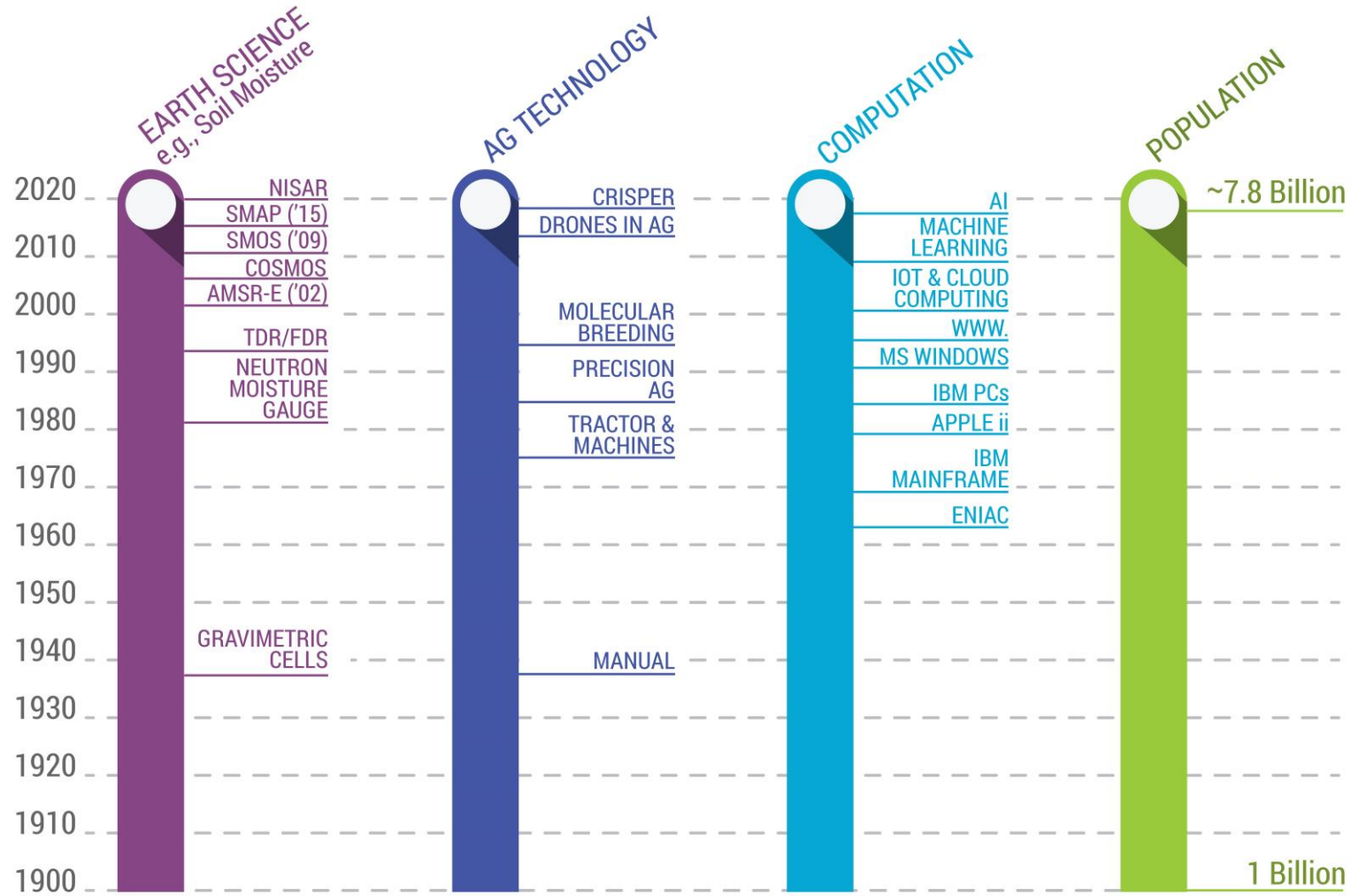TEXAS A&M UNIVERSITY

AI for Ag

May 17th, 2022

Artificial Intelligence (AI) in Production Agriculture
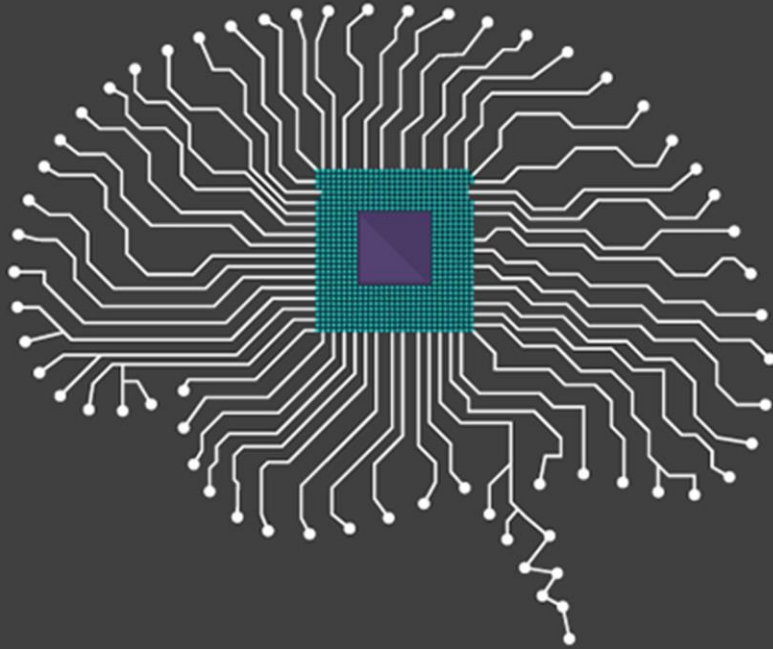
The Challenges and Opportunities

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Overview and Rationale

Machine learning is a subset of AI, and it consists of the techniques that enable computers to figure things out (**learn**) from various structured, unstructured, nonlinear, and diverse (BIG) **data** and deliver AI applications to **make decisions**.

Deep learning, meanwhile, is a subset of machine learning that enables computers to solve more complex problems.

- process information in a way similar to the human brain
- have interconnected processing elements working in parallel
- learn by example
- cannot be programmed to perform a specific task
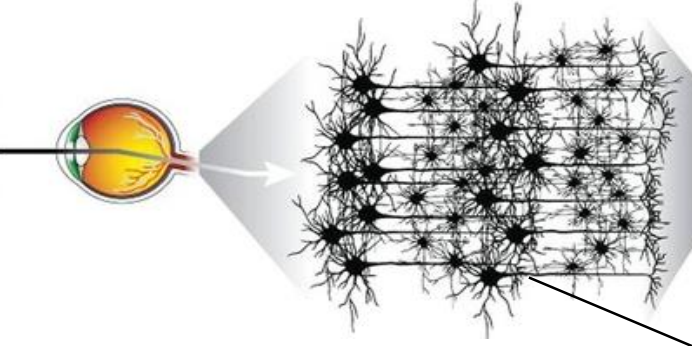- find out how to solve the problem by themselves
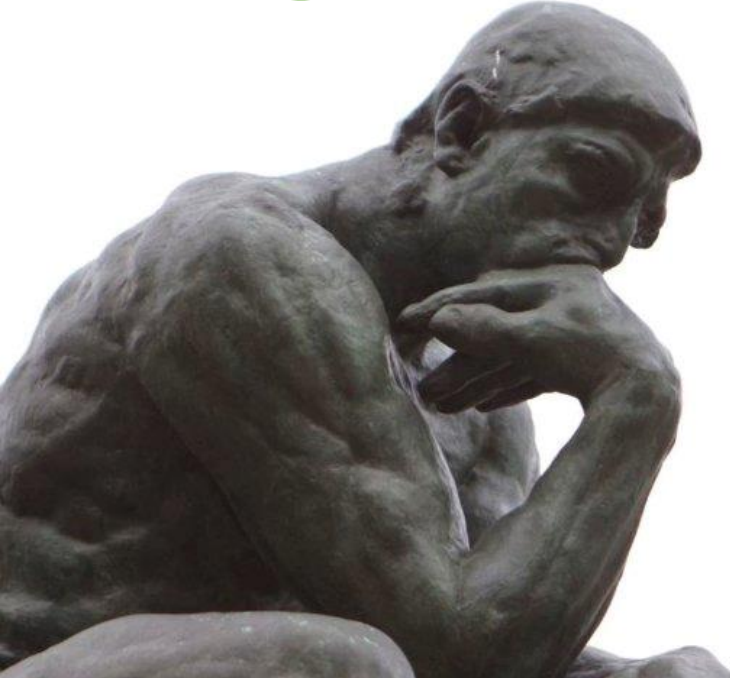
The Biological Neural Network

#@#%$#
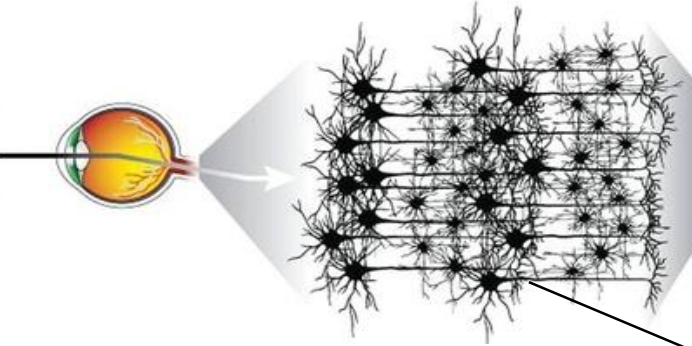
Fish

- Gills
- Fins
- Streamlined body

Zebra

- Long face
- Four legs
- Black&white stripes
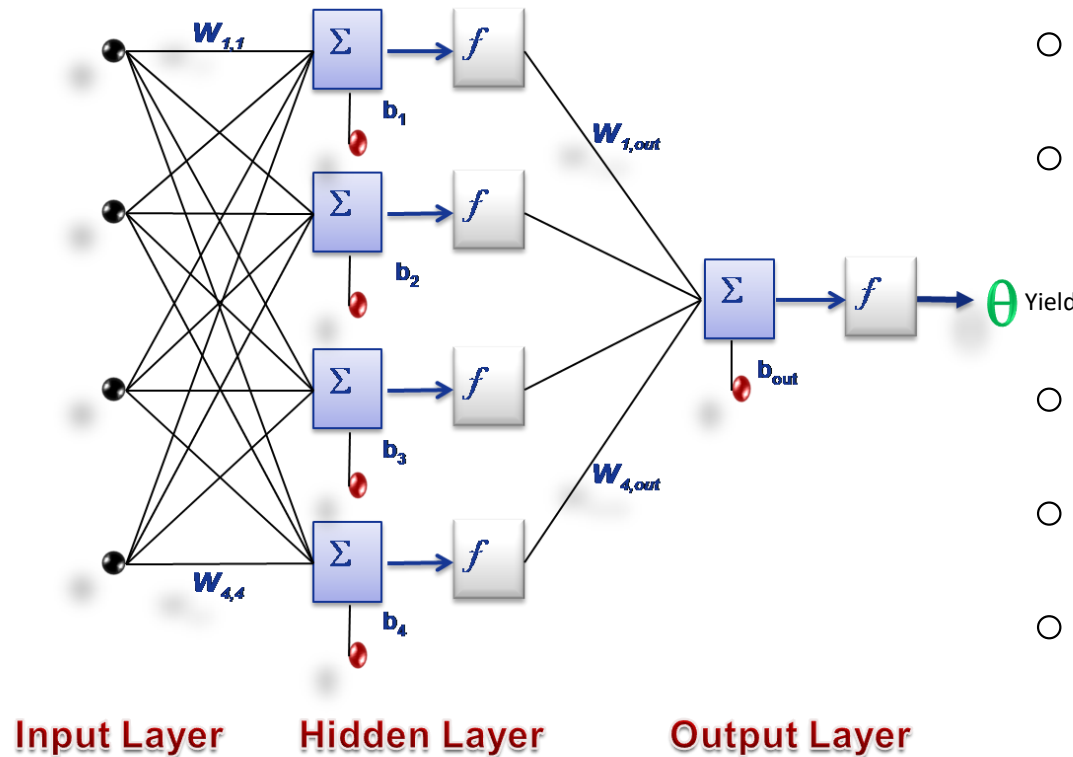
Artificial/Bayesian Neural Network

Example

Genomics / Plant Traits

Natural Resources Availability (Land, soil, water,..)

Crop Management Practices (Tillage, Irrigation, Fertilization, Pest,..)

Climate Uncertainty (Precip, Temp,..)

$W_{1,1}$ Σ f b_1 $W_{1,out}$

Σ f b_2

Σ f b_3

Σ f b_4 $W_{4,4}$ $W_{4,out}$

Σ b_{out} f θ Yield

Input Layer   **Hidden Layer**   **Output Layer**

- Input neurons
- Processing unit
  - Summation
  - Transfer function
- Output neuron
- Connections
- Weights & biases

Learning Processes

- **Associative mapping**
  - **Auto-association**
  - **Hetero-association**
- **Regularity detection**
- **Fixed networks**
- **Adaptive networks**
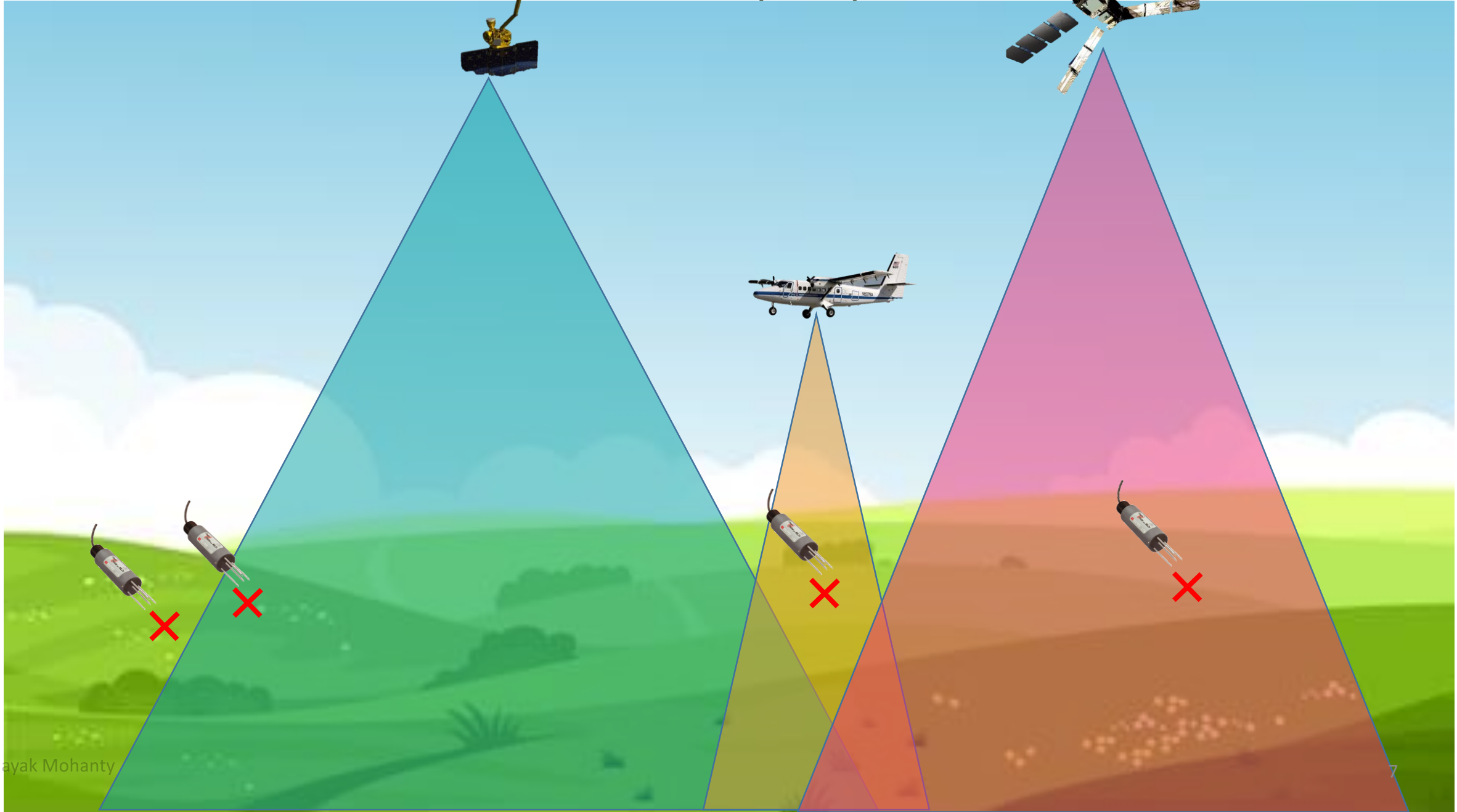- **Supervised learning**
- **Unsupervised learning**

Advanced Data-Driven Tools

Nonlinearity and Deep Learning
Nonstationary Spatial Scaling
Spatio-Temporal Data Fusion
Multiresolution Gap Filling
Data Mining & Transfer Function

Challenges for AI Adoption in Agriculture
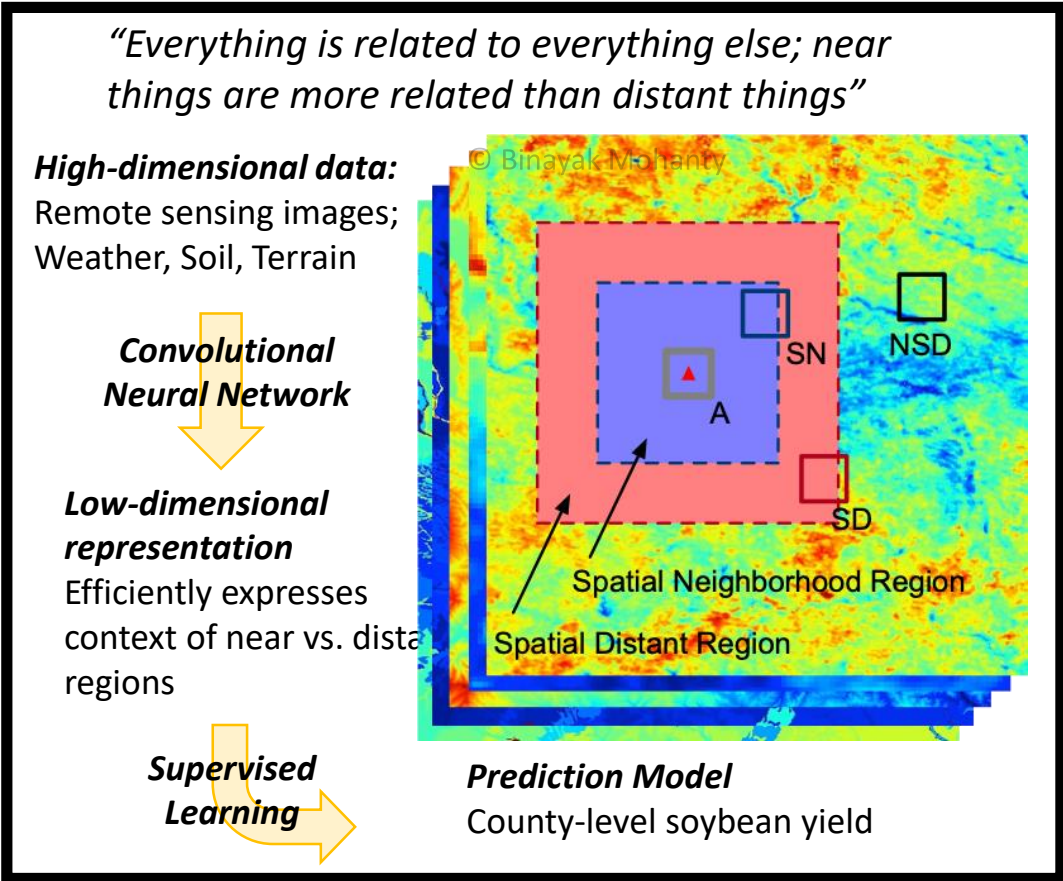
- Agriculture is **local**
- Inability to tightly control conditions
- **High-cost** associated with changing the specialized equipment
- Painfully **slow iterations** of the build, measure and learn loop
- Past performance **does not predict future** performance or impending disasters
- A deeply interconnected web of **disparate stakeholders**
- Agriculture is **AI-expertise deficient**

1 RELATIONSHIP DISCOVERY AND LEARNING WITHIN COMPELX DATA

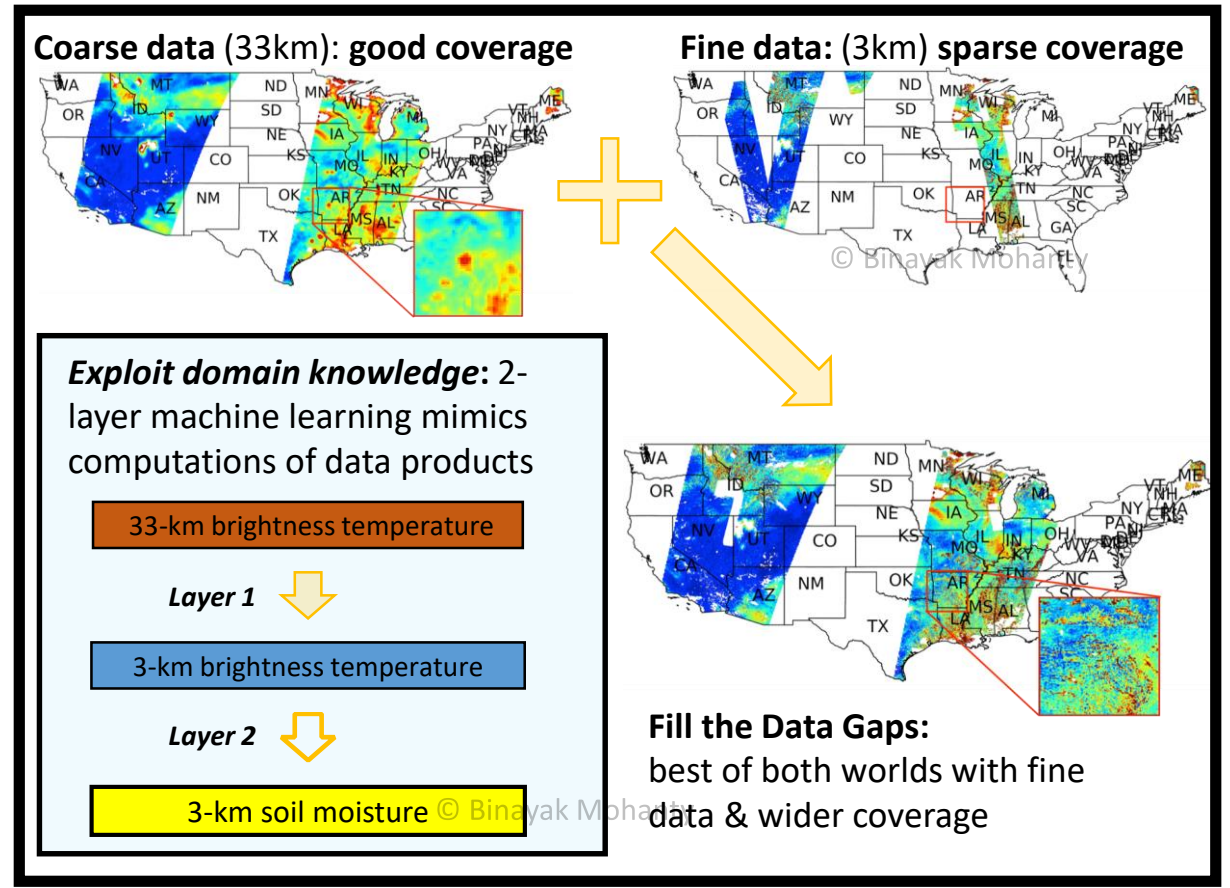**2** EXPLOITING DOMAIN KNOWLEDGE WITHIN MACHINE LEARNING MODELS

Prior work: unsupervised representation learning on geodata + supervised learning of crop growth

Prior work: extend coarse & patchy satellite–based data: learn dependence on fine scale terrestrial & aerial data

"Everything is related to everything else; near things are more related than distant things"

High-dimensional data:
Remote sensing images; Weather, Soil, Terrain

Convolutional Neural Network

Low-dimensional representation
Efficiently expresses context of near vs. dista regions

SN

NSD

A

SD

Spatial Neighborhood Region

Spatial Distant Region

© Binayak Mohanty

Supervised Learning

Prediction Model
County-level soybean yield

Coarse data (33km): **good coverage**

Fine data: (3km) **sparse coverage**

© Binayak Mohanty

Exploit domain knowledge: 2-layer machine learning mimics computations of data products

33-km brightness temperature

Layer 1

3-km brightness temperature

Layer 2

3-km soil moisture © Binayak Mohanty

Fill the Data Gaps: best of both worlds with fine data & wider coverage

Mao, Liu, Duffield, Yuan, Ji, Mohanty (2020)

Mao, Kathuria, Duffield, Mohanty (WRR, 2019)

AI Enhanced Decision Making in Agriculture

Coordinated IMPACTS

❑**Research:** Develop improved AI tools for knowledge generation and decision making for natural resources, crop traits and agricultural management choices

❑**Education:** Train and encourage a new generation of trans-disciplinary researchers to focus on AI tools in agriculture

❑**Knowledge Transfer:** Influence stakeholders to adopt AI approaches and stimulate stakeholder enthusiasm for AI through outreach to change outcomes (e.g., improving data sharing and simplifying analysis for their own work)