Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

UNIVERSITÄT OSNABRÜCK

What AI and Robotics could and couldn't offer for re-thinking agricultural systems

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1. AI (and Robotics) …

2. … and their potential for AgTech

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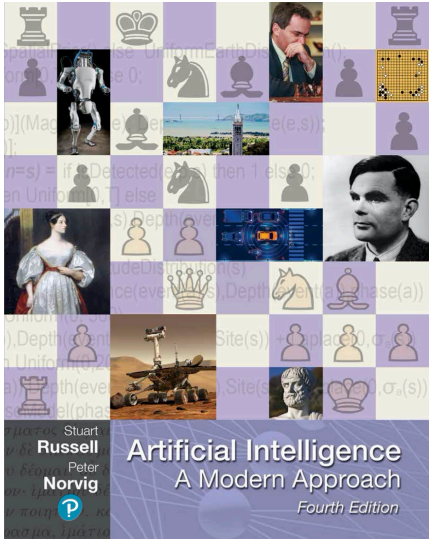
2. … and their potential for AgTech

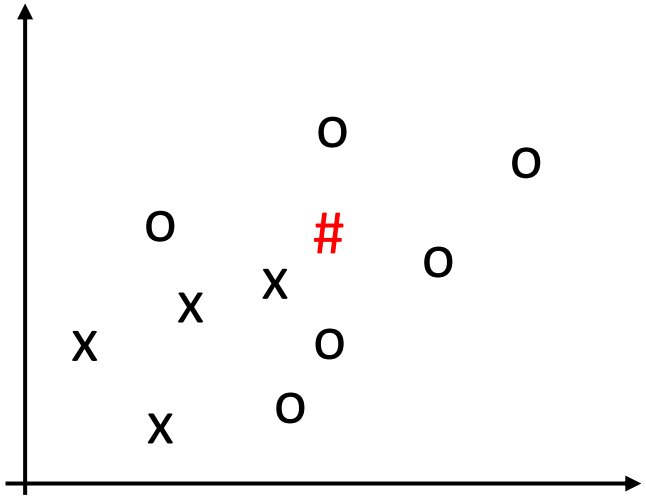
AI, as many (including me) see it

Informatics methods and techniques for building artificial systems (agents) able to act in a goal-directed way in environments featuring incomplete control, independent dynamics, and/or imperfect knowledge.



Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach (4th Ed.). Pearson, 2020.

For example



Is # an x or an o?
Decision based on incomplete information:

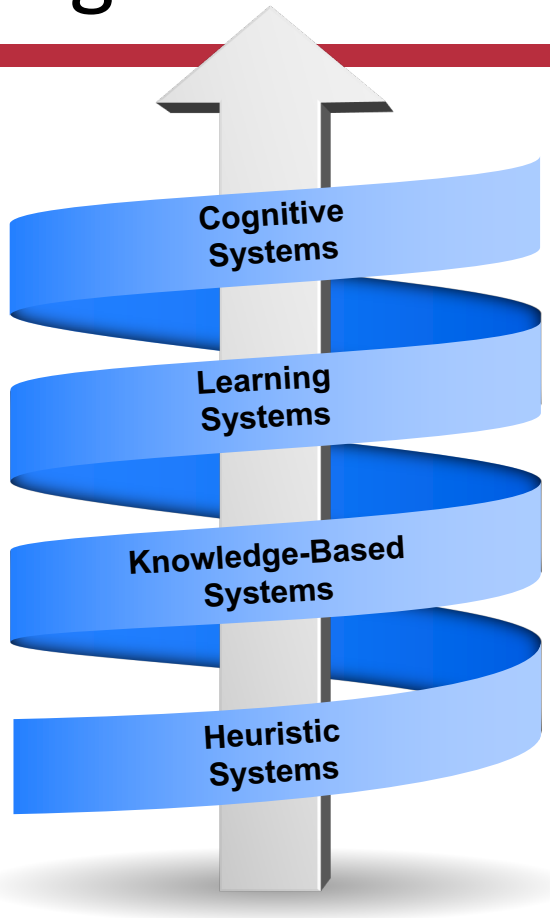
- model-based nominal (e.g., logics, rules, search)
- model-based statistical (e.g., Bayesian networks)
- data-based (e.g., machine learning methods)

For many good reasons,
Machine Learning methods have had a great impact recently, but …

Isn’t the Pythagorean Theorem still math?

Phases of AI research …

Wolfgang Wahlster, modified



Phase 4: from 2015 — **Integration of machine learning and knowledge-based methods**

Phase 3: until 2015 — **Machine learning from big data sets**

Phase 2: until 1995 — **Automatic reasoning in hand-crafted knowledge bases**

Phase 1: until 1970 — **Heuristic search and reasoning methods**

… and that includes robots!
And applications!

1. AI (and Robotics) …

2. … and their potential for AgTech

– machine learning, robotics, semantic technologies

Some projects in the background of this part

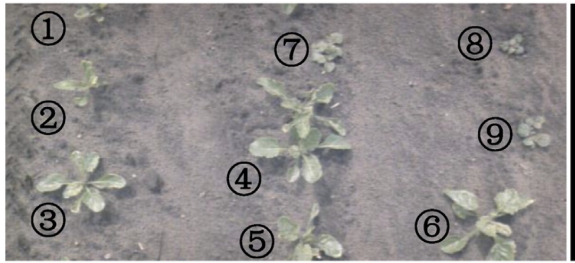
- Agro-Nordwest – Experimentierfeld zur digitalen Transformation im landwirtschaftlichen Pflanzenbau (BMEL)
- Agri-Gaia – Ein agrarwirtschaftliches KI-Ökosystem (BMWI)
- RESKIL – Ressourceneffiziente KI für eingebettete Systeme in Landmaschinen (BMEL)
- CognitiveWeeding – Selektives Unkraut- und Beikrautmanagement mit Hilfe Künstlicher Intelligenz (BMU, upcoming)

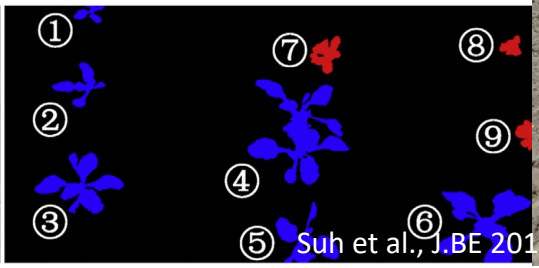
Before I continue

- Whenever you introduce new technology,
  consider re-thinking the old processes!
- You Ag people must say where to go, not we AI people!
- But do understand the potential of AI,
  to see what it could help in the re-thinking!

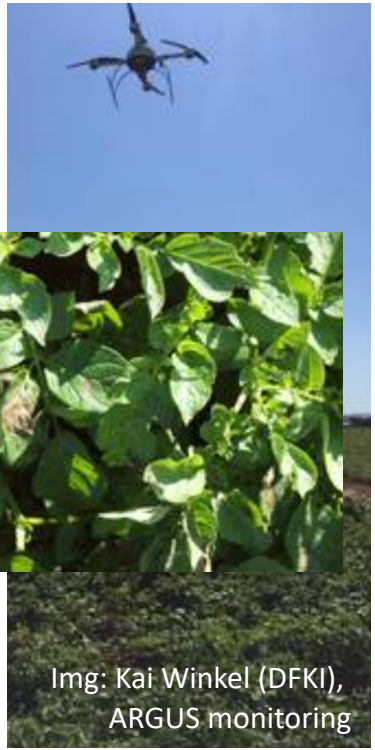
#1: machine learning/data analysis

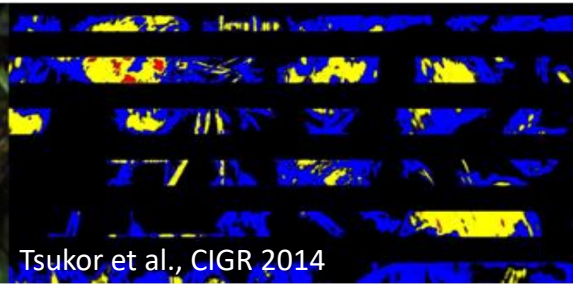
e.g., weeding & volunteer potatoes,
sugar beet classification,
potato blight





Suh et al., J.BE 2018





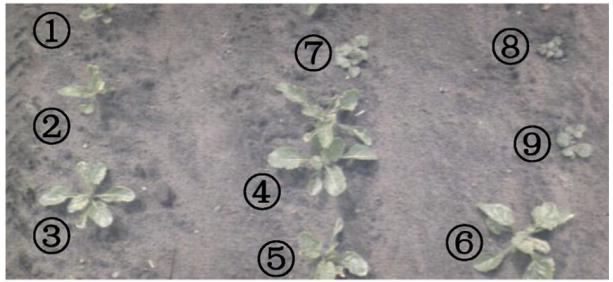
Tsukor et al., CIGR 2014

Img: Kai Winkel (DFKI),
ARGUS monitoring

Feature: how far will trained classifiers get?

E.g., crop-weed-“other plant” distinction

- trained classifiers likely single chance of doing it
- challenges:
  - greatly different appearances (stadium, environment conditions, health state, …)
  - get enough (classified) training images – synthetic images good enough for (pre-)training?
  - individual plants not segmented in situ
  - amalgamate appearance/data with expectation/knowledge about type and utility of non-crop plants



vs.

SWOT ML/data analysis in Ag

Strengths

- make use of rich data corpora available (machines/processes, geo-/satellite data, weather, …) – no use running a farm without

Opportunities

- connect data across the complete agri-food value chain in digitalization (⇒ GAIA-X)
- create data-based business models in Ag

Weaknesses

- data quality often insufficient for training (lack of “clean”, un-biased, classified data)
- selection of training data crucial for validity of training results
- using ML/DA technology currently impossible for most persons in Ag
- lack of integration of ML technology and knowledge-based methods

Threats

- “expectation failure” for data analysis methods/technology in Ag (as elsewhere)
- lack of acceptance for data transparency (“ownership”, privacy issues, fear of being controlled, …)

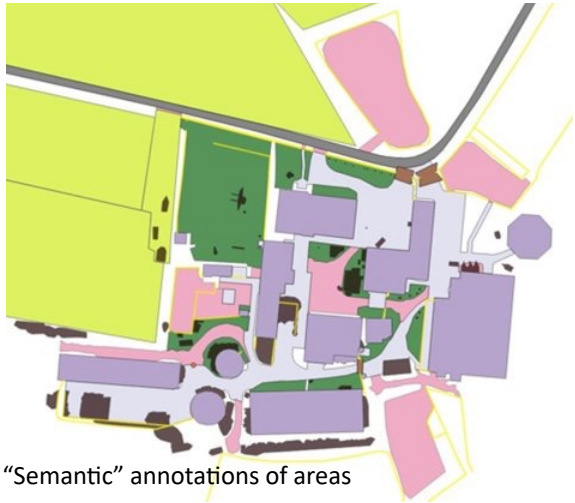
#2: “agricultural robotics”

Springer Handbook of Robotics (2016_2)
Ch. 56: Robotics in Agriculture and Forestry
(M. Bergerman, J. Billingsley, J. Reid, E. van Henten)

There is no such thing as an agricultural robot.
There is robotics technology in agriculture.

Feature: long-term robot autonomy …

… requires context-sensitive action, requires a hybrid working area representation, including a semantic layer for closed-loop planning, monitoring, and user communication!



"Semantic" annotations of areas

Current research: creating and updating the resp. maps from sensor data & other available data

Kisliuk, B. & al., GIL-2021

SWOT robotics technologies in Ag

Strengths

- wide variety of SW and HW components integrated in closed-loop,
  with much full-/semi-automation potential
- robots often scalable in size and “team” size
- first exemplars/functions in the market

Weaknesses

- technology as a whole subject to research
- autonomous manipulation capabilities often lacking (hardware components brittle/clumsy)
- replacing current processes/components 1:1 by robotic technology makes little sense
  ⇒ re-thinking processes needed

Opportunities

- huge potential for economically and ecologically useful machines/processes in the context of transformation of Ag and digitalization of the agri-food chain

Threats

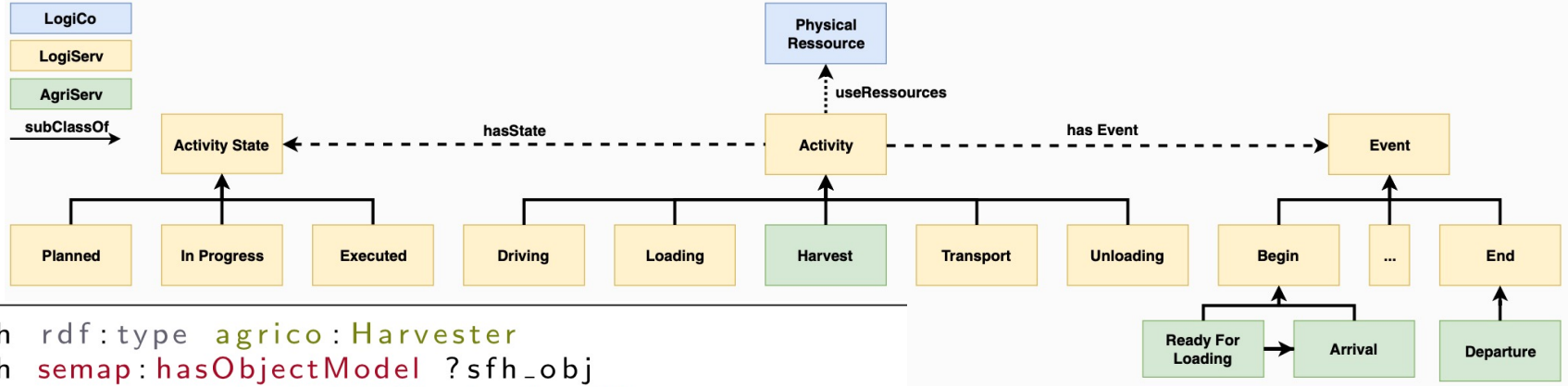
- lack of co-evolution of machinery and processes leads to lack of acceptability of technology
- lack of acceptance of technology among stakeholders or society
- lack of suitable legal & financial regulations for long-term autonomous physical machines

#3: semantic technologies in Ag

- even if data can be analyzed and classified, semantic description layer needed for communicating results and for reasoning
  (machines, humans, nodes in value chains, …)
- much-used AI approach: ontologies
  (e.g., in Semantic Web: OWL – web ontology language)
- many approaches in Ag since a long time
  (AGROVOC/FAO, iGreen ontology/KTBL+DFKI a.m.o.)
- crucial description layer for system explainability, verifyability, certification

Feature: semantic process monitoring

Challenge: based on real telemetry+sensor data, monitor co-operative process (maize harvest) live(!) in terms of an agricultural ontology, including qualitative spatial & temporal relations

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Deeken, H. & al., J. Appl Intell 2019

SWOT semantic technologies in Ag

Strengths

- sem. tech. offer description layer for describing, analyzing, communicating, reasoning on a high layer of “meaning”
- rich knowledge, high TRL regarding the resp. formalisms, technology

Weaknesses

- no widely accepted and used ontology in Ag
- interpreting data in terms of semantic categories is among the chief non-understood problems in AI in general (“Moravec’s paradox”)

Opportunities

- widely accepted and shared semantic layer for Ag applications would boost manufacturer-independent information exchange (⇒ GAIA-X)
- sem. tech. would help make Ag applications more robust (specification, verification)

Threats

- lack of acceptance of sem. tech. approaches (e.g., due to Moravec’s paradox)

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To take home

- AI has a lot of technologies to offer – old ones and new ones
- Ag is a perfectly fitting application area for AI (data-rich, knowledge-rich, uncertain, under no full control, yet structured and goal-directed)
- AI goes well together with digitalization
- some AI-based components may improve existing functions or processes (some do it already); others would make sense only in widely re-structured processes
- in re-thinking Ag processes, Ag, not AI, persons (scholars, practitioners) must lead
- understanding basic AI principles is required for Ag persons in developing the right expectations wrt. using AI in the re-thought Ag systems
- the re-thinking appears to go well together with the general agri-food chain transformation that is requested by so many

Thank you for your time! Questions?

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