Qld Veg Automation News

January 2019

This newsletter reports on results from the vegetable levy funded project VG15024: *Vision systems, sensing and sensor networks for managing risks and increasing productivity in vegetable crops*.

The project ended in December 2018. This update presents results from the QUT/DAF work on rapid yield assessment using vision systems and machine learning.

What benefits to industry?

Near-real time information on in-crop fruit numbers, their maturity and quality would provide valuable information to growers and agronomists for improving workforce allocation, estimating product packouts and organising markets proactively down the value chain. These are all factors for reducing input costs and increasing productivity.

Tools to accurately and rapidly assess fruit quanity and quality in-crop automatically could provide data on crop variability within a field, across a farm and within and between seasons. This fits well with precision agriculture and future automated crop management.

Rapid yield assessment is an essential first step towards automated crop forecasting. The ability to detect fruit and assess its maturity in-crop is a developmental step towards selective robotic harvesting of fruiting crops.

The research question

Over a two year period, the QUT and DAF team collected data from capsicum crops grown under commercial conditions in a greenhouse at Giru (five trials) and from field-grown crops at the DAF Gatton Research Facility (ten trials). The research question was:

Can robotic-vision systems provide reliable data for rapid crop yield assessment?

Capsicum was chosen as the 'proof of concept' crop as it is of high value to the national vegetable industry. It also builds on QUT's previous research within DAF's Strategic Investment in Farm Robotics Program: Agbot 2 and Harvey, the capsicum harvester.

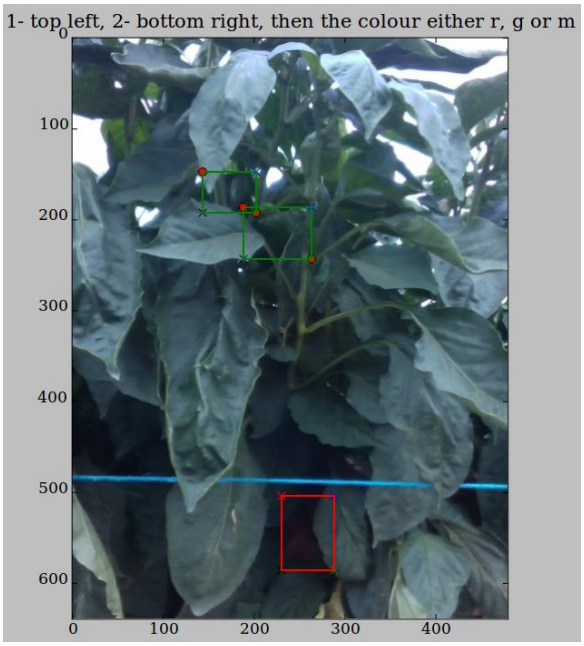
Capturing the data

First, sensory (vision) data are acquired from the crop using a camera system. Then, visible capsicum fruit are labelled in-crop and filmed.

Using this video footage, researchers manually annotate (ground truth) the number and quality attributes of each capsicum visible in the camera imagery taken from sample rows. The sample area is then harvested and fruit graded for size and quality (colour, size, defects) as per industry standards.

Developing the vision system

Data captured by cameras are divided into three independent sets: a *training* set to develop the algorithms, a *validation* set and a *testing* set to assess the accuracy of the system for (i) detecting the capsicum and (ii) estimating fruit quality in camera imagery. This data is then evaluated against the underlying fruit counts.



An example of the annotation tool used *(field-grown crop). The bounding box locations for the capsicum are shown. The colour of the bounding box indicates its quality (based on the imagery). Red indicates ripe (red) capsicum, magenta indicates breaking colour capsicum and green indicates green capsicum. In this example two green and one red capsicum are annotated.*

The system consists of three sub-systems:

Detection – finding the fruit amongst the leaves in the crop

Tracking – resolving which fruit is where and keeping a record of its ripeness (colour)

Underlying fruit count – estimating the number of fruit present on the crop based on the number of fruit seen by the tracking system.

Protected cropping trials

QUT's initial algorithms could find about 80 in 100 fruit in camera imagery and correctly classified 94% green, 91% red and 70% breaking colour fruit with an average accuracy of 90% across the three colour categories.

Crop grown in the polytunnel at Giru *showing red, breaking colour and green capsicum.*

Field-grown crop trials

Researchers optimised the vision system using considerable amounts of data from field-grown capsicum crops with 1,834 images (6,426 fruit) manually annotated.

Camera and compute specifications

After testing several systems, QUT used the relatively inexpensive Intel RealSense SR300 to capture data. Newer camera technology is already available. The systems developed in the work can run on a powerful desktop computer.

QUT can provide technical and operating specifications for potential cameras and compute requirements for processing to enable this technology to be deployed.

Results for the optimised system

In field-grown crops, QUT's vision system could find fruit in camera imagery with 75% accuracy.

Performance of the system was similar for single and double row capsicum, across the two varieties tested and slightly better when data was captured with cameras mounted on a robot.

The system correctly classified 99.1% green and 84.5% red capsicum but only 18.7% breaking colour fruit as the system confused 'red' with 'breaking' colour in 45.3% of cases. Acccurately estimating 'ripeness' is therefore challenging even with a fruit tracking system.

When the 'red' and 'breaking' classifications were combined, the results improved considerably. Mounted on a robot, the error was 1.9% for green and 13.7% for red+breaking fruit.

If fruit is visible to the tracking system, then estimates for underlying fruit counts are reasonable at 20% error for red+breaking and 32% for green (all size fruit) for such a challenging system as field-grown capsicum.

Machine learning is based on the idea that that computer systems can learn from data, recognise patterns and make decisions with only minimal human intervention. It is a branch of artificial intelligence.

What next?

QUT will make the data sets available to the global research community to help advance vision systems technology across applications. Future work could include:

- Newer cameras, improving algorithms and further testing the system on robotic or other platforms.
- Building on the work to forecast crop yields and as tools for quantifying yield variability within a block or farm or season.
- Further develop the detection and tracking system for selective robotic harvesting.

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Hort Innovation Strategic levy investment | VEGETABLE FUND

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