VG15024

Vision systems, sensors and sensor networks

to manage risks and increase productivity in vegetable production systems

1 rapid yield assessment
2 early problem detection
3 industry engagement

BOWEN GUMLU Growers Association Inc. Collectively we grow

Lockyer Valley Growers

Bundaberg Fruit & Vegetable Growers

Hort Innovation

QUT

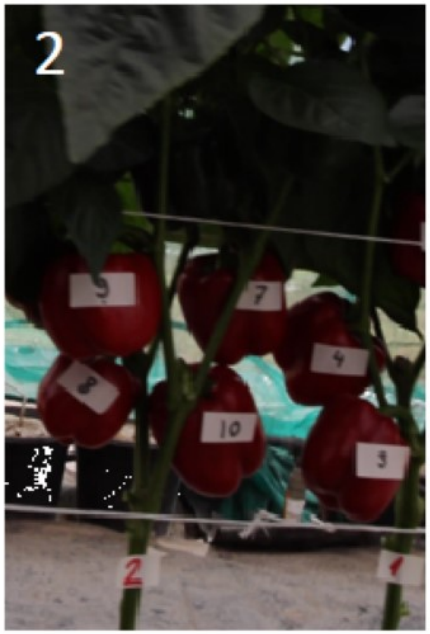
DATA 61

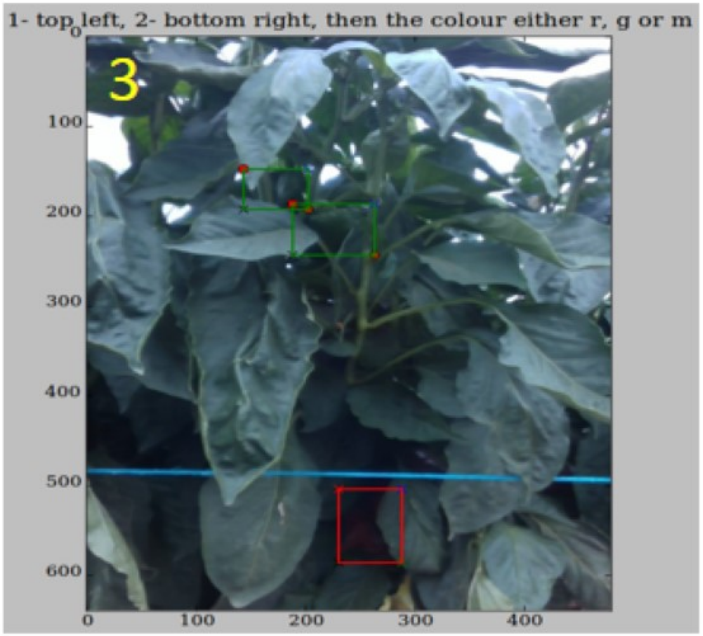
CSIRO

Queensland Government

Rapid yield assessment with vision systems (QUT/DAF)

1. QUT scan the crop - capture colour images of crop with inexpensive 2D and 3D sensors (cameras)
2. DAF label all visible individual fruit while still on the plants
3. Crop is filmed and DAF use this video footage to manually note fruit location and quality attributes on scanned images – green, red, mixed





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4. DAF pick and assess capsicum fruit for size, colour, weight and marketability

5. QUT use 50% of fruit detections in camera imagery to train algorithms, the other 50% are used to test the accuracy of the algorithms

6. QUT validate machine learning algorithms against actual yield data

Harvest Date 19/01/2018 Second harvest PLOT ID 4 A East.

Plot Number	Diameter (mm)	Height (mm)	Weight (gms)	Colour and Size	Comments
1	61	67	75	S Sunburn	
2	90	??	177	M Sunburn	
3	38	52	29	Us G	
4	82	83	169	M Sunburn	
5	48	56	36	Us G	
6	58	53	41	Us Sunburn	
7	60	66	69	Us Sun	
8	60	58	56	Us G	
9	54	56	39	Us Sunburn	
10	65	56	73	SG	
11	51	60	41	Us Sunburn	
12	83	87	194	MR	
13	88	88	269	MR	
14	77	58	119	SG	
15	100	107	350	LR	
16	64	64	86	SG	Sunburn

Summary Of Plot	Small Count	Small Weight	Med (55-110 mm) Count	Med (55-110 mm) Weight	Large (110-158 mm) Count	Large (110-158 mm) Weight	Sunburnt Count	Sunburnt Weight	Small Red	Small Shrunk	Small Green	Medium Red	Medium Shrunk	Medium Green	Large Red	Large Shrunk	Large Green	Comments
	2.910	33	4.187	15	3.889	4			6	3	10	12	12	2	12	5	1	25 977
							M 8											R 18 16
							S 6											
							Us 9											

1/2

Early results – finding fruit in camera imagery

Protected-cropping capsicum – five sets of data

- QUT's initial algorithms can find about 80 out of 100 fruit in camera imagery.
- Correctly classify 94% green, 91% red and 70% mixed colour capsicum – 90% average

For field-grown crops – ten sets of data

- QUT's initial algorithms can find about 70 fruit out of 100 in camera imagery.
- Correctly classify 94.5% green, 93% red and 33.3% mixed colour fruit - 91.5% average
- Any differences between Warlock & SV6947 and single & double rows?

Is there a consistent relationship between camera imagery and actual yields?

Field grown

Protected cropping

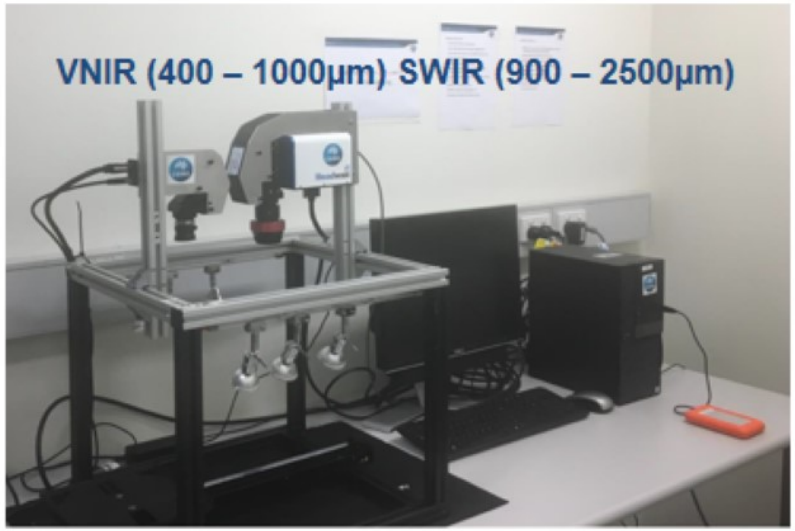
Can hyperspectral imaging detect crop problems early - perhaps before the human eye can?

Tomato Spotted Wilt Virus (TSWV) in capsicum – CSIRO/DAF

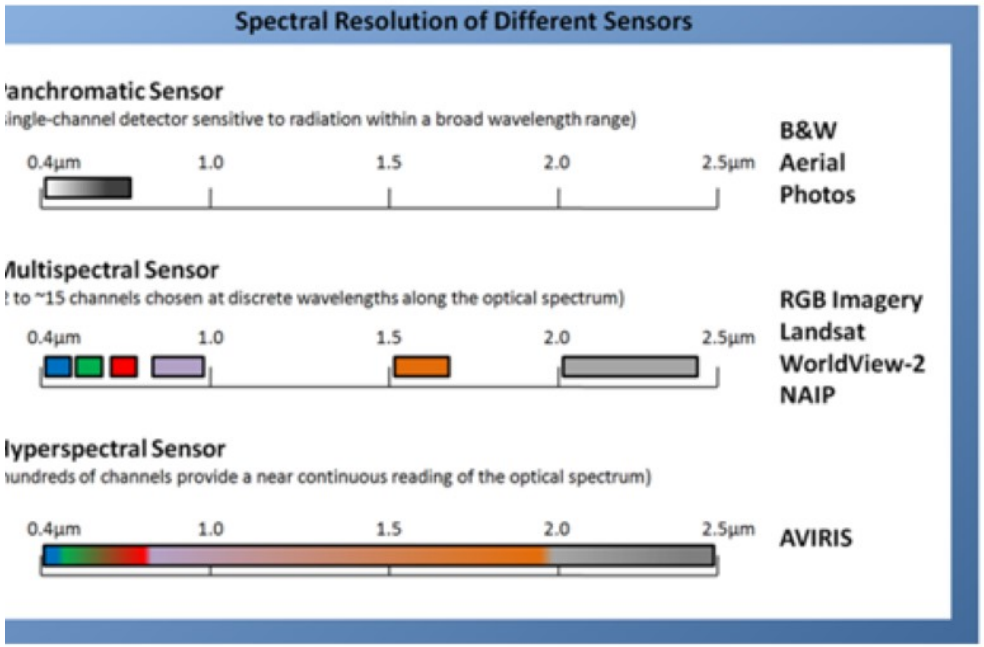
- Glasshouse and dark room at EcoSciences Precinct in Brisbane
- Three pot trials based on cutting leaves from plants
  - Better than 80% accurate for detecting sampled single leaves with virus symptoms
  - Can't track symptom development in a leaf over time
- Two whole plant scanning pot trials completed May/June 2018

Pot trial 3 - roof top glass house

Leaf scanning set up – two cameras



getation Indexes Explained (Web Link)



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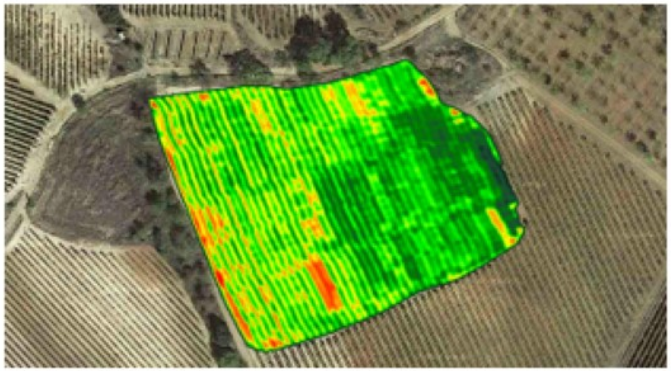
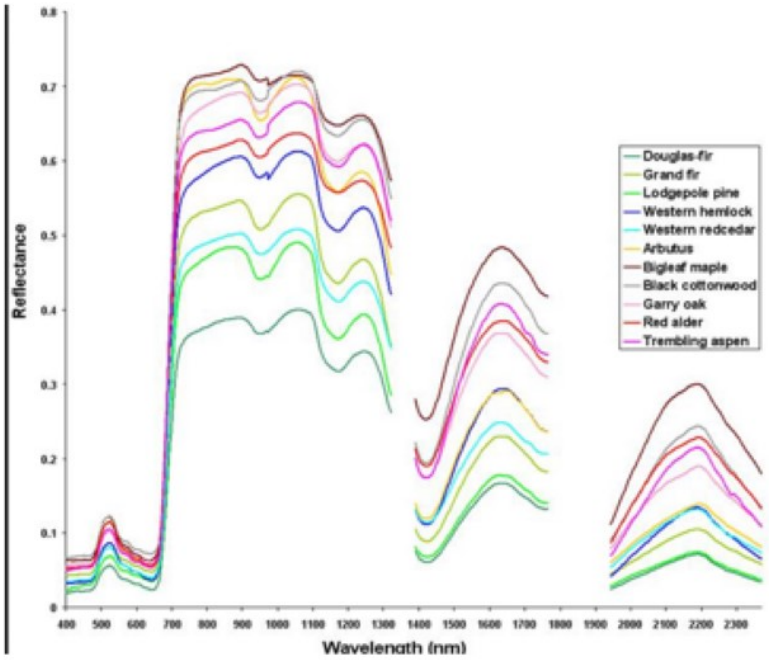


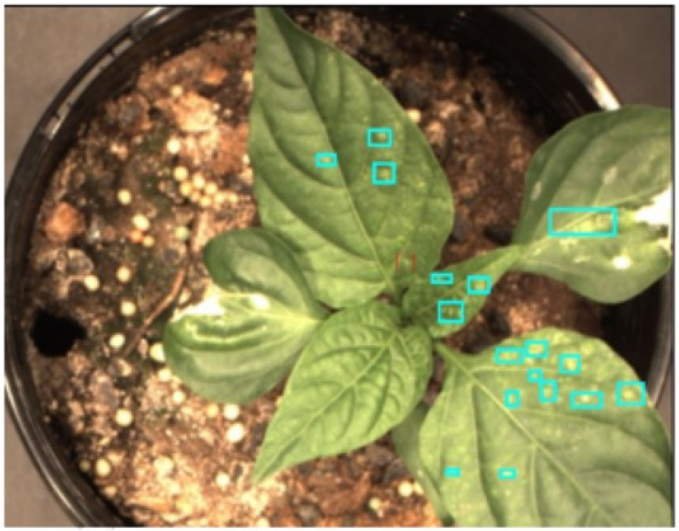
Web reference :https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XL-5-W4/299/2015/



Web reference: http://irsslab.forestry.ubc.ca/research/data-fusion/

CSIRO Online Annotation Tool

Whole plant scanning - pot trials 4 & 5



Virus Annotation

Try to select regions of virus symptoms of the plant in the picture.

Draw rectangles on each region of a leaf that have virus symptoms. Try to avoid having overlapping rectangles.

Remove Region

Please specify which virus symptoms are visible in this region.

- [x] Mosaic
- [ ] Ringspots
- [ ] Deformity
- [ ] Puckering

Previous Region Next Region

Your purpose here is to identify all the leaves on the plant in each image. Mark the centre of each leaf once.

Remove Targetor

Previous Targetor Next Targetor

Back Done

Scanning completed
Trials closed down

DAF ground-truthing:

- Diagnostics
- Image annotation

CSIRO data analysis:

- no results as yet

Industry engagement & communication
= Fit-for-purpose technology

- Annual regional forums – Bowen, Bundaberg & Gatton
  - researchers linked in via webinar for presentations & Q&A
- BGGA, BFVG & LVG collaboration
- Two page project updates – sent out widely via email
  - local grower organization's, IDO's & VegNet, research community
- Grower levy partner webinars – one grower per region

Outcomes (Knowledge + Understanding + Capacity + Practicality)

- **Capsicum rapid yield assessment**
- ✓ Fruit classification algorithms developed and field tested on commercial varieties
- ✓ Appropriate cameras / sensors identified and field tested
- ✓ Technology challenged by "real farm" environment, light, dew, mud etc.
- ✓ Need for large labour / time input to provide fruit classification data to "train" system
- ✓ Technology development partners operate in "real farm" environment
- ✓ Potential for this "yield / harvest module" to be added to Harvey the Robotic Capsicum Harvester

- **Hyperspectral imaging / early problem detection**
- ✓ Test the "talk" of hyperspectral cameras' ability to deliver real time field disease detection
- ✓ Developed Australia's first data set of **hyperspectral reflectance data** for healthy and virus infected capsicums
- ✓ Whole plant scanner camera system developed and tested

- *Both rapid yield and early problem detection research work involves:*
  - ❖ collecting lots of real "field" data to develop, training and evaluate computer algorithms
  - ❖ understanding and integrating biological, plant pathology, agronomy specialist knowledge with engineering, robotics, and machine learning

Next Steps :

- ➢ Interrogate capsicum rapid yield assessment data and further develop automated accurate yield prediction and fruit classification systems potential.
- ➢ Test the capacity to utilize hyperspectral cameras for early disease detection in the field environment

Thank you for your interest in our research

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Presenter: David Carey

on behalf of

Dept Agriculture & Fisheries

(Horticulture and Forestry Science)

and

QUT

(Science and Engineering Faculty, Electrical Engineering, Computer Science, Robotics and Autonomous Systems)

and

CSIRO

(The Robotics and Autonomous Systems Group at CSIRO Data61research)

project research partners

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Horticulture Innovation Australia

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