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

• 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
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

TV White Spaces

Few miles

(Farmer’s home/office)

Cloud

- Weak Connectivity
- Prone to outages

Wi-Fi, BLE

Sensors
FarmBeats Gateway (Windows 10 Azure IoT Gateway)

- Sensor Interface
  - MQTT Broker
  - FTP Server
  - Video Processor
- Local Computation
  - HeatMap Gen
  - Panorama Gen
  - EdgeCNN
- Web Server
  - Storage
  - Cloud Sync
  - Cloud Sync
- Drone Flight Planner
- Camera
- Drone
- FTP
- TCP

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

- 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
FarmBeats can accurately expand coverage by orders of magnitude using a sparse sensor deployment.
Application: Cow-Shed Monitor

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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:
  
  o Definition of narrowband white space devices
  
  o Limit operations only to data, no voice or video
  
  o Limit the frequency of data communications
  
  o Limit the maximum channel size to 100 kHz, although allow the bonding of up to two channels
  
  o Limit the maximum conducted and radiated power of a 100 kHz narrowband channel to that allowed in any 100 kHz of a broadband channel
  
  o Allow for geofencing
  
  o Increase height above ground level
  
  o Require that narrowband IoT channels can’t use the top and bottom 250 kHz in an available channel
  
  o 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


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