DIGITAL AGRICULTURE

TECHNOLOGY INNOVATION IN COMPLEX PRODUCTION ENVIRONMENTS

Harold van Es
CHALLENGES WITH AGRICULTURE

• Feed a global population of 10B by 2050 with diminishing land and water resources.
  • More crop per drop
  • More crop per grain of soil
• Agriculture is complex:
  • interacting physical, biological, and chemical processes,
  • wide diversity of production environments, practices, and socio-economic conditions
CHALLENGES WITH AGRICULTURE

• Agriculture creates sustainability concerns:
  • High water and energy use
  • Environmental problems (water & air quality, GHG, soil degradation)
  • Labor issues (availability, working conditions, chemical exposure)
WHAT IS DIGITAL AGRICULTURE?

• deployment of computational and information technologies to improve production, profitability and sustainability in agriculture

• offers opportunities through the ubiquitous availability of highly interconnected and data-intensive technologies (*Fourth Industrial Revolution*)

• applies to all crop and livestock systems

bit.ly/NYSDigitalAgReport
DIGITAL AGRICULTURE
TECHNOLOGY INNOVATION IN COMPLEX PRODUCTION ENVIRONMENTS

Better Food
Profitable Farms
Sustainability

Data analytics
System optimization
Smart machines
Science

after Nyrop
DIGITAL AGRICULTURE IS “INDIVIDUATION”

Reflects a shift from generalized management of farm resources towards highly optimized, individualized, real-time, hyper-connected and data-driven management.

Data are key.....
DIGITAL AGRICULTURE ENABLING TECHNOLOGIES

1. Cross-Cutting

- Computerized Farm Management Systems
- Computational Decision Tools
- The Cloud
- Sensors
- Robotics
- Digital Communication Tools (cellular, broadband, etc.)
DIGITAL AGRICULTURE ENABLING TECHNOLOGIES

2. The Field

- Precision geo-locationing (GPS, DGPS, RTK)
- Geographic Information Systems (GIS)
- Yield Monitors
- Precision Sampling
- Spectral Sensing (Proximal and Remote)
- UAV/UAS (drone)
- Auto-steering and Guidance
- Variable Rate Technology
Yield Monitor Data

- High spatial resolution
- Insights into yield-limiting factors
- Multi-year data most valuable for data mining
- Annual variation
Simple Data Analytics
Profitability assessment from yield monitor data

All profitable
Clear profitability zones
Economically sensitive

Profitability ($/acre) based on $550 cost of production

Cornell University
College of Agriculture and Life Sciences
AUTOSTERING TO FIELD ROBOTS

- Timely field operations
- Labor savings
- In-season management
- Real-time sensing and application
- Multiple units to achieve tasks

Rowbot.com
SPECTRAL REFLECTANCE SENSING

Platforms
- Satellite
- Airplane
- UAV
- Proximal
Visible (RGB)
Multispectral V-NIR (3-5 bands)
Hyperspectral (100+ bands)
RESEARCH APPLICATION:
FIELD-BASED RAPID PHENOTYPING

Credit: Andrade-Sanchez and Heun
Gore and Thorpe
SPATIAL AND TEMPORAL N MANAGEMENT
(ADAPT-N, FACILITATED BY THE CLOUD)
RECOMMENDATIONS VS ECONOMIC OPTIMUM N RATE

On average 26$/ac higher profit, 65 lbs/ac less N applied and 53% reduction in environmental losses
DIGITAL AGRICULTURE ENABLING TECHNOLOGIES

3. Livestock

• Radio Frequency Identification (RFID)

• Automatic Milking and Feeding Systems

• Livestock Software Models
CONTROLLED ENVIRONMENT AGRICULTURE
INDOOR OR GREENHOUSE
DIGITAL AGRICULTURE INVESTMENTS

1. **Capital investments** that promote efficiencies (computer hardware/software; robotic milking systems; auto-steering; VRT equipment; sensors; yield monitors)

2. **Service investments** that provide actionable information (remote sensing; cloud-based nutrient models; feeding models; etc.). Typically on per-acre cost basis.

3. **Farm knowledge investments**: Actionable information for a specific farm, animal, or field location (optimum variety and seeding rate, site and time-specific fertilizer and pesticide application, field workability, etc.)
INDIRECT BENEFITS OF DA

• New knowledge
• On-farm research; improved research technologies
• Climate change adaptation and mitigation
• Record keeping
• Employment
  • Reduced unskilled labor through automation and robotics
  • More skilled and professional jobs
  • New ag-tech companies
Nebraska farmers survey (Castle et al., 2015):

- Survey respondents were comfortable sharing their data with trusted partners, such as university researchers or educators (45%), relatives (39%), and local cooperatives (39%).
- But more respondents trusted their data with “no one” (23%) than with equipment dealers (18%), equipment manufacturers (17%), or neighbors (13%).
Ag Data Transparent aims to function as an industry watchdog by offering certification on data ownership, privacy, aggregation, sharing, transparency, consistency, portability, anonymization, and opt-outs.

• Remaining concern:
  • the vast majority of farm data will be stored and controlled by large equipment or seed/chemical companies.
  • this will constrain future public research efforts for next-generation agricultural management guidelines.
Ag-Data Explorer

SSURGO Soils Map & Data
View breakdown of soil type and average NCCPI (National Commodity Crop Productivity Index) for this field.

Avg NCCPI = 0.62

<table>
<thead>
<tr>
<th>Soil</th>
<th>Acres</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cazenovia silt loam, 2 to 8 percent slopes</td>
<td>12.78</td>
<td>41.94%</td>
</tr>
<tr>
<td>Lakemont silty clay loam, 0 to 3 percent slopes</td>
<td>1.34</td>
<td>4.39%</td>
</tr>
<tr>
<td>Odessa silt loam, 0 to 3 percent slopes</td>
<td>14.58</td>
<td>47.85%</td>
</tr>
<tr>
<td>Ovid silt loam, 2 to 6 percent slopes</td>
<td>1.77</td>
<td>5.82%</td>
</tr>
</tbody>
</table>

Credit: Joshua Woodard

Harold van Es – Digital Agriculture: Technology Innovation in Complex Production Environments
Regulatory community needs to adapt to a more complex digital farming environment

Record keeping

• Digital yield and as-applied records from fertilizer, manure and pesticide applicators are documented
  • rationale for fertilizer/pesticide decisions
  • incentive payments (carbon credits, green payments, etc.)
• Animal records can document animal treatment, justify the use of health interventions, and facilitate product source tracking.
COMMUNICATION AND TELEMATICS IN RURAL AREAS

- GPS
  - Low vs high accuracy
  - Coverage
  - Consistent availability
  - Public vs private networks
- Cellular (incl. position correction)
- Broadband
SUMMARY THOUGHTS

• Agriculture is challenged in multiple ways
  • Future production needs
  • Sustainability

• Digital Agriculture poses opportunities to address complexity and uniqueness of production environments

• Benefits for broad-acre crops to high-value products

• Science and engineering need to be combined with business innovation to achieve desired outcomes