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)

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

Sensors

Cloud

Microsoft Azure
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

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
FarmBeats Gateway (Windows 10 IoT Gateway)

- **Sensor Interface**
  - MQTT Broker
  - FTP Server
  - Video Processor

- **Local Computation**
  - HeatMap Gen
  - Panorama Gen
  - EdgeCNN

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

- **Web Server**
  - (Offline Access & 3-D Walkthrough)

- **Storage**

- **Web Server**

- **IoT Hub**

- **Cloud Sync**

- **Streaming Analytics**

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


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