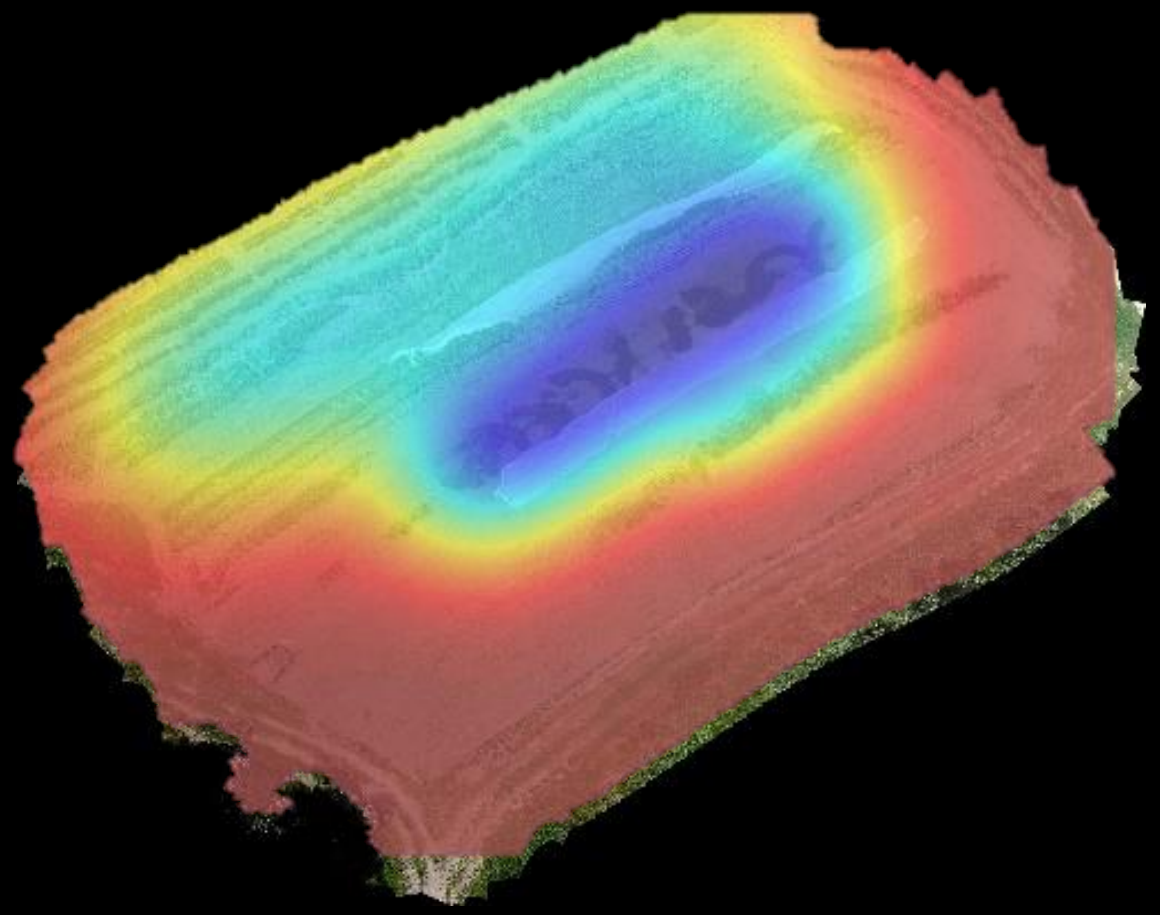
FarmBeats: AI & IoT for Data-Driven Agriculture

Microsoft

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

(Farmer's home/office)

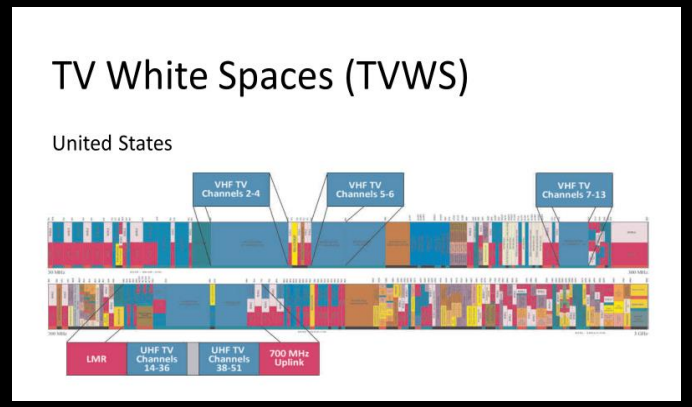
Cloud

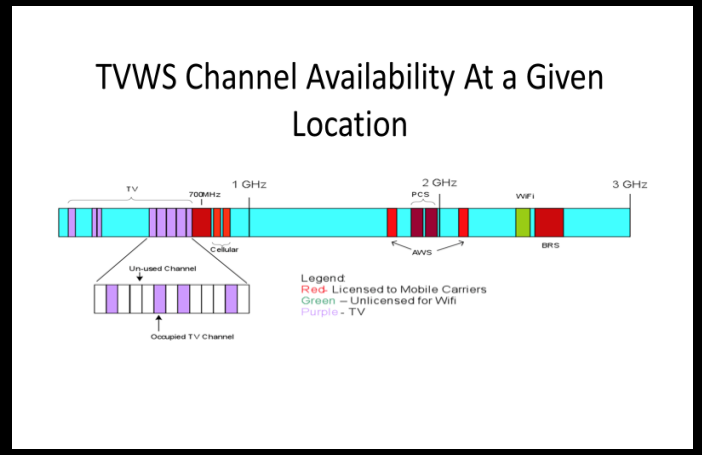
Sensors

- Few miles away
- Obstructed by crops, canopies, etc

TV White Spaces in the Farm

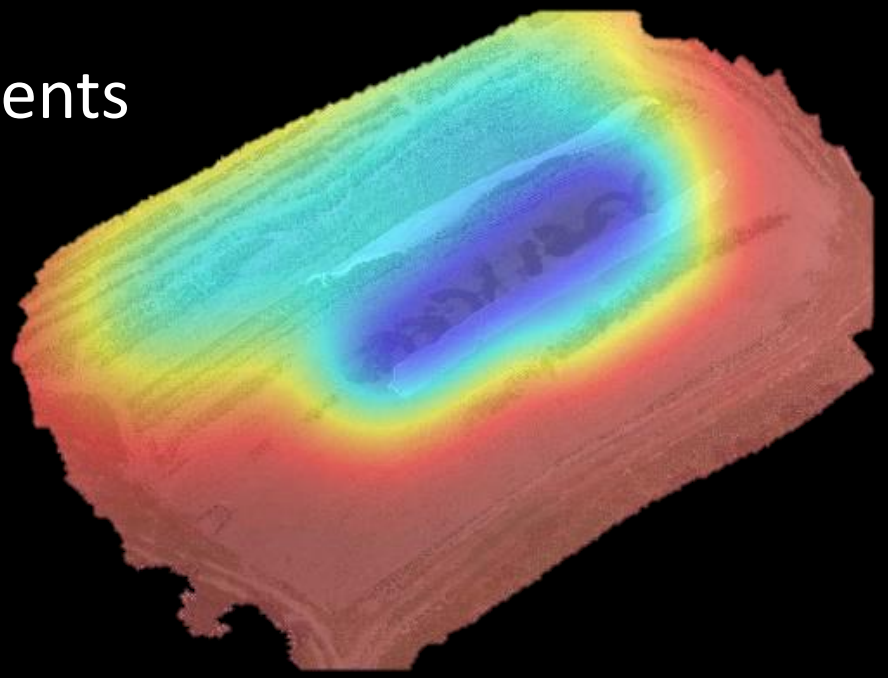
- What are the TV White Spaces?
  - Unused TV channels
- Benefits over Wi-Fi, Zigbee, etc
  - High throughput at long range
- Key insight for farms:
  - “lots” of TV spectrum is available, more than 100 MHz
  - Just like Wi-Fi router covers the home, TVWS base station can cover the farm





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?

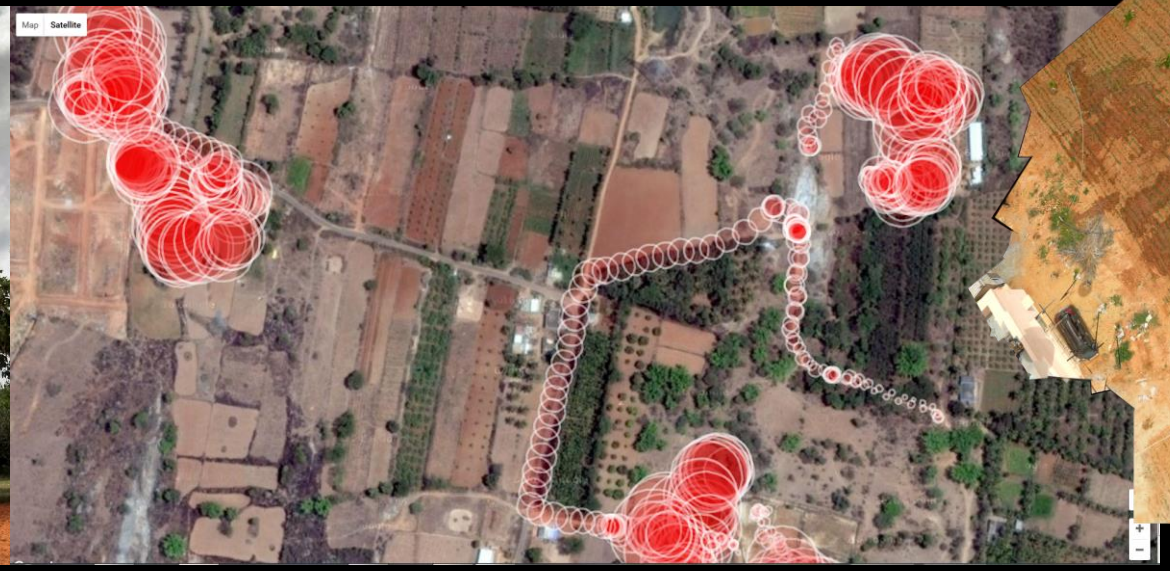
Idea: Use UAVs to Enhance Spatial Coverage

- 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)

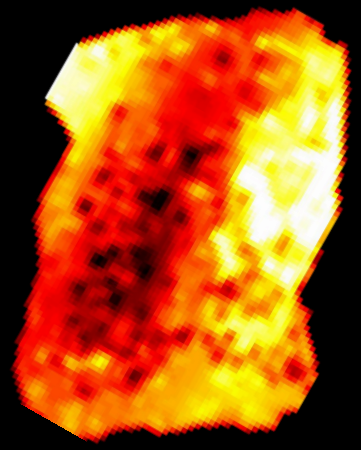
- UAVs have a few limitations:
  - limited battery life
  - Regulatory concerns
  - Cost > 1000 dollars



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

- Weak Connectivity
- Prone to outages

Base Station

TV White Spaces

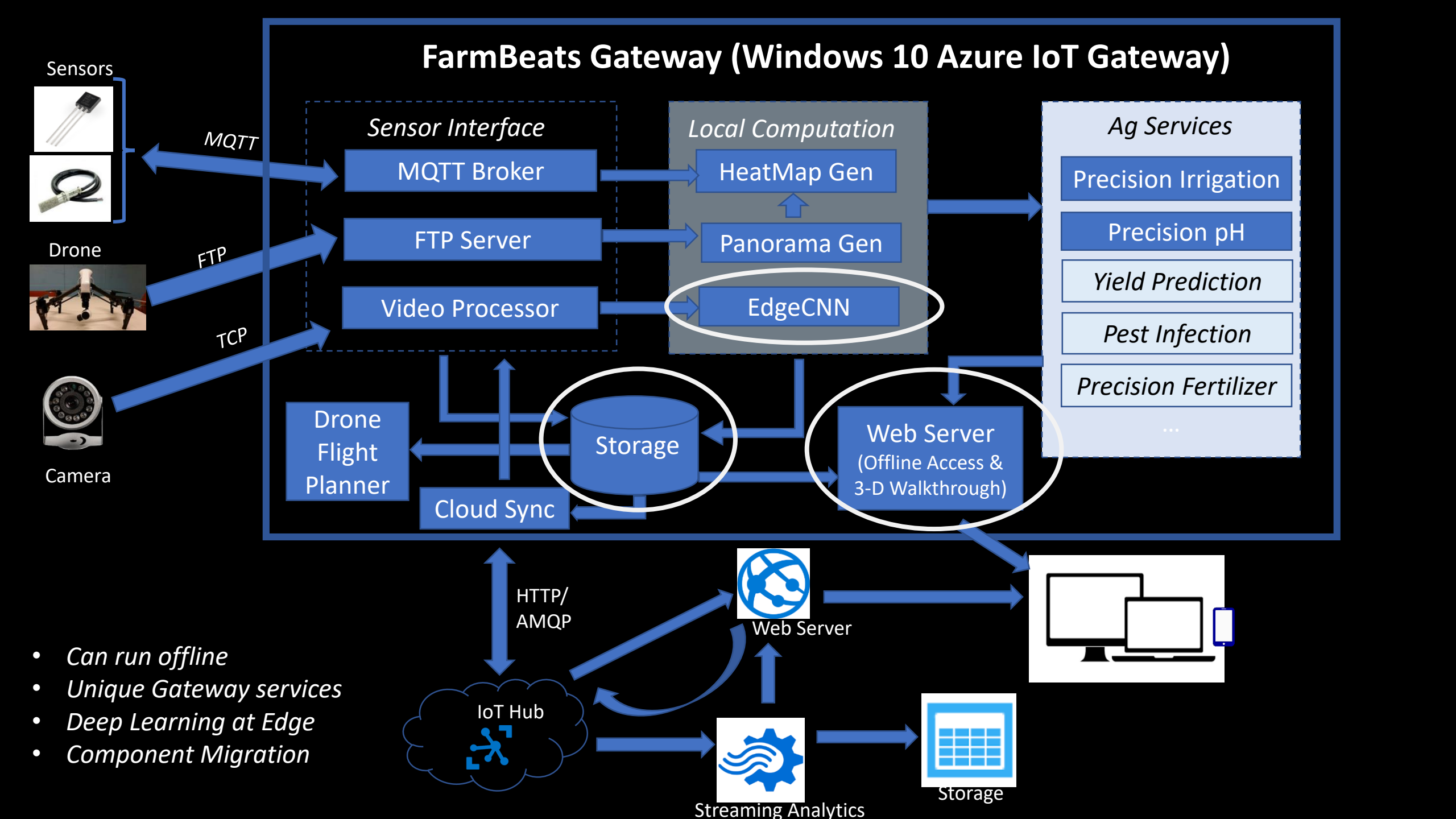
Few miles

(Farmer's home/office)

Cloud

Wi-Fi, BLE

Sensors



- *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

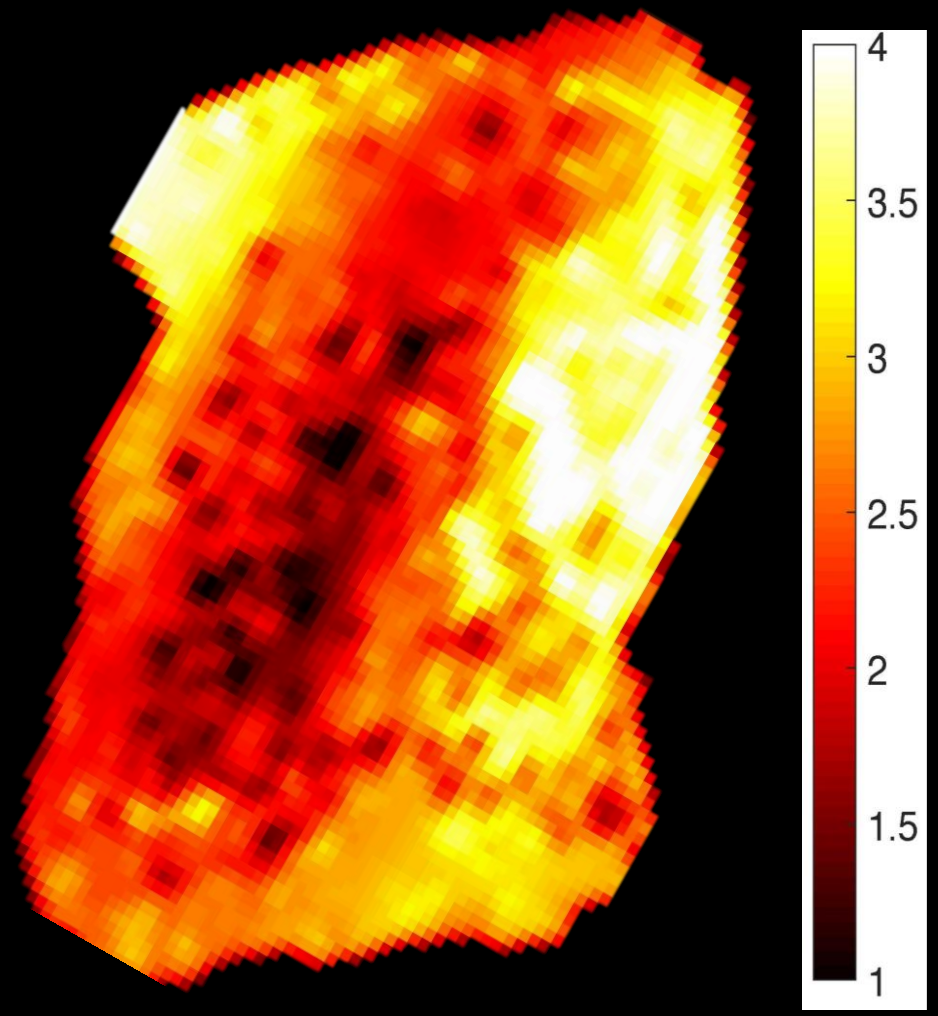
Cow excreta

Cow Herd

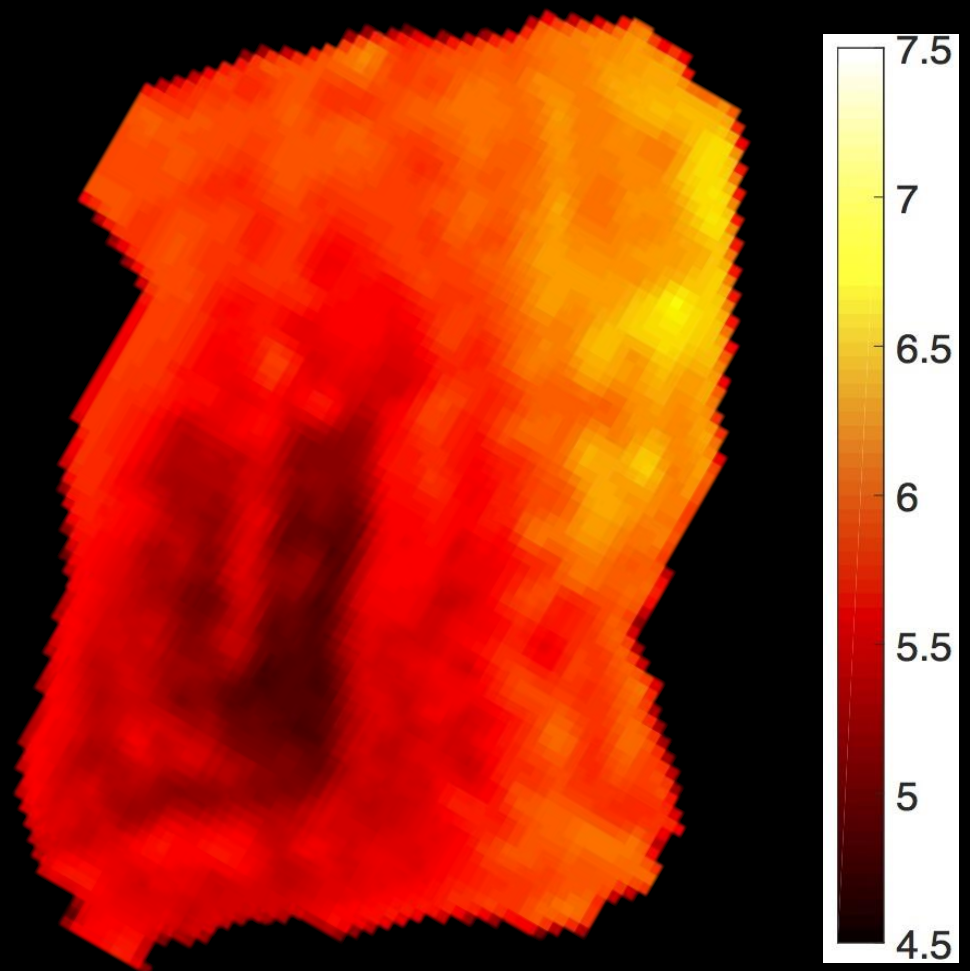
Stray cow

Precision Map: Panorama Generation

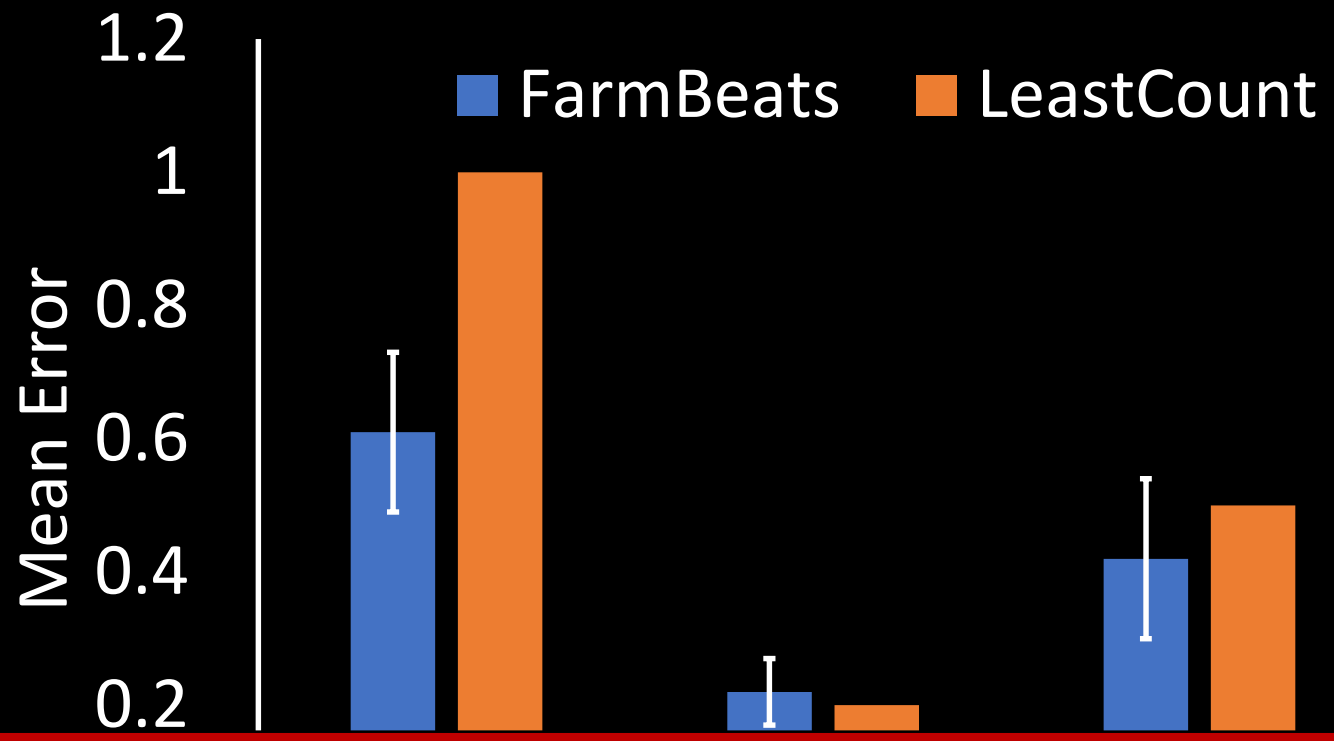
Precision Map : Moisture



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

Regulatory Challenges to IoT Applications in the TVWS

- TVWS technical rules developed with broadband use in mind
- Some of the issues for narrowband applications in the TVWS:
  - Conducted power spectral density limits
  - Conducted adjacent channel emission limits
  - A fixed or portable device – it depends
  - Height above ground level
  - Accommodation of PSME reservations that have to be registered quickly
  - Geolocation requirements

DSA Should Consider Adding a Narrowband Section to its Model Rules

- Some suggestions on what a framework might include:
  - Definition of narrowband white space devices
  - Limit operations only to data, no voice or video
  - Limit the frequency of data communications
  - Limit the maximum channel size to 100 kHz, although allow the bonding of up to two channels
  - Limit the maximum conducted and radiated power of a 100 kHz narrowband channel to that allowed in any 100 kHz of a broadband channel
  - Allow for geofencing
  - Increase height above ground level
  - Require that narrowband IoT channels can’t use the top and bottom 250 kHz in an available channel
  - Initially calculate separation distances assuming there is a 100 kHz narrowband TVWS signal operating on each 100 kHz segment within the 6, 7, or 8 MHz channel at maximum radiated power

Thank you!

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Questions

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

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