FarmBeats: AI & IoT for Data-Driven Agriculture

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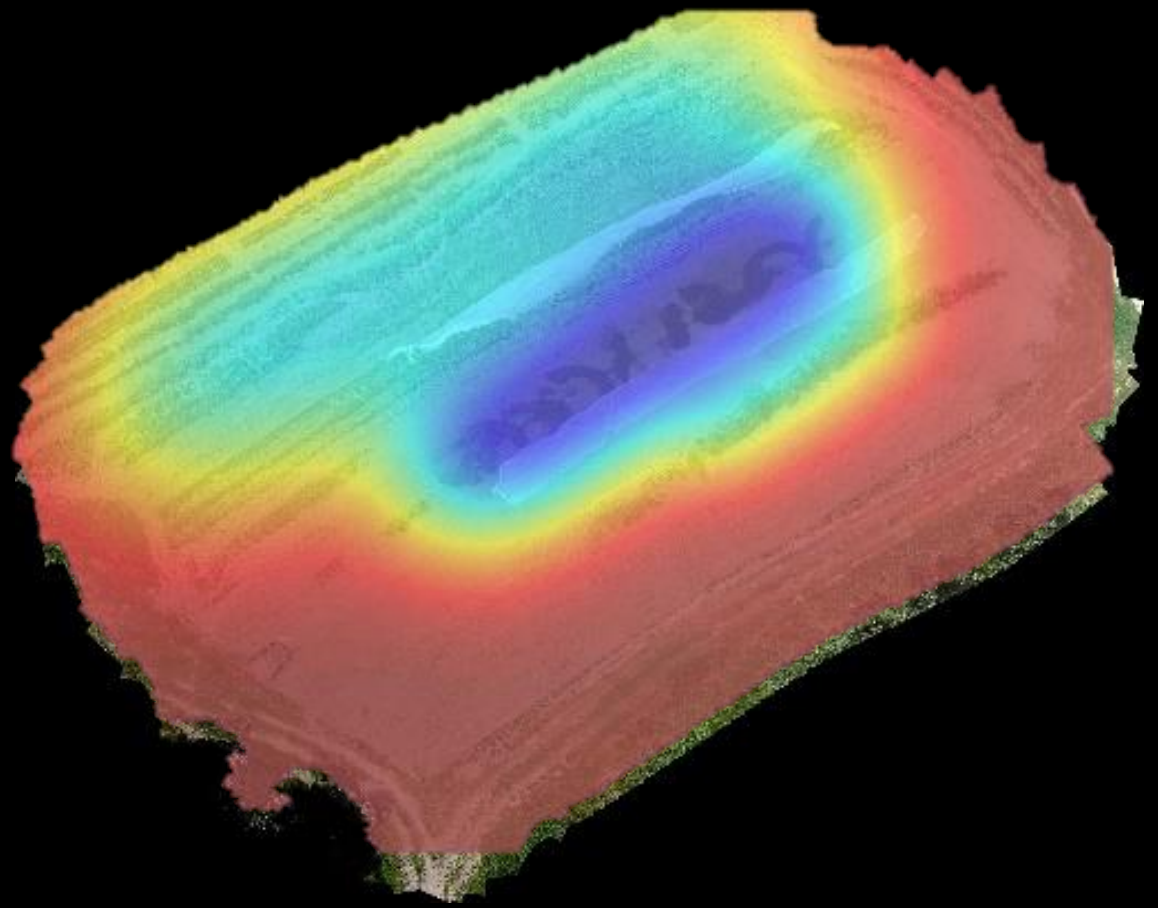
Data-Driven Agriculture



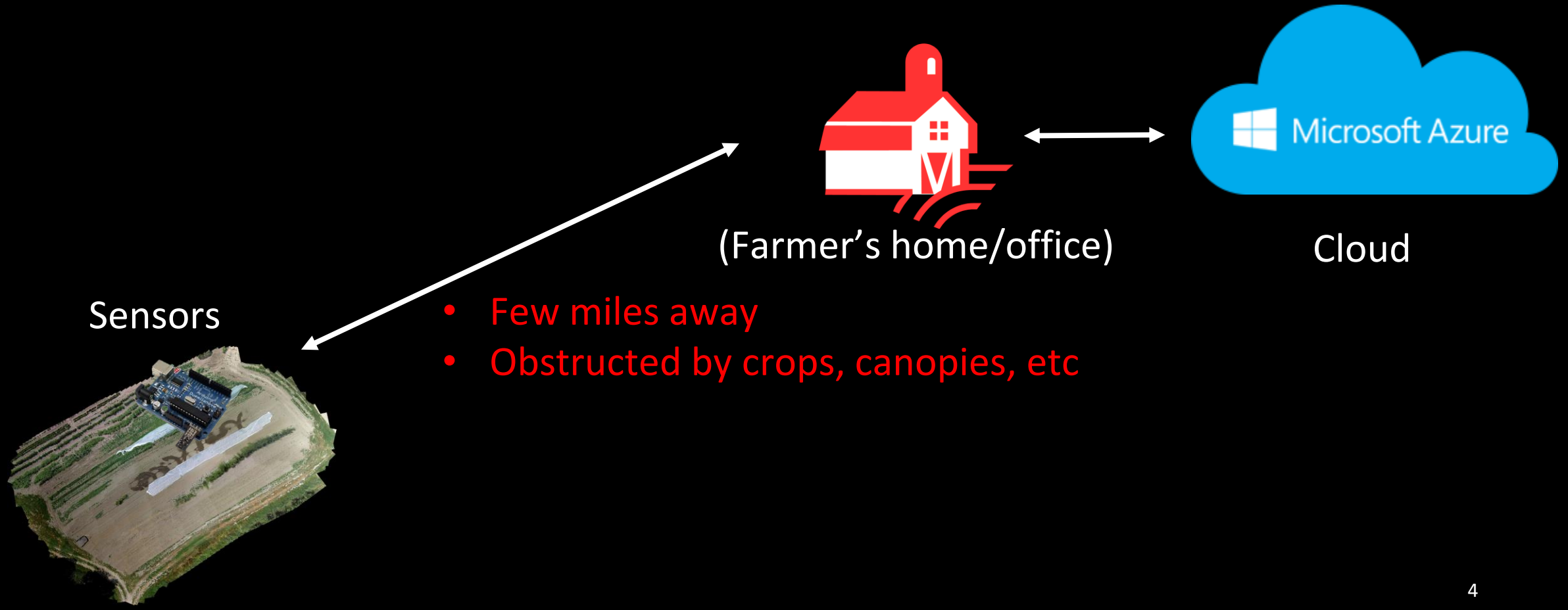
Ag researchers have shown that it:

- Improves yield
- Reduces cost
- Ensures sustainability

But…

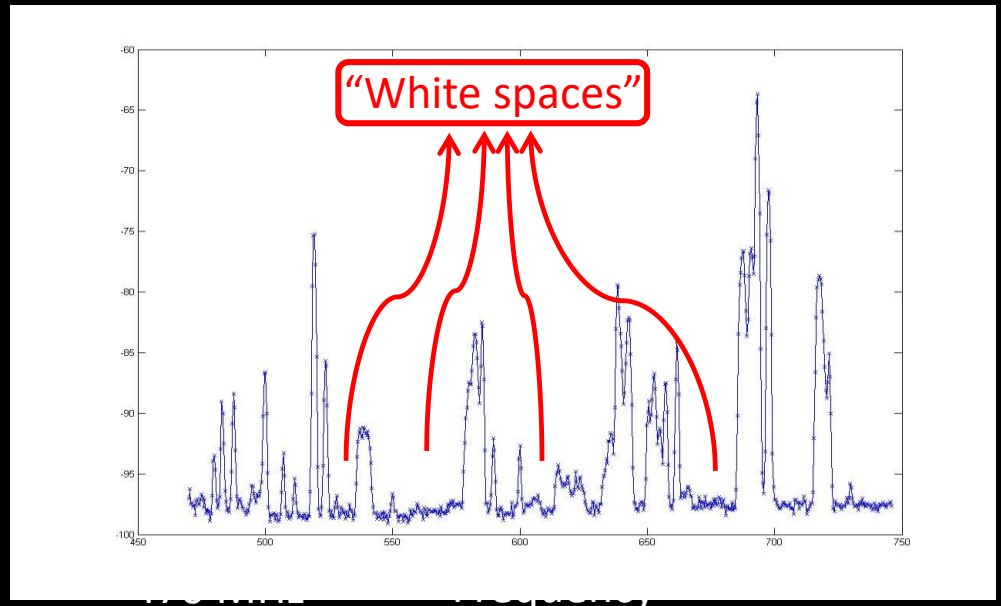
According to USDA, high cost of data collection
prevents farmers from using data-driven agriculture

Challenge 1: Internet Connectivity



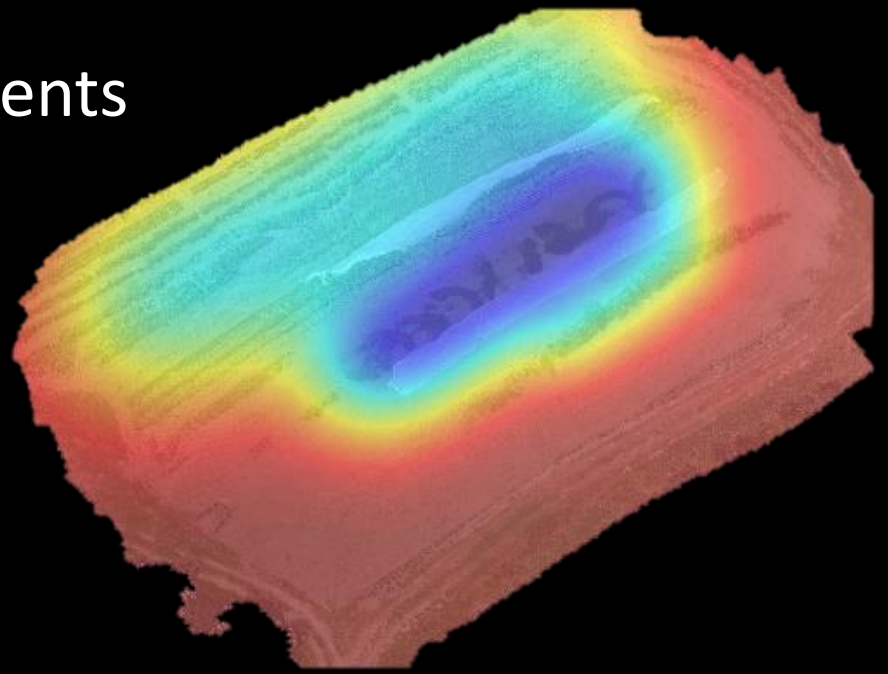
TV White Spaces in the Farm

- What are the TV White Spaces?
  - Unused TV channels
- Benefits over Wi-Fi, Zigbee, etc
  - High throughput at long range
- Key insight for farms:
  - “lots” of TV spectrum is available, more than 100 MHz
  - Just like Wi-Fi router covers the home, TVWS base station can cover the farm



Challenge 2: Limited Resources

- Need to work with sparse sensor deployments
  - Physical constraints due to farming practices
  - Too expensive to deploy and maintain



- How do we get coverage with a sparse sensor deployment?

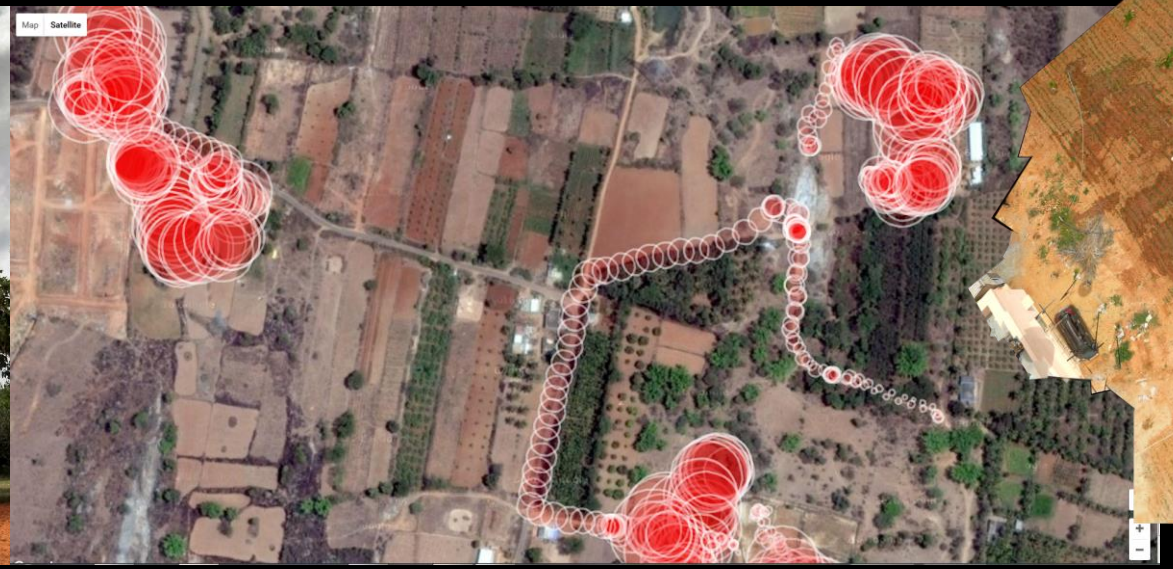
Idea: Use UAVs to Enhance Spatial Coverage

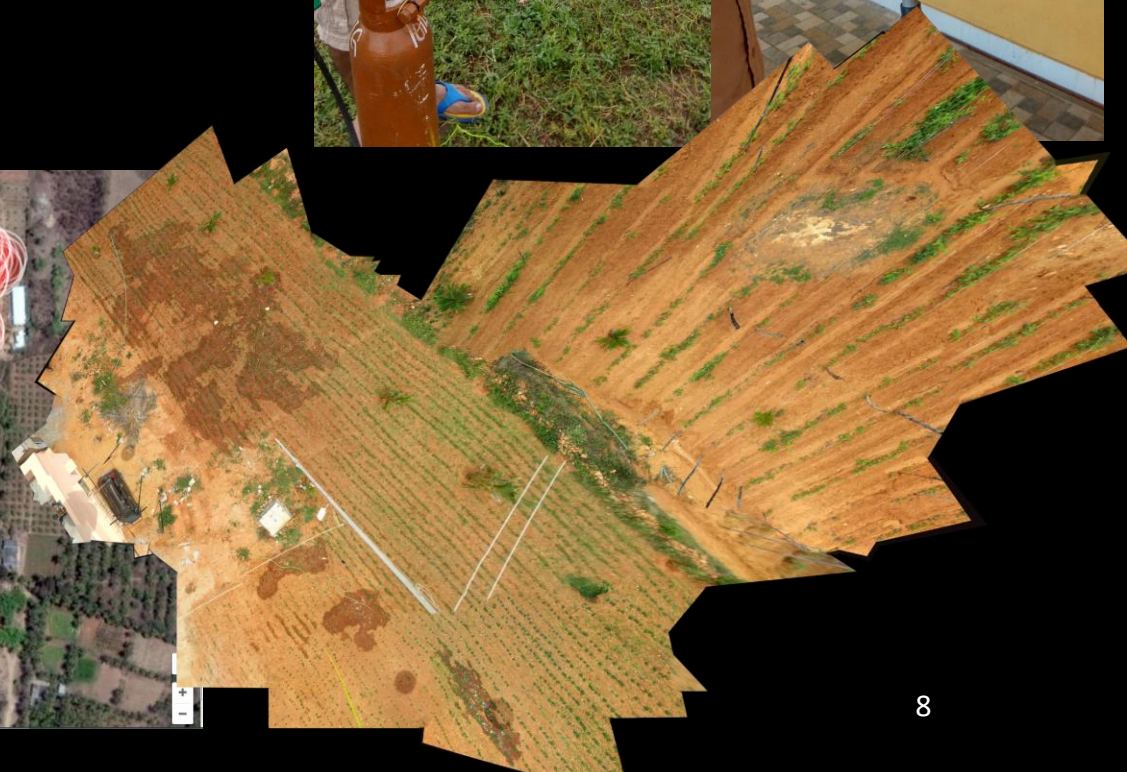
- Drones are ~1000 dollars and automatic
- Can cover large areas quickly
- Can collect visual data

Combine visual data from the UAVs with the sensor data from the farm

Low-cost Aerial Imagery: Tethered Eye (TYE)

- UAVs have a few limitations:
  - limited battery life
  - Regulatory concerns
  - Cost > 1000 dollars

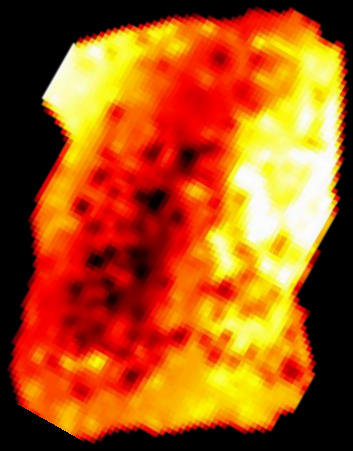




Idea: Use Drones to Enhance Spatial Coverage

Drone Video

Panoramic Overview



Precision Map

FarmBeats can use drones to expand the sparse sensor data and create summaries for the farm

Challenge 3: Internet at Farmer's House

Base Station

- Weak Connectivity
- Prone to outages

TV White Spaces

Few miles

(Farmer's home/office)

Microsoft Azure

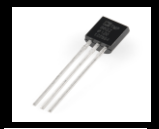
Cloud

Wi-Fi, BLE

Sensors

FarmBeats Gateway (Windows 10 IoT Gateway)

Sensors



MQTT

Drone

FTP

TCP

Camera

Sensor Interface

- MQTT Broker
- FTP Server
- Video Processor

Local Computation

- HeatMap Gen
- Panorama Gen
- EdgeCNN

Ag Services

- Precision Irrigation
- Precision pH
- *Yield Prediction*
- *Pest Infection*
- *Precision Fertilizer*
- ...

Drone Flight Planner

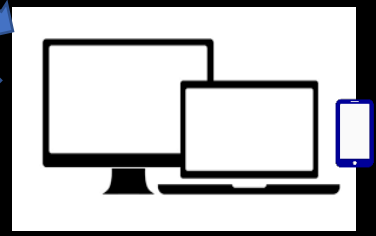
Storage

Cloud Sync

Web Server (Offline Access & 3-D Walkthrough)

HTTP/ AMQP

Web Server



IoT Hub

Streaming Analytics

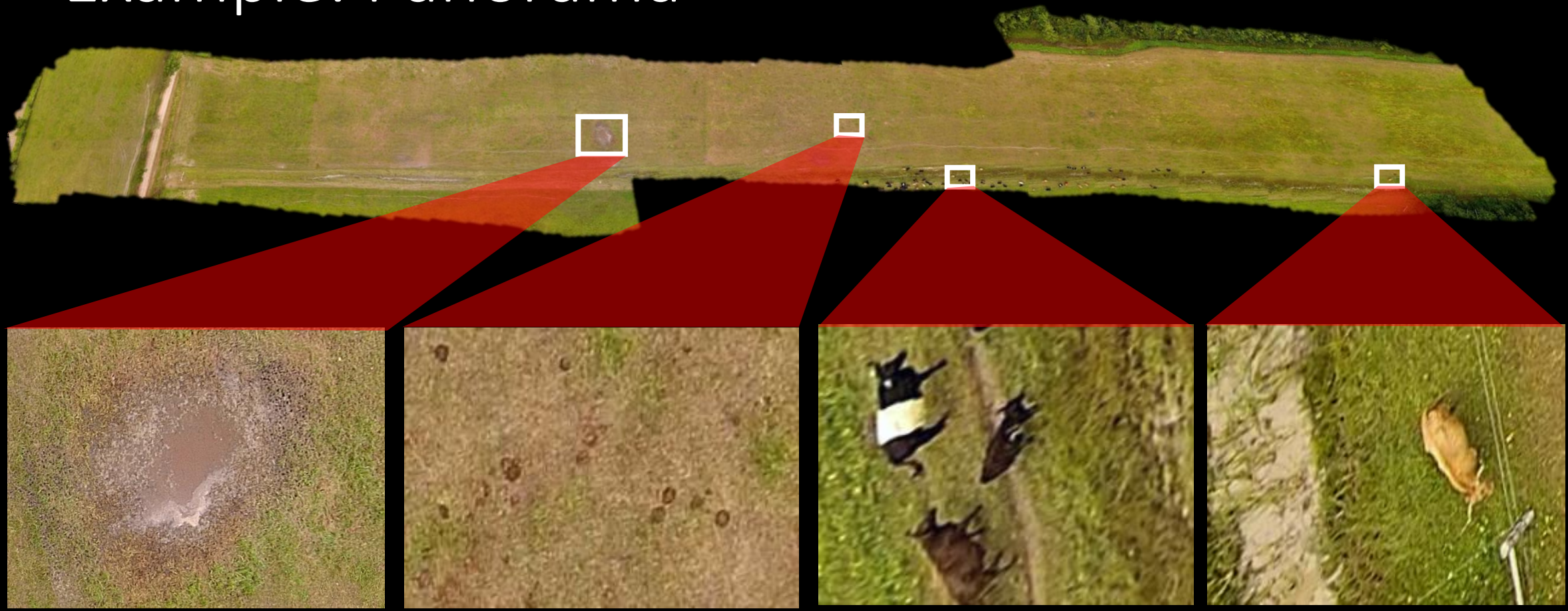
Storage

- *Can run offline*
- *Unique Gateway services*
- *Deep Learning at Edge*
- *Component Migration*

Deployment

- Six months deployment in two farms: Upstate NY (Essex), WA (Carnation)
- The farm sizes were 2000 acres and 5 acres respectively
- Sensors:
  - DJI Drones
  - Particle Photons with Moisture, Temperature, pH Sensors
  - IP Cameras to capture IR imagery as well as monitoring
- Cloud Components: Azure Storage and IoT Suite

Example: Panorama



Water puddle

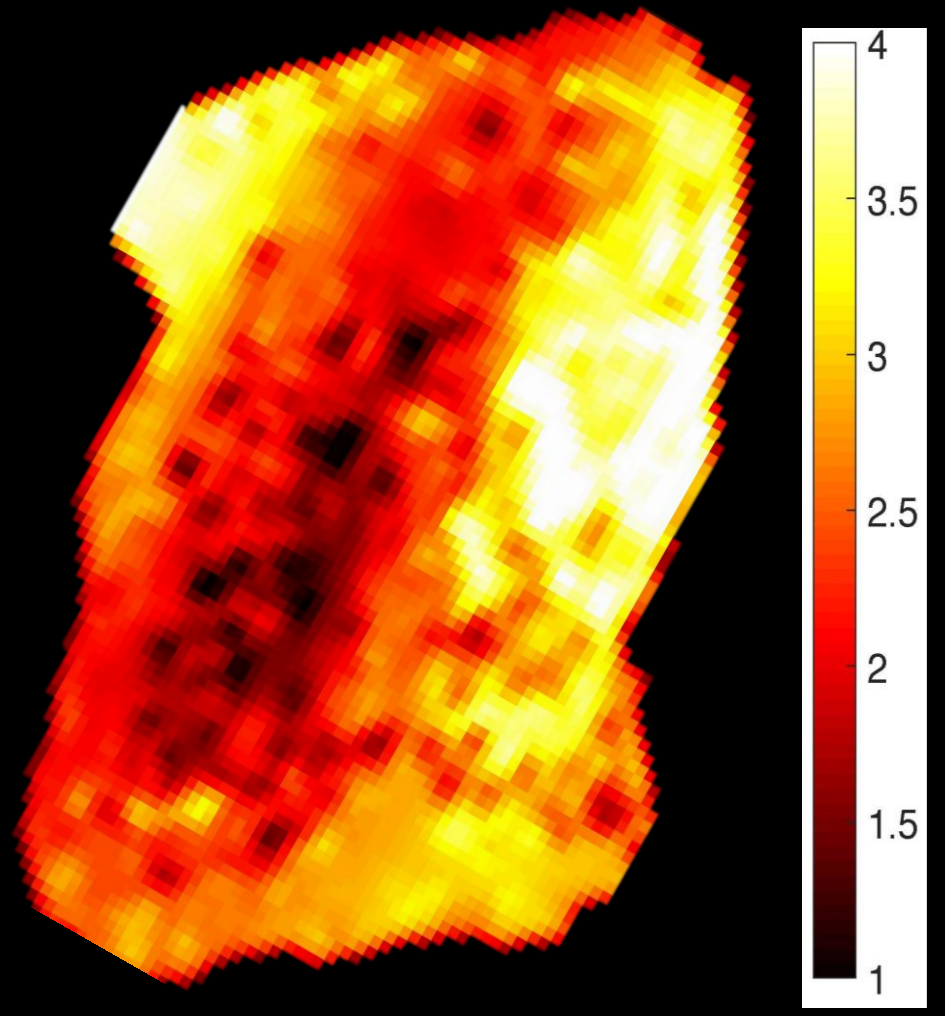
Cow excreta

Cow Herd

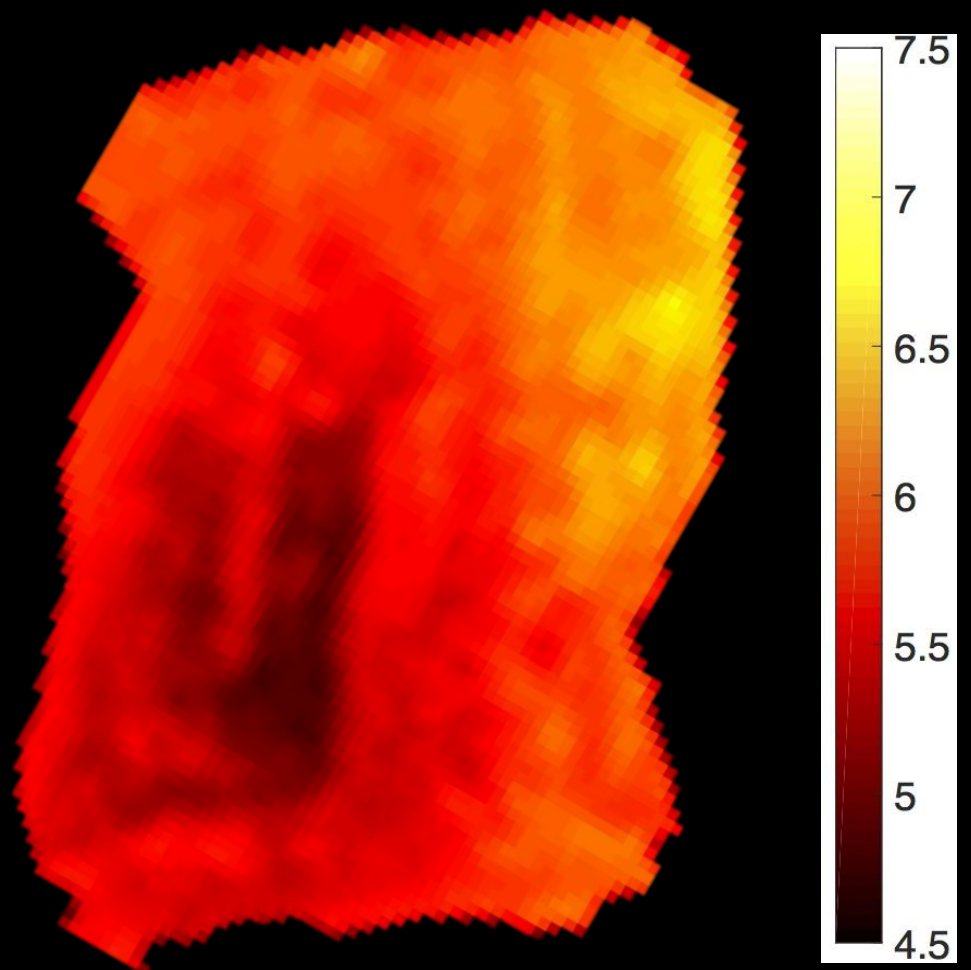
Stray cow

Precision Map: Panorama Generation

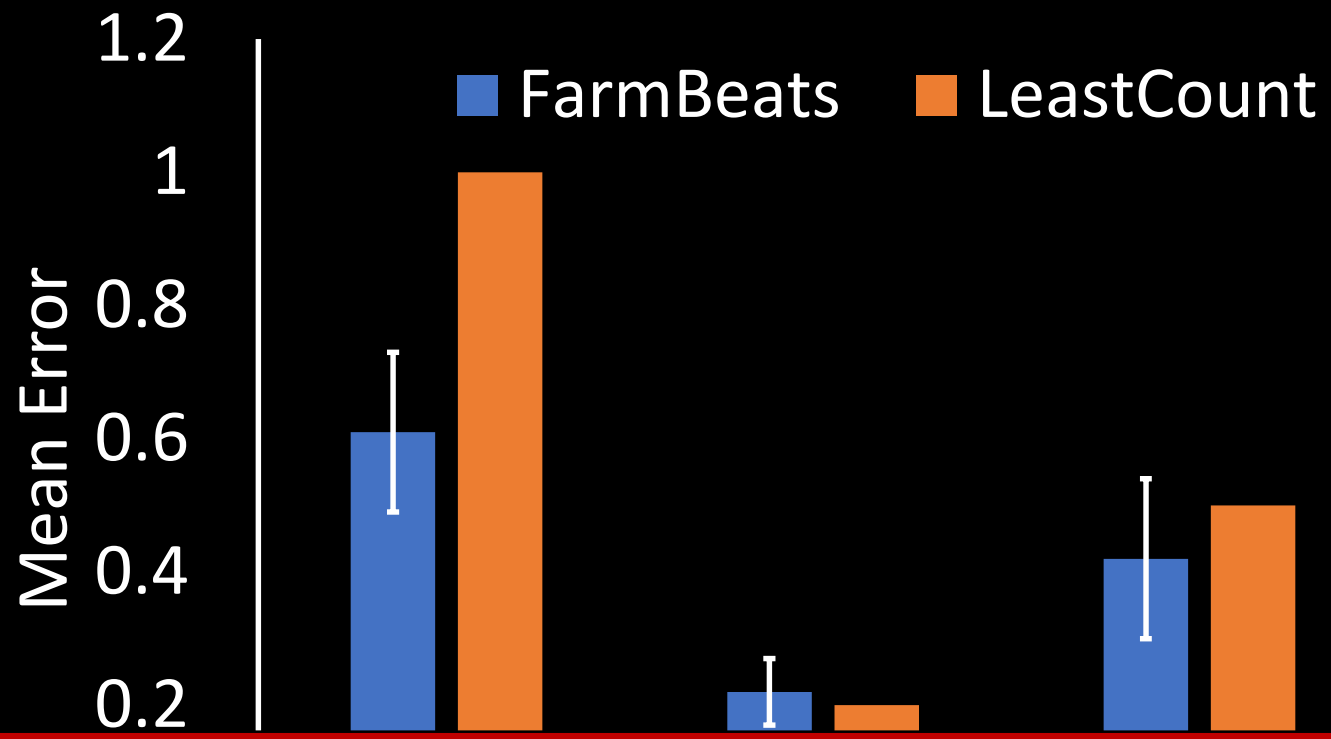
Precision Map : Moisture



Precision Map : pH



Precision Map: Accuracy



FarmBeats can accurately expand coverage by orders of magnitude using a sparse sensor deployment

Conclusion

- FarmBeats: End to end IoT system for environments constrained by:
  - Limited internet connectivity
  - Power Variability
  - Sparse Sensor Deployment
- Acts as a tool to enhance farm and farmer productivity
- Used by farmers for applications beyond precision farming

Thank you!

Sean Stratman, Dancing Crow Farm, WA

Mark & Kirstin Kimball, Essex Farm, NY

Questions

http://www.microsoft.com/en-us/research/project/farmbeats-iot-agriculture/

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