.g., don't expect AI conferences and DFG to be happy with your work!)

Quest for fundamental understanding

Bohr's Quadrant

pure basic research

Pasteur's Quadrant

use-inspired basic research

pure applied research

Edison's Quadrant

no research here

Quest for use

low — high

high — low

Questions?

DFKI PBR projects

www.dfki.de/web/forschung/forschungsbereiche/
planbasierte-robotersteuerung/projekte-pbr/