FarmBeats: Empowering Farmers with Affordable Digital Agriculture Solutions

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The Agricultural Challenge

Global Access

1 in 9 people are undernourished (UN)

65% Reduce poverty for 65% of the world’s poor who live in rural areas and work in farming

70% more food is needed by 2050

Sustainable Production

70% of global water resources are needed for Agriculture

24% of global greenhouse emission comes from Agriculture

251T liters of water to be saved in 2030 from implementing Smart Agriculture

Need for Economic Growth

30% of global workers are employed by Agriculture

10-30% Agriculture contributes 10% of global GDP and up to 30% in low income countries

$4.8T Global Agriculture revenue

Source: Sustainability development goals, UNITED NATIONS 2017
Data-driven agriculture

Precision agriculture has shown to:

- Improves yield
- Reduces cost
- Ensures sustainability
New Opportunities...

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

**AI-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
According to USDA, high cost of manual data collection prevents farmers from using data-driven agriculture.
An end-to-end system that enables seamless data collection and insights for agriculture

FarmBeats
Challenge: Farm connectivity

Cloud

Farmers home/office

Few miles away and obstructed by crops, canopies, etc.

- Soil Moisture Sensors
- Drone Video
- Wind Speed/Direction Sensors
- pH Sensors
Challenge: Farm connectivity

Farmers home/office
Base station

Cloud

Soil Moisture Sensors
Drone Video
Wind Speed/Direction Sensors
pH Sensors

TV White Space frequencies used to carry data signals
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

Project Count by Project Type

Internet Access: 12
Energy Access: 10
Agri. / IoT: 45

Project Count by Funding Type

Grant: 25
Pilot: 20
Commercial: 19
Grant - Other: 3
(Bank): 1
(TIE): 1
TV White Spaces in the Farm

What are the TV White Spaces?
Unused TV channels

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:
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 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
Idea: Use Drones to Enhance Spatial Coverage

Drone Video → Panoramic Overview → Sparse Sensor Data → Precision Map
Idea: use drones/balloons to enhance spatial coverage

FarmBeats can use drones to expand the sparse sensor data and create summaries for the farm.
Challenge: Cloud Connectivity

- Weak connectivity
  - Prone to outages

- Cloud
- Farmers home/office
- Base station

Whitespace frequencies used to carry data signals

- Soil Moisture Sensors
- Drone Video
- Wind Speed/Direction Sensors
- pH Sensors
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
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.*

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<table>
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<th>Number of Forecasted Data</th>
<th>Mean Absolute Percentage Error</th>
<th>Soil Moisture</th>
<th>Soil Temperature</th>
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<td>4.5</td>
<td>5.0</td>
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<td>Model 2</td>
<td>3.8</td>
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<td>5</td>
<td>Model 3</td>
<td>3.0</td>
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</table>
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

2016-02-22 13:31:49
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

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**Results:** Strobe can accurately detect moisture and EC change in soil
GAUDI – Multi modal simulations for driving farm intelligence

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

Current Model – 447 plants

Different farm & weather conditions

Same Model – 187 crops, the model misses a few plants!!

Parameter Tuning adapts model

Total crop count = 260
Model adaptation to increase accuracy!

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

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)
Investment focus areas

- Series A-C investments
- Financially focused
- Check size $2M-$10M
- Board engagement
- Enterprise only
- Founder friendly