Improved bean and carrot irrigation using automated site-specific control and sensing

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NCEA-IWRM full-time research staff:
5 agricultural engineers
1 mechatronic engineer
2 electronic engineers
2 software engineers

NCEA-IWRM in 2016-17:
Current projects: 6;
Current students: 4 PhD, 3 Hon.

NCEA-ARM full-time research staff:
5 mechatronic engineers
5 electronic engineers
4 software engineers
2 mechatronic professors

NCEA-ARM in 2016-7:
Current projects: 7;
Current students: 6 PhD, 3 Hon.;
CASA-approved Remote Pilots: 2
Need for precision in farming inputs
Site-specific irrigation

- Can be over 200% variation in irrigation requirements: soil water holding capacity, elevation
- Variable-rate irrigation (VRI) hardware and variability mapping can be used

Dairy pasture in Tasmania: Horticulture field in Kalbar:
VRI hardware

- Solenoid valve on each dropper
- Zones controlled with pulse width modulation and speed control to adjust flow rate
- Valley, Lindsay Zimmatic, Reinke, Trimble
Commercial VRI use

- Cost about $1500/ha – includes VRI hardware, GPS, software, remote access
- Generally 0-20% yield increase or water reduction reported in literature
- Generally used for avoiding roads
- Only 10% of VRI purchased still used
VRI research

- Research trials in horticulture, corn, pasture and cotton in Australia, New Zealand and USA
- Inputs are soil type, soil moisture, temperature, crop growth

IRTs in Texas: Cameras in QLD:
Prescription map development

- Centre pivot fields divided into $1^\circ$ sectors and zones
- Original VRI systems needed manual entry of volumes
- SST/PCT can export data to define zones

Original map:  VRI map:
Monitoring soil moisture
Monitoring – aerial imagery

Variability in bean canopy:
Monitoring – machine imagery

Smartphone camera

Height from quad bike sensor

Canopy cover from cameras

0 Height (mm) 250
NCEA VRI research

- CPLM VRI is historical map based
- Developing automated control strategies

1. Sensors
   - fixed sensors
   - historical maps
   - on-the-go sensors

2. Control strategy
   - convert data to irrigation application
   - model-based control needs calibration with infield data

3. Real-time irrigation adjustment
   - actuators to apply irrigation
Control system components

- Data input – real-time fixed sensors, historical maps, on-the-go sensors
- Control strategy – algorithms to convert sensor data to irrigation requirement
  - Model-based control needs calibration with infield data
- Actuators – apply irrigation requirement

Model calibration

Pulsing solenoids on VRI

Source: Valley
Model calibration

- Model is calibrated in each cell
- Sensitivity analysis to determine input parameters to adjust
- Automatically adjust input parameters until output reflects measurements
Data pre-processing

- Convert all data layers to spatial grid
- Kriging to assign value to each cell within field
- Robustness evaluation being conducted on number and location of sensors and cameras required

Fixed sensor  Ground vehicle  Cameras on pivot
Simulation of sensor-based control

1. EM38 map imported into VARiwise
2. Plant available water content map
3. Centre pivot uniformity can be imported
4. Control options
   A. Fixed irrigation schedule
      Irrigation is applied according to user-specified dates and amounts
   B. Soil moisture deficit-triggered irrigation
   C. Adaptive control

<table>
<thead>
<tr>
<th>Sensor location</th>
<th>Variability in machine uniformity</th>
<th>Yield (bales/ha)</th>
<th>Irrigation water use efficiency (bales/ML)</th>
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</table>
Control system on centre pivot
Real-time camera-based plant sensing to update irrigation:
Practical on-farm machine vision systems
Other machine vision: 
Irrigation monitoring

Thermal images from tower

Drone

Camera tower

Thermal images from tower

Ground  Crop

Water
Other machine vision: Remote site monitoring

Real-time image analysis can detect shape, colour, height

Wheat variety trial

Wheat flowers

Commercial funding body
Aim:
Perform image analysis of drone imagery of a field to automate scouting operations, e.g. look for weeds

Method:
• Perform flight: 23.5 Ha, 2.34 cm / pixel
• Process images into orthomosaic: time 4 hours, 34000 x 31000 pixels
• Analyse images: green-from-brown, time 60 seconds
• Convert pixel co-ordinates to GPS and create KML (Google Earth) file

Results:
• Orthomosaic with <10cm to 10m error
  ➢ Prescription map for spray tractor
  ➢ Extend to weeds in crop, plant size and real-time processing

Other machine vision:
Weed spot spraying
Summary

- Framework developed for data processing at a range of spatial resolutions
- Linked control strategy output with commercial VRI system for cotton and dairy irrigation sites

Next steps

- Online data management and processing for cotton and dairy data and control
- Evaluation of control strategies at all sites over next year