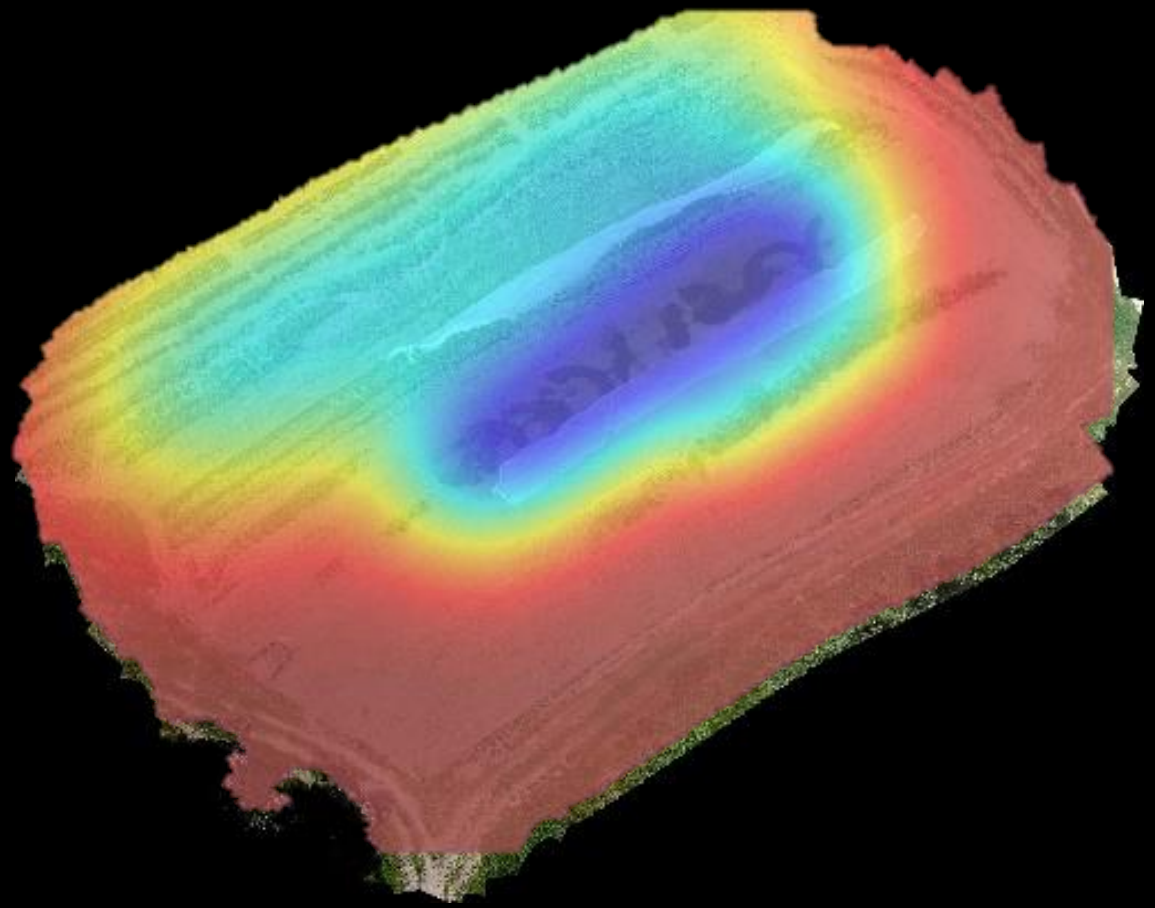
FarmBeats: AI & IoT for Data-Driven Agriculture

Data-Driven Agriculture



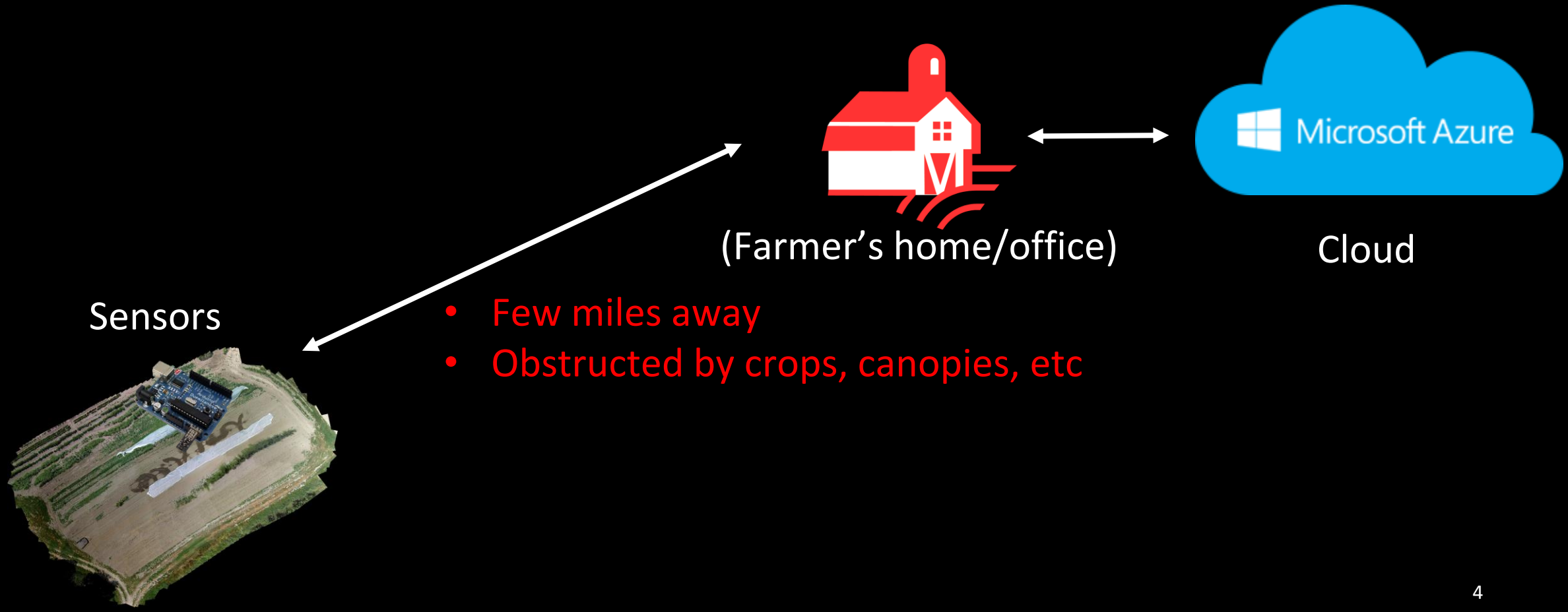
Ag researchers have shown that it:

- Improves yield
- Reduces cost
- Ensures sustainability

But…

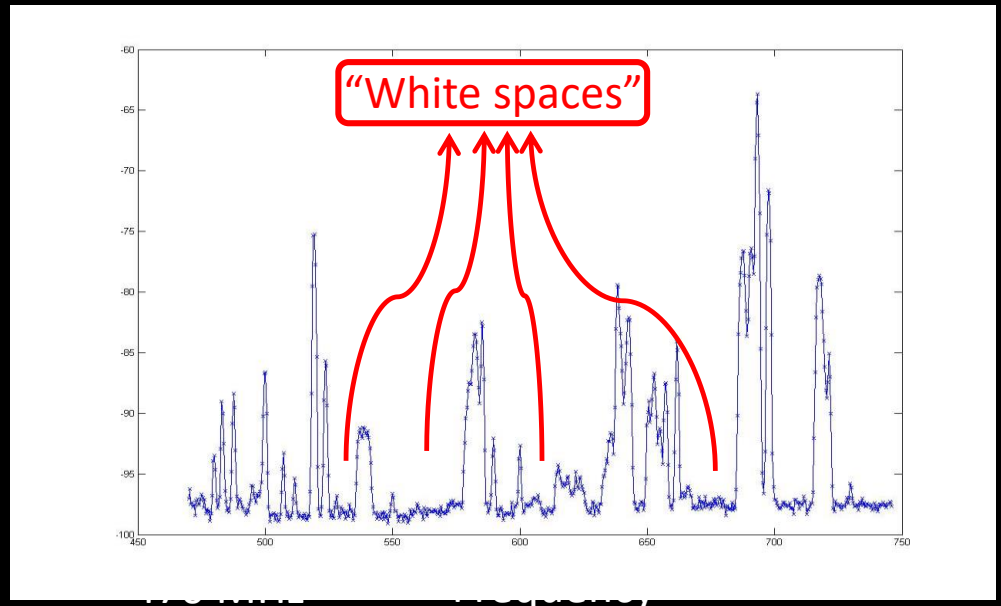
According to USDA, high cost of data collection
prevents farmers from using data-driven agriculture

Challenge 1: Internet Connectivity



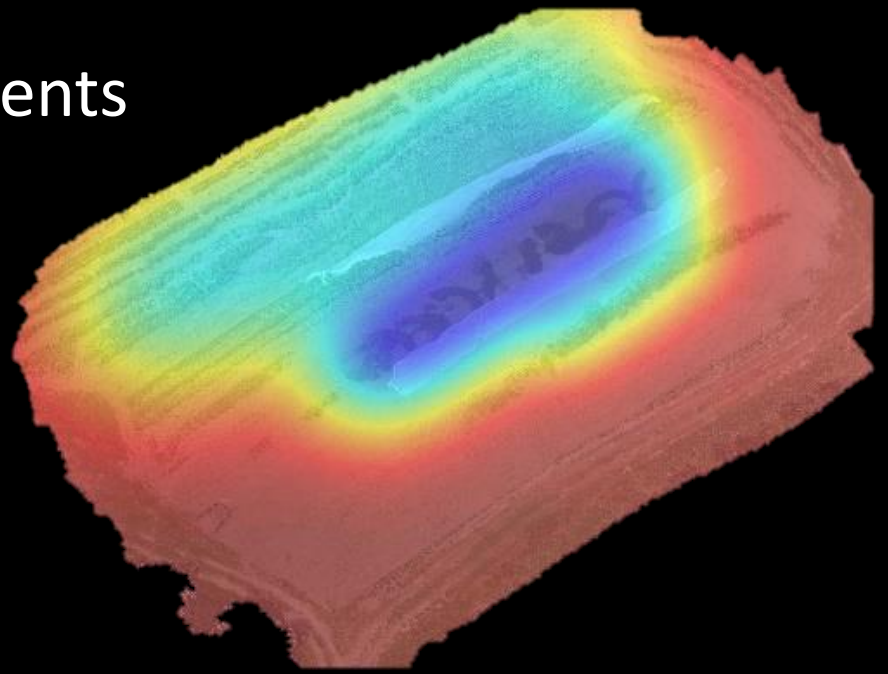
TV White Spaces in the Farm

- 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?

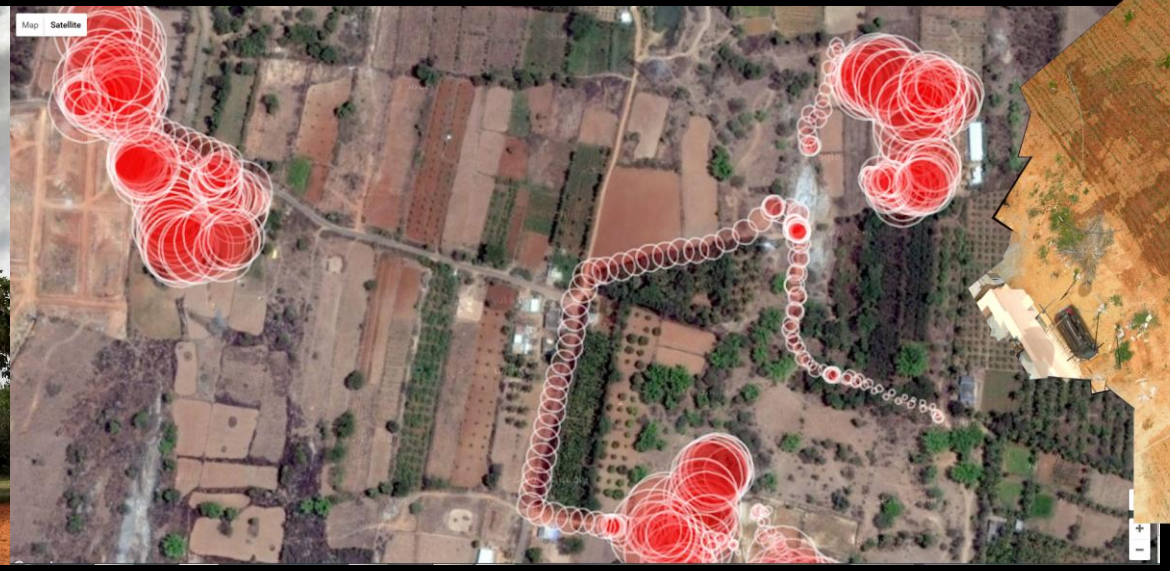
Idea: Use UAVs to Enhance Spatial Coverage

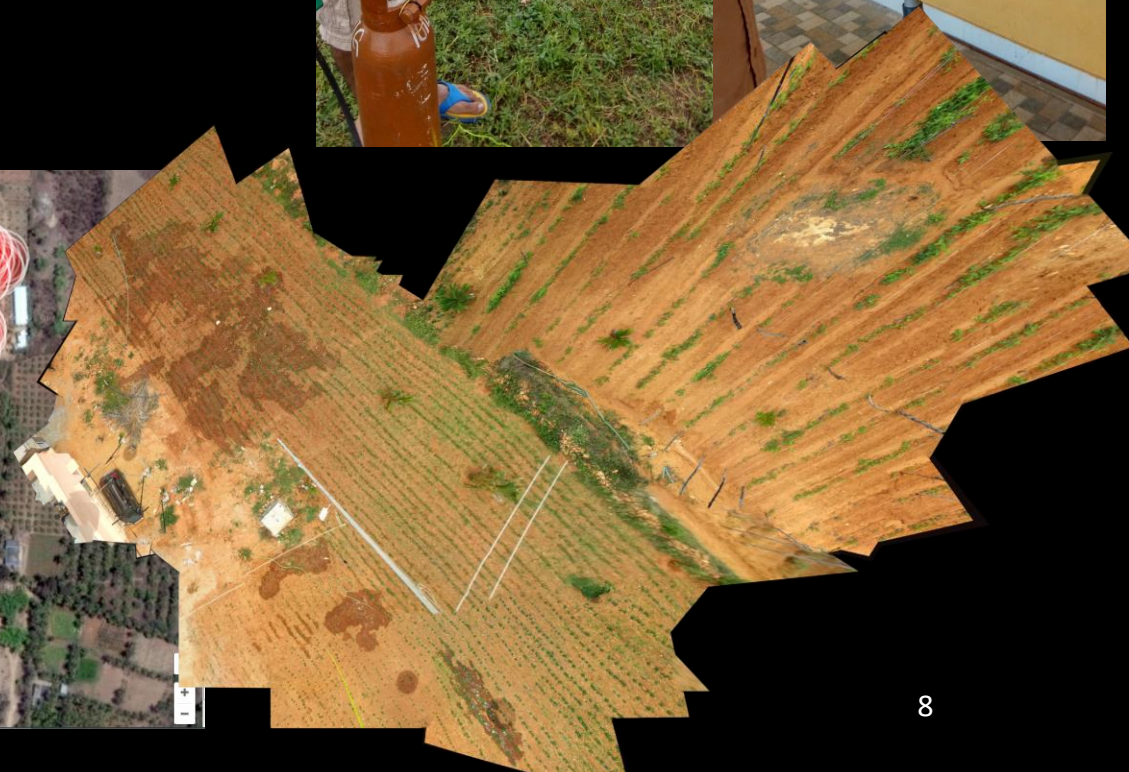
- Drones are ~1000 dollars and automatic
- Can cover large areas quickly
- Can collect visual data

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

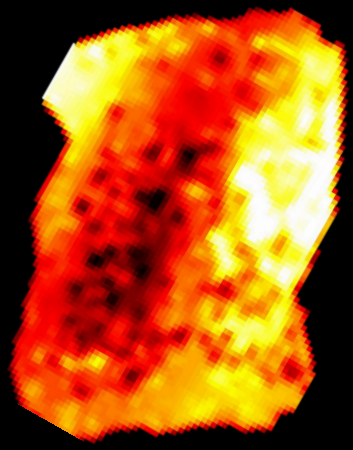




Idea: Use Drones to Enhance Spatial Coverage

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

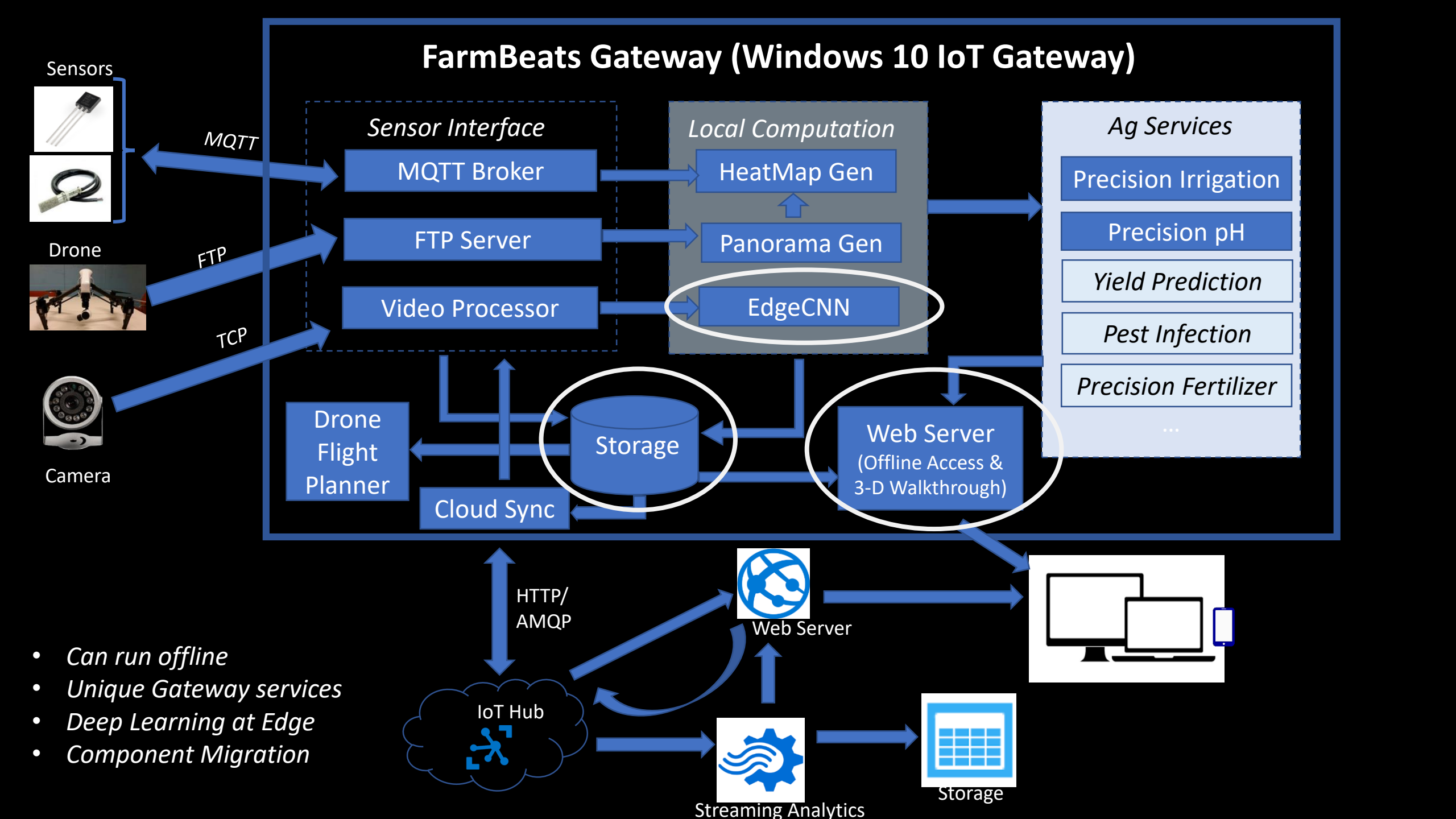
(Farmer's home/office)

Microsoft Azure

Cloud

Wi-Fi, BLE

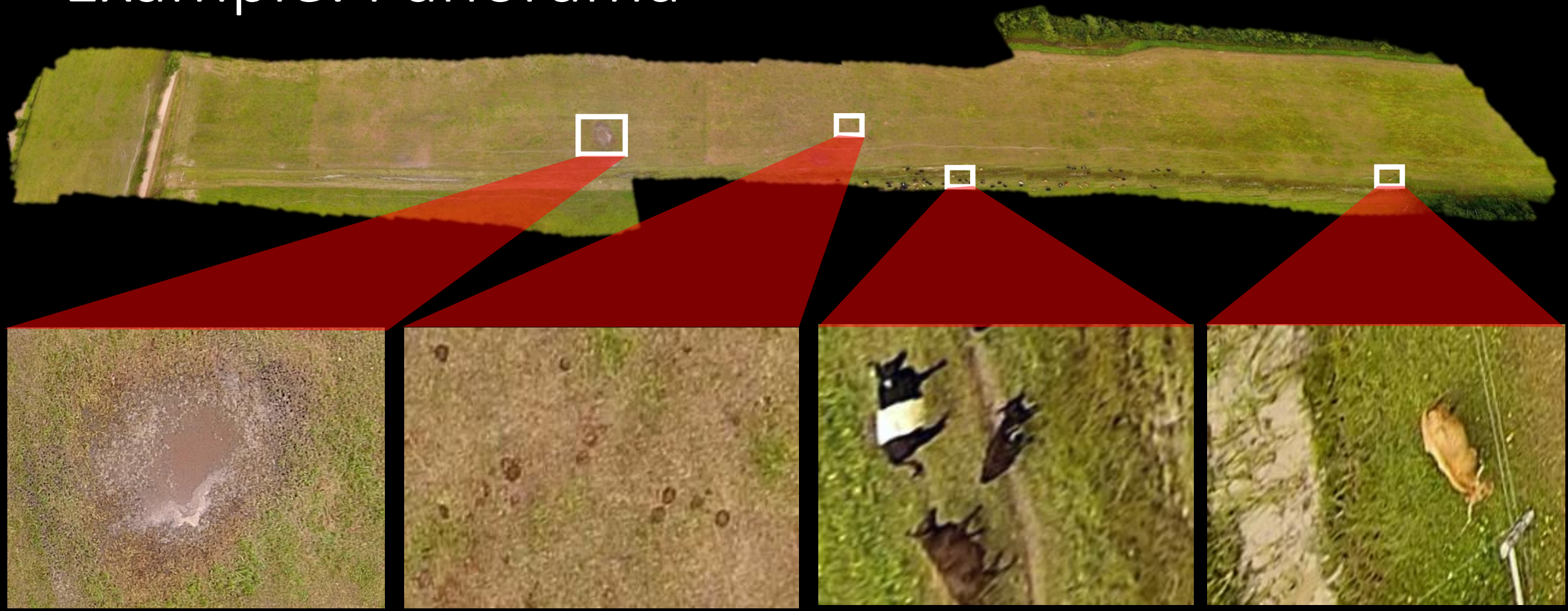
Sensors


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

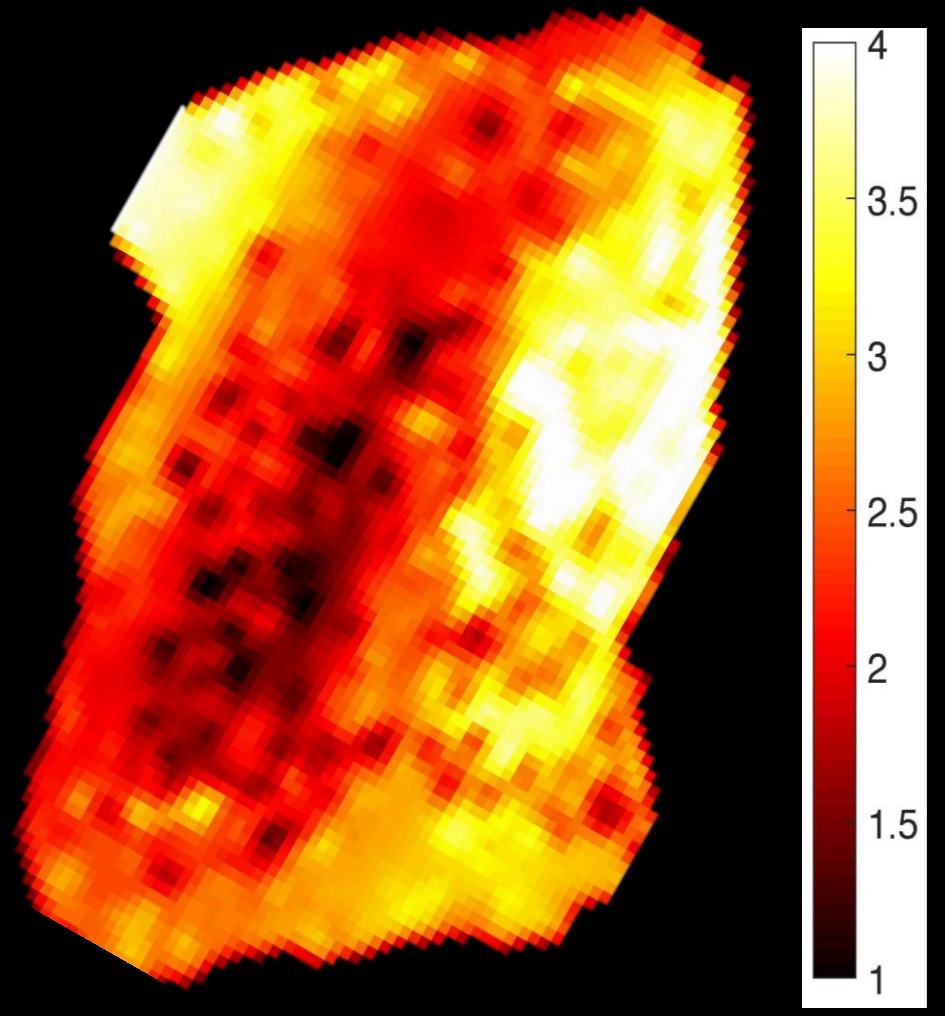
Cow excreta

Cow Herd

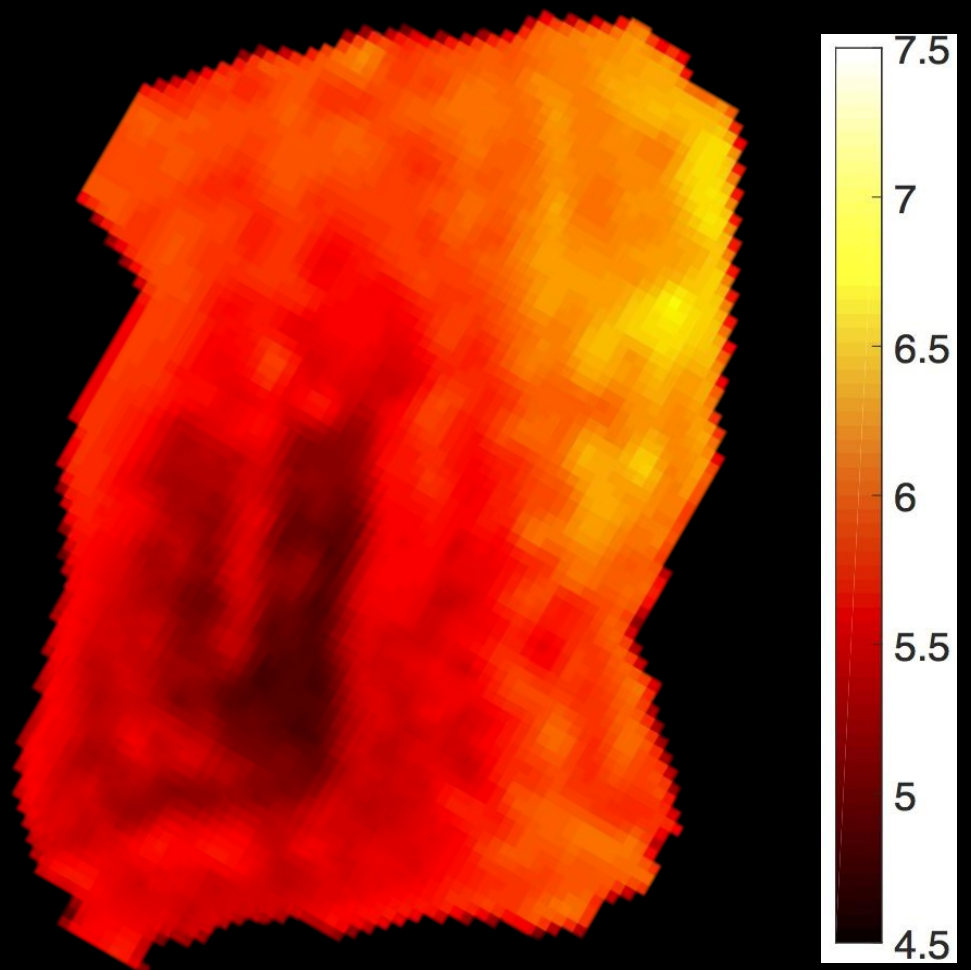
Stray cow

Precision Map: Panorama Generation

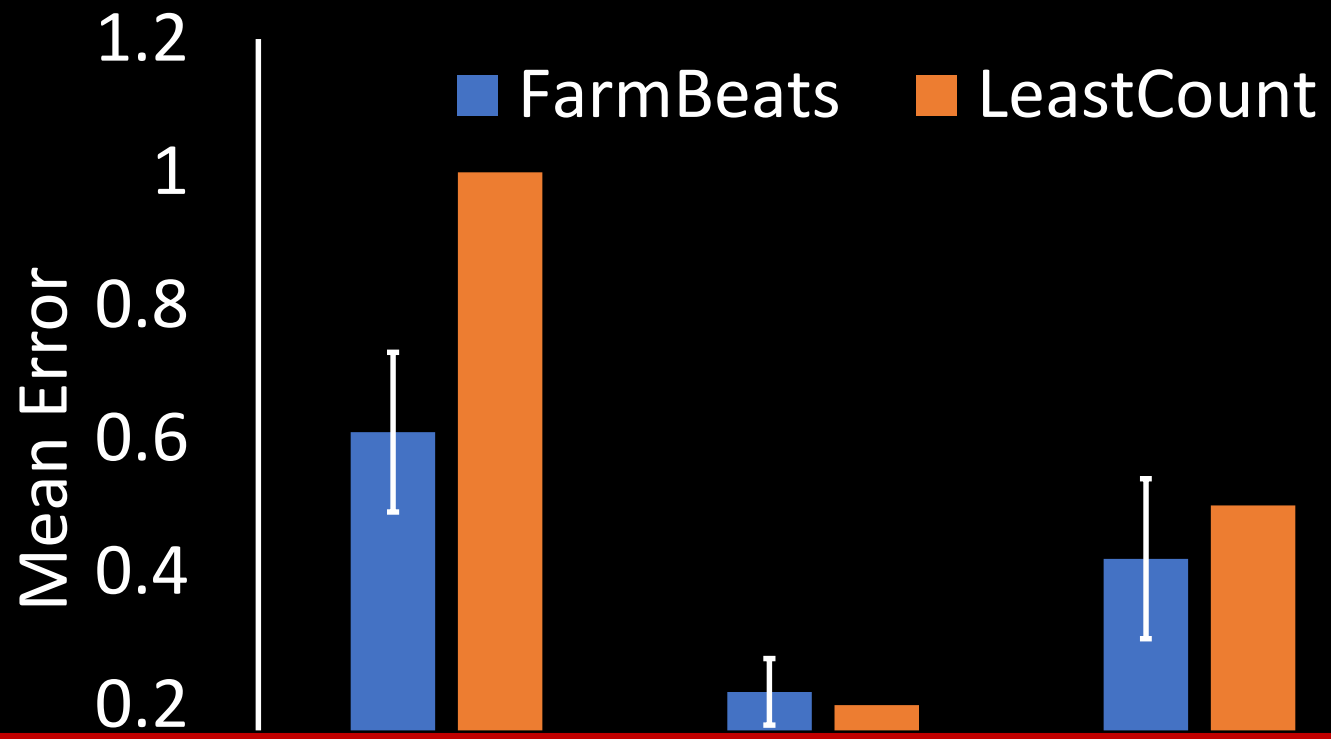
Precision Map : Moisture



Precision Map : pH



Precision Map: Accuracy



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

Application: Cow-Shed Monitor

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!

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Questions

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

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