Field Robotics and Intelligent Systems

Salah Sukkarieh
Partners/Sponsors

- The University of Sydney
- Australian Government Research Council
- Horticulture Innovation Australia
- Australian Department of Agriculture, Fisheries and Forestry
- GRDC
- Australian Government
- NSW Department of Primary Industries
- MLA
- Australian Government Land & Water Australia
- Queensland Government
- Queensland Government Department of Agriculture and Fisheries
- Forest & Wood Products Australia
- AUSVEG
- APAL
Outline

- Air Robotics and Intelligent Surveillance Systems

- Ground Robotics and Machine Learning - the 20%

- Ground Robotics and HMI - the 80%

- Looking ahead
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1999-2007: Demonstration of a Decentralised Air Surveillance System

Build your own system...
(platform, navigation, sensing, flight control...)

~$700k / platform
Terrain Mapping – Single and Cooperative
2006: Plate from Costs Decrease ~$50k, Autopilots become available ~$30k

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2007
Machine Learning Starts
(Support Vector Machines become popular)
2008-2010: Better Machine Learning Algorithms
2015: Red Imported Fire Ant Mound Detection – QLD Biosecurity

Vogt et al, Dynamic Thermal Structure of Imported Fire Ant Mounds, Journal of Insect Science Vol.8
Most Complex Software System
2016: Northern Inland: Multi spatial & temporal resolution

Figure 32: Results of the SAM classification of World View 2 data across the entire satellite data set. The classes are: soil (yellow), mining and locust (blue), escalyt (red) and other vegetation (green). The UAV survey area is outlined in red.
2017: Automated detection of weeds across different resolutions
Stochastic Machine Learning Algorithms
Cloud Based Architecture
Commercial Systems for Ag – some examples

- Aerial Services
  - 1497 CASA certified
  - 143 for Aerial Survey/Photography
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RIPPA + Subsystems for Vegetables
Operational Crop and Soil Mapping

Crop metrics
- Crop: Broccoli
- Plants: 12134
- Avg Size: 164cm²
- Avg NDVI: 0.39

Weed metrics
- Weeds: 253
- Avg Size: 16cm²

Foreign Objects
- Objects: 23

Week 6 – NDVI Values
- 14 rows from row 7 to 20
- Number of data points: 9742

Row: 10, Depth: 98mm
GPS Coordinates: -37.927370, 144.709175

Raw Image

NDVI Map

- Moisture (FWT)
- Temperature (deg C)
- Conductivity (s/cm)
Next Steps – Yield Prediction and Variability Reduction

**Growth models**

**Fertiliser needs**

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**Bed 73**  
**Row C**  
**Plant # 482**

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
<th>Week 9</th>
<th>Week 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>10g</td>
<td>18g</td>
<td>54g</td>
<td>96g</td>
<td>118g</td>
<td>174g</td>
<td>232g</td>
<td>298g</td>
<td>343g</td>
<td>373g</td>
</tr>
</tbody>
</table>

**Plant History**

**Week 7:**  
**Bed 73**  
**Row C**  
**Plant # 482**

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**Yield Prediction**

++ fertiliser  
+ fertiliser  
do nothing
Apple Trials
Moving to better Pastures
Cow Tracking
Autonomous Weeding
Grains
Weed Detection

valid image 54

valid image 55

valid image 56
Laser Weeding

- High flexibility
- Targeted
- Low energy
- Small/lightweight
**Laser weeding**

- **Controlling late post**
  - 2 minute treatment
  - 1/3 survival

- **Future work**
  - Larger laser - ~100W
  - Larger weeds
  - Determining upper limit
  - Damage quantification

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Low cost and easy to assemble

The di-wheel consists of two powered wheel modules joined by an expandable central shaft.
Commercial Small Holder Farmers
Field Trial

Farmhand travels down row crop collecting data
Tree Crop Trial
Pacific Island Trial
Next Generation Growers
Commercial Ground Robotics for Ag - examples

Blue River Technology

Optimize Every Plant

Blue River Technology is leading the next generation of smart crop-care equipment.

Meet the E-Series

AGROBOT

An innovative generation of smart crop-care equipment designed to perform autonomy where skill and experience are normally required.

Case IH unveiled an autonomous concept vehicle at Farm Progress Show in Boone, Iowa. The concept vehicle is a cab-less Concept 5 autonomous tractor.

Autonomous Tractor Corporation Aims to be the Tesla for Tractors

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From Autonomous Platforms to Autonomous Operations
Mining example

Significant potential comes from better understanding the resource base.

Source: Hugh Durrant-Whyte, “Rise of the machines” (Maurice Lubbock Memorial Lecture, Oxford University, Oxford, United Kingdom, May 14, 2016)

McKinsey&Company
The Apple Process

Rectangles and arrows indicate the natural process

Measurements and controls

A flower of 6 buds
Ad-petals “strong flower”
so will all become flowers and probably apples

1st indication at future number of flowers

6 petals/bud - very strong
4 petals/bud, weak. delay to full

Dormant → Green Tip → Green buds first appear in flowers of six
Some buds become pino

Measure bud colour

Petals fall off, that last 30%-40% of flowers become fruit

Chemical Control

Chemical Control

Measure growth rate

3 day cycle

Control by hand thinning

Control by hand thinning

Green

Petals open into flower

Pears grow

Apples grow

Time

Peak flowering (23rd)
Sept to 19th October
Predicton 7 days early
this year (normal is 10th-10th October)

Flowers typically fall after 0 to 7 days (can take 2 wks)

Flowering occurs in a wave across the farm, possibly
from near the base to the top and not all occur at the same time

+35 days from peak bloom, can no longer apply chemicals

1 week, Early September, ~7 to 10 days

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Spin-in and Spin-out technologies…

- Robotics
  - Automated Platforms
  - Intelligent Implements
  - Novel Sensors
  - Crop Manipulation Tools
  - Automated decision support tools
  - Multi-Platforms
  - ...

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