SmartFarm: Computing Research for the Next-Generation of Precision Agriculture

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Using Computing to Sustainably Feed a Growing Population Panel
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Precision Agriculture (Ag)

- Adapt farm practices to crop/field variability to increase production
  - Measure & understand variability
  - Use this information to optimize input use
  - Automate some/all of these steps
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- Computing research
  - Observation (sensing, measuring) & actuation
  - Algorithms: AI, ML, statistical/data analyses
  - Systems: Hardware & software for automation and decision support

- Plus multidisciplinary research collaborations to tailor solutions to Ag
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The Cloud + Data Analytics Has Revolutionized E-Commerce
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- What will you buy?
- When will you buy it?
- What will you pay?

Cloud Computing Systems

Math and Statistics (Code!)

Algorithms: Inference & Prediction
The Cloud + Data Analytics Has Revolutionized E-Commerce

Observation

Cloud Computing Systems

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Algorithms: Inference & Prediction

- What will you buy?
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Can we use it to revolutionize agriculture?
Revolutionizing Precision Ag

- Sensing, measuring, and monitoring
  - Vast amount of data surrounding the crop lifecycle
    - Weather, records, sensors, imagery, ...
  - Sense/actuate: Internet of Things (IoT)
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  - If tailored to the Ag domain
    - Leverage multi-disciplinary collaboration
    - Provide data driven decision support + automation

- What should I grow?
- When should I water?
- What will my yields be?
Revolutionizing Precision Ag

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What about the systems?

- What should I grow?
- When should I water?
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Cloud Systems Were Not Designed for Rural Precision Agriculture

- Clouds work for large scale data aggregation, processing, sharing
- Rural precision Ag introduces **new challenges**
  - Vast acreage to sense, measure, monitor, actuate, & automate
    - Sensors/actuators: large in number, very low cost, **battery powered** + solar, resource constrained, in harsh environments
    - Can’t ship data to cloud: Radio power goes like the square of the distance
    - Many decisions/operations are *purely local* - moving this data is wasteful
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- Intermittent or no Internet connectivity
- Data privacy = grower’s economic advantage
Our Approach:
Move the cloud (code) to the data
Sensing Tier

Edge Tier

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Edge Systems

On-Farm

Public-cloud-compatible

Mini clouds

Resource Constrained

No Internet Connection? No Problem.
Sensing Tier

Edge Tier

Our Approach:
Move the cloud (code) to the data

Edge Systems
On-Farm
Public-cloud-compatible
Mini clouds

Data travels much shorter distances!

No Internet Connection? No Problem.

Resource Constrained
Sensing Tier

Edge Tier

Our Approach: Move the cloud (code) to the data

Cloud Tier

Edge Systems
- On-Farm
- Public-cloud-compatible
- Mini clouds
- Grower controls data sharing

Resource Constrained

Public Clouds

Resource Rich

Public clouds

Amazon web services

Microsoft Azure

Google Cloud Platform
Our Approach: Move the cloud (code) to the data

Edge Tier:
- Edge Systems
  - On-Farm
  - Public-cloud-compatible
  - Mini clouds
  - Grower controls data sharing

Cloud Tier:
- Data analytics apps
- External data sources
- Public Clouds
  - Amazon Web Services
  - Microsoft Azure
  - Google Cloud Platform

Resource Constrained
- Sensing Tier

Resource Rich
- Cloud Tier
Our Approach: Move the data ONLY as far as required.
How Can We Write Apps for Such a Complex System?
Goal: Expedite Innovation in Precision Ag

- Our Approach:
  - SPOT: Software platform for Apps
  - Apps run on all tiers without modification
  - Security, access, & deployment control
  - Designed for on-farm use
    - 100x more power efficient
    - Than existing cloud/edge solutions
  - Free & open source
Lessons Learned: The Future of Precision Ag

- Academia has freedom to consider new approaches
- Cloud works well for some things
- Domain-specific design = new directions with vast potential
- Build communities & demonstrable deployments via open source

- Collaborations are key to expediting innovation
- Across disciplines; academia, government, & industry

Exciting Innovations Just Over the Horizon...
A New Kind of Computer Science Research for Ag

Academia + Industry + Government
• Systems + Algorithms + Domain Sci.
• Problem driven & empirical
  • Sustainable, efficient, useful
• Societal & regional impact
• Multidisciplinary collaboration
• Demonstrable, applied, & open
• Engage students & farm communities
Thanks!

- **Collaborators:** UCSB, Lindcove REC, CalPoly, Fresno State, UCDavis, UCR, NCState, Powwow Energy, Sedgwick Reserve, Private Growers

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**UCSB RACELab**

The Lab for Research on Adaptive Computing Environments

Computer Science Department, Harold Frank Hall (E-5), Santa Barbara, CA

**Students:**

- Fatih Bakir
- Kerem Celik
- Gareth George
- Shereen Hussein
- Wei-Tsung Lin
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