Empowering Farmers with Affordable Digital Agriculture Solutions

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Data-driven agriculture

Precision Agriculture has been shown to:

- Improve yield
- Reduce cost
- Ensure sustainability
New Opportunities…

Connected Farms
Data collection with sensor deployments, drone flights, and farm equipment

Al-based Advisory
Real-time, actionable insights based on the ground conditions combined with remote sensing and weather patterns

Precision Farming
Irrigation, Fertilizing, Weeding and Spraying applications

Traceability
Use of blockchain to track usage & compliance
New Opportunities

Scaling up Disruptive Agricultural Technologies in Africa, August 19
According to USDA, high cost of manual data collection prevents farmers from using data-driven agriculture.
Challenge: Farm connectivity

Few miles away and obstructed by crops, canopies, etc.
Challenge: Farm connectivity

TV White Space frequencies used to carry data signals

Cloud

Farmers home/office

Base station

Soil Moisture Sensors

Drone Video

Wind Speed/Direction Sensors

Tractor
Microsoft Research has been studying this for over a decade...

Networking Over White Spaces (KNOWS)

TV channel on network

Unused TV channel
Airband

Active Projects: 69
Population Covered: 11,778,136
Population Connected: 594,918
Energy Access: 705,360

Project Locations

Internet Access by Project Type

Energy Access by Funding Type
Challenge:
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
SpaceEye: AI for Seeing Through Clouds in Satellite Imagery

- Uses **RADAR** signals that can penetrate clouds
- Combines data from radar and optical satellites to **reconstruct imagery hidden by clouds**
- Powered by new machine learning and AI techniques
Idea: Use Drones to Enhance Spatial Coverage

- Drone Video
- Panoramic Overview
- Sparse Sensor Data
- Precision Map
FarmBeats uses satellites & drones to enhance spatial coverage.

**Precision Map:**
- **Moisture**
- **pH**

**Color Maps:**
- **Moisture** scale: 1 to 4
- **pH** scale: 4.5 to 7.5

![Satellite and drone icons]
The Real World

- Cloud
- Weak connectivity
- Prone to outages
- Farmers home/office
- Base station
- Soil Moisture Sensors
- Drone Video
- Wind Speed/Direction Sensors
- pH Sensors

Whitespace frequencies used to carry data signals
The Real World

Weather Data (rain, wind, pollen)  Seed vendors / Argonomists / Farmers

Recommendations (daily best practices)

Cloud

FarmBeats Gateway (Azure IoT Edge)

Farmers home/office  Base station

Sensors

Whitespace frequencies used to carry data signals
FarmBeats Gateway (Azure IoT Edge)

- MQTT Broker
- FTP Server
- Video Processor
- HeatMap Gen
- Panorama Gen
- Edge CNN
- Drone Flight Planner
- Storage
- Web Server

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

IoT Hub

Web Server

Streaming Analytics

Storage
Deployment

Deployments in several locations including WA, CA, NY

Farm sizes range from 0.5 – 9000 acres

Sensors:
• DJI Drones
• FarmBeats sensor boxes with soil moisture, temperature, wind speed/direction sensors
• IP Cameras to capture IR imagery as well as monitoring

Cloud Components: Azure IoT Suite
Micro-Climate Forecasting

Goal:
Microclimate weather forecasting model based on FarmBeats sensors in the field.

Impact:
Knowing microclimate enables better modeling of plant diseases, application timing, and risk management.

Challenges:
Forecast important variables for accurate plant disease prediction, not included in current weather forecasts (results shown).

Results:
Soil moisture & temperature forecasting error less than 10%.

Forecast for low temp was 42 degrees. Micro-Climate forecast was 31 degrees in lower areas of the field. Actual was 30 degrees. Instead of spraying grass herbicide, the farmer waited and avoided large crop damage in some of the most productive areas.

*The lower the error, the better the prediction.
Example: Panorama

- Water puddle
- Cow excreta
- Cow herd
- Stray cow
Precision Map: Panorama Generation
Precision Map: Moisture
Precision Map : pH
Application: Cow-Shed Monitor
Strobe: low-cost soil moisture and EC sensing using Wi-Fi

Motivation: existing sensors are expensive
• ~100s of dollars

Strobe design: Wi-Fi cards with 2+ antennas
• Relative time-of-flight & amplitude

Results: Strobe can accurately detect moisture and EC change in soil

- Sandy loam
- Silt loam
- Potting S1
- Potting S2
- Potting S3

Strobe calibrated
Decagon GS3 sensor
Simulate farms with various conditions – different plant growth stages, field area, field abnormalities, species of plants, etc.

Validating ML models
- Different conditions
- Different Farms
- Different seasons ...

Example – crop counting

Different Corn growth stages
- Stage 0 – 0 inches
- Stage 1 (V1) – 13 inches
- Stage 2 (V2) – 18 inches
- Stage 3 (V3) – 30 inches
- Stage 4 (V4) – 42 inches
- Stage 5 (V7) – 67 inches
- Stage 6 (V9) – 91 inches
- Stage 7 (V12) – 105 inches
- Stage 8 (VT) – 113 inches
- Stage 9 (R2) – 117 inches
- Stage 10 (R6) – 115 inches

Parameter Tuning adapts model

Total crop count = 260
Model adaptation to increase accuracy!
Microsoft’s Approach to Agriculture

Research
- FarmBeats IoT, Cloud, AI
- Indoor Farming
- Simulations

Products
- Azure IoT, IoT Edge
- Azure Blockchain
- Azure FarmBeats

Societal Impact
- AI for Earth
- AirBand
- TechSpark
Microsoft brings technology & IT skills support to World Bank’s One Million Farmers program
Conclusion

**FarmBeats**: A system that enables seamless data collection and insights for agriculture

Acts as a tool to enhance farm and farmer productivity

**Microsoft’s entire stack for Agriculture:**

Data Capture (Azure IoT), providing Insights (Power BI), secure storage (Azure Data Lake), Traceability (BlockChain), AI & ML (Azure ML & Cognitive Services)