

The Future of Al in Agriculture

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Artificial Intelligence in Agriculture

Al is established in agriculture – adoption and scope are growing, but... with plenty of un-explored or under-explored Al applications.

For this workshop:

What is AI?

A survey of AI landscape and Ag AI whitespaces

Facilitated Discussion



What is AI?

The science of making machines (agents) that:

Think like people

Act like people



"narrow AI", not AGI



Al is designing Rational Agents, which

- Exist in an environment
- Take in sensory information
- Possess and use knowledge
- Act rationally (so as to achieve goal of maximizing expected utility of outcomes resulting from actions)



src: after Russel & Norvig, Artificial Intelligence: A Modern Approach.



Where is AI in use?

Search

Task and resource scheduling

Speech recognition, autocaptioning, Natural language processing

Robotic navigation and obstacle avoidance

Image recognition

Games

Fraud detection

Autonomous vehicles

Industrial robotics

Surveillance

Facial and gesture recognition

Medical diagnosis, treatment recommendation

Drug discovery

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Entertainment recommendation systems

Customer service 'bots

Materials discovery



Colgate/Apple E1 AI toothbrush image src: <u>https://www.trustedreviews.com/reviews/colgate-</u> <u>smart-electronic-toothbrush-e1</u>



What's Al

Machine Learning Learning from Data

Deep Learning

ML using Deep-Neural Networks

Deep ANNs, Convolutional NN,

Recurrent NN, Deep Bayesian NN

Generative Adversarial Networks

Deep reinforcement learning

Artificial Intelligence

Dimensionality reducers

Reinforcement learning

Rational Agents Search, Adversarial search, Probabilistic search, Monte Carlo tree search; Case/rules-based expert systems, Linear and nonlinear regression Logical theorem provers Generative probabilistic classifiers Deduction systems, QA **Discriminative classifiers** Constraint satisfaction Inductive reasoning Satisfiability solvers Clustering

Data science

Statistics

Optimization, **OR**

Modeling & Simulation



Al for Agriculture (an Al R&D datapoint) *

* Based on Association for the Advancement of Artificial Intelligence AI Topics publications indexing

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All Industries (213, 564 tagged conference, journal, workshop, symposia papers)

- 1) Information Technology (63k)
- 2) Health / Medicine (43k)
- 3) Education (34k)
- 4) Government (31k)
- 5) Leisure / Entertainment (30k)
- 6) Transportation (28k)
- 7) Banking / Finance (19k)
- 8) Media (17k)
- 9) Auto / Trucks (13k)
- 10)Law (13k)

20)Food & Agriculture (778)

30)Shipbuilding (13)

AI Technologies tagged

- 1) Machine Learning (294; incl/ DL 84)
- 2) Reasoning / Representations (84)
- 3) Natural Language Processing (35)
- 4) Computer vision (28)



Agricultural Adoption and Opportunities for Al

Artificial Intelligence

Rational Agents

Search, Adversarial search, Probabilistic search, Monte Carlo tree search; Case/rule-based expert systems; Logical theorem provers, Deduction systems, QA; Constraint satisfaction

Satisfiability solvers

Ag robotics route planning Transportation, warehousing Crop and resource scheduling Ubiquitous

 Crop selection, resource mgmt., processing, shipping, retail



Agricultural Adoption and Opportunities for Al

Machine Learning

Learning from Data Linear and nonlinear regression Generative classifiers – NB, BN, MRF, HMM Discriminative classifiers – LogReg, SVM, ANN, CRF Inductive reasoning – DT, RF Graph/ML Clustering – k-means, DTW Feature selection/engineering tools Dimensionality reducers Reinforcement learning

Prediction of Ag yield, NR mgmt., econ Phenotype, IoT, UAS/satellite spectral, time-series based prediction for G x E x M, NLP/AR/VR

Risk; distrib; supply chain ag data/time series crop mapping

Key for high dimensionality agriculture ML for G x E x M x P; proxy Ag robotics for inspection, production, processing



Agricultural Adoption and Opportunities for Al

Image/UAS/satellite-based feature recognition, localization, segmentation for regression/classification/rare-event detect for G x E x M Equipment acoustic/vib based prediction; NLP Computer vision; AR/VR, UAV/robotic nav/ob detect/avoid Sensor-based DL for precision ag, NR optimization; Deep Learning ML using Deep-Neural Networks Deep ANNs, Convolutional NN, Recurrent NN, Deep Bayesian NN Generative Adversarial Networks Deep reinforcement learning;



AI for Agriculture

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Thoughts on going forward for AI \Leftrightarrow **Ag**(computer engineer perspective):

- 1) Ag is behind many industries in adoption of AI
- -- slightly less so when we take the broad view of the Food System

2) ML/AI technologies are available to Ag for the taking, but this will require meeting half-way (or more??)

-- start here: <u>https://aitopics.org/search</u>

3) Agriculture/Food System as application space should be attractive to Al community:

Social good is core value in AI community. Ag is as socially good as at gets: hunger, nutrition, environment, poverty, sustainability, bias, health

Al advances fueled in part by grand challenge goals, contest mentality, open source/open data/open model, crowd sourcing, and hackathon execution



Facilitated Discussion – background

My role is agriculture research and I have a need for or interest in AI in Ag

My role is food production, processing, delivery, wholesale, or retail

My role is AI, data science, computer science with an interest in AI in Ag

My role is something else and I thought this might be interesting



Facilitated Discussion – assets and interest

My interest and capabilities are in dealing with acquisition, storage, manipulation, curation, delivery of data

My interest and capabilities are in modeling

My interest and capabilities are in statistics, optimization, OR

My interest and capabilities are in developing AI/ML/DL algorithms and tools

My interest and capabilities are in integrating AI/ML into larger systems/processes

My interest and capabilities are in deploying AI in production

My interest and capabilities are education, training, outreach, policy



Facilitated Discussion – primary gap

My primary gap is in dealing with data size/volume

My primary gap is lack of data, missing data

My primary gap is lack of integration of data, multi-scale/multi-modal data

My primary gap is ML/DL model complexity, transfer model accuracy, or model training resources

My primary gap is in making AI/ML usable in my system without requiring AI experts

My primary gap is training users of AI/ML technology in Ag



Facilitated Discussion – data

I produce or use:

Remote sense data – UAS, ground imaging, satellite

Phenotype data

Plant, animal, host, or pest/disease genome data

Water, growth regulator, nutrient application and measurement data

My data is observation/sensor data related to transportation, processing, storage

My data is related to retail, marketing, sales, consumption



Facilitated Discussion – ML models

My research/applications rely on rule, case, constraint, physics, or process models for decision making

My research/application uses machine learning (feature set explicit)

I have challenges in determining which ML models to use

I am constrained by too little data to train accurately

My feature dimensionality is too large to manage effectively

My research/applications rely on proxies whose accuracy concerns me



Facilitated Discussion – deep learning

I don't work with deep neural networks

I build and train my own DNN models from my or other's data

I use pretrained models and optionally retrain (transfer learn)

I do not have resources to train neural networks

I am concerned about explainability of my DNN results