NNI Sensor Workshop: The challenges in taking sensors from lab to machine

Ernest Streicher
9-10-2014
## Agenda

<table>
<thead>
<tr>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Deere at a Glance</td>
</tr>
<tr>
<td>Sensor use in Agriculture</td>
</tr>
<tr>
<td>Challenges for on machine use</td>
</tr>
<tr>
<td>Case Study: Oil Condition Sensing</td>
</tr>
<tr>
<td>What’s Next</td>
</tr>
</tbody>
</table>
John Deere at a Glance

- **Headquarters:**
  Moline, Illinois, United States

- **Samuel R. Allen**
  CEO and chairman since 2010

- **Employees worldwide:**
  67,000

- **Total net sales and revenues:**
  $37.795B

- **Net income:**
  $3.357B

- **R&D**
  $1.477B
  → $5.7M each working day

- **Capital Investment**
  $1.158B
John Deere’s Solution Portfolio

- Agricultural Equipment
- Construction Equipment
- Turf Equipment
- Forestry Equipment
- Financial Services
- Power Systems
- Intelligent Solutions Group
- Worldwide Parts Services
Serving those linked to the land
# Phases of AG-Technology

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Solutions</td>
<td><img src="image1.png" alt="Example Image" /></td>
</tr>
<tr>
<td>Intelligent Equipment</td>
<td><img src="image2.png" alt="Example Image" /></td>
</tr>
<tr>
<td>Scale / Productivity</td>
<td><img src="image3.png" alt="Example Image" /></td>
</tr>
<tr>
<td>Basic Mechanization</td>
<td><img src="image4.png" alt="Example Image" /></td>
</tr>
</tbody>
</table>
## Sensors Developed by Evolution

**Motivations:**
- Food
- Survival
- Quality of life (safety and comfort)

<table>
<thead>
<tr>
<th>Biological Sensor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight (dark-adapted eye)</td>
<td>10 photons/sec-cm$^2$</td>
</tr>
<tr>
<td>Infrared (snake)</td>
<td>$10^{-4}$ W/cm$^2$ @ 300 K</td>
</tr>
<tr>
<td>Acoustic (ear)</td>
<td>0.5-angstrom vibrations</td>
</tr>
<tr>
<td>Electric field (fish)</td>
<td>$10^{-2}$ $\mu$V/m</td>
</tr>
<tr>
<td>Displacement (scorpion)</td>
<td>1 angstrom</td>
</tr>
<tr>
<td>Smell (moth)</td>
<td>1 molecule</td>
</tr>
<tr>
<td>Ultraviolet radiation (bird)</td>
<td>$10^{10}$ photons/sec-cm$^2$</td>
</tr>
<tr>
<td>Seismic (frog)</td>
<td>1 micro-g</td>
</tr>
<tr>
<td>Magnetic (pigeon)</td>
<td>$10^{-2}$ gauss</td>
</tr>
<tr>
<td>Smart sensor (frog’s eye)</td>
<td>“On-chip” processing with algorithms for array processing, edge enhancement, and changing contrast</td>
</tr>
</tbody>
</table>
Sensor Applications

Machine control:
Pressure, position, speed

Sensing Machine Output:
Yield
Weight
Moisture

Sample collection:
Soil characteristics
Grain quality
Moisture
Oil Condition
How big is Ag Business for Sensing Needs?

Millions:
Machines, Farms

Billions:
Agronomic Zones

Trillions:
Plants
Challenges moving from lab to machines

The Environment

Obtaining a representative sample

Value Proposition
  Accuracy versus cost
  Predicting customer value

Component Availability
  Supplier and technology
Environment for on Machine sensors

Temperature

Storage: -40C/+85C
Operating: 0-70C

Vibration

Dust

Chemicals
Sampling challenges

Moving crop

Non – contacting preferred

Uniform sample
Videos of operations

Environment on and around the machine

Material flows for sampling

Sensors in use

https://www.youtube.com/watch?v=hqC_HhubyJM&feature=youtu.be
http://www.youtube.com/watch?v=C9g0q9QYe4Y
http://www.youtube.com/watch?v=Sxxf5lqzhi8
http://www.youtube.com/watch?v=5N-JzQOIN2M
## Case Study - Fluid Property Sensor

### Year 1 Activities

<table>
<thead>
<tr>
<th>Program Activities</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Prototypes  &lt;br&gt;Lab measurements  &lt;br&gt;Plan production design</td>
</tr>
<tr>
<td>Application</td>
<td>Plan mounting locations  &lt;br&gt;Plan fluids</td>
</tr>
<tr>
<td>Customer Feature</td>
<td>Prognostics  &lt;br&gt;Extend change intervals  &lt;br&gt;Eliminate oil scanning</td>
</tr>
</tbody>
</table>

[Graph showing viscosity over time with labels for Northland Viscosity at 100°C, Northland Limit, FPS Viscosity - Temp Compensated, FPS Warning, and FPS Alarm.]
## Case Study - Fluid Property Sensor

### Year 2 Activities

<table>
<thead>
<tr>
<th>Program Activities</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Production intent Verification tests and corrections</td>
</tr>
<tr>
<td>Application</td>
<td>Test on vehicle Resolve application issues Diagnostics</td>
</tr>
<tr>
<td>Customer Feature</td>
<td>Prognostics Extend change intervals Eliminate oil scanning</td>
</tr>
</tbody>
</table>
## Case Study - Fluid Property Sensor

### Year 3 Activities

<table>
<thead>
<tr>
<th>Program Activities</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Production ready</td>
</tr>
<tr>
<td>Application</td>
<td>Continue field testing</td>
</tr>
<tr>
<td>Customer Feature</td>
<td>Early warning for major issue</td>
</tr>
<tr>
<td></td>
<td>Trigger oil scanning</td>
</tr>
</tbody>
</table>
Case Study – Fluid Property Sensor

Year 4 Activities

Customer feedback –

Insufficient value, continue oil scanning

Re-evaluate sensor plans
Unique Opportunities Because of Nano

Remote sensing – eliminates sampling problem

More data points versus grid sampling

Opportunity to sense more parameters: constituents/chemistry
## Agenda

- John Deere at a Glance
- Sensor use in Agriculture
- Challenges for on machine use
- Case Study: Oil Condition Sensing
- What’s Next
Thank You!