Qld Veg Automation News

February 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 CSIRO/DAF work on early plant disease detection using hyperspectral imaging combined with machine learning.

What benefits to industry?

This work was high risk but with potentially large future pay-offs for industry.

Early detection of crop disease widens the choice of strategies available for managing problems effectively and helps limit disease spread.

Automated crop health monitoring could be applied to a whole field and would augment current pest and disease monitoring approaches.

This fits well within a precision agriculture framework where control measures might be applied selectively to sections of a field or potentially, on an individual plant basis. This would reduce costs and production risks, increase productivity and lessen risk of negative impacts on the the environment.

Pot trials for hyperspectral imaging

Over a two year period, CSIRO and DAF researchers completed five glasshouse pot trials using Tomato spotted wilt virus (TSWV) in capsicum as the 'proof of concept' disease-crop combination to answer the question:

> *Can hyperspectral imaging detect crop problems early, perhaps before the human eye can?*

A proportion of plants is inoculated with virus then leaves are scanned under controlled lighting conditions (dark room) with two sophisticated hyperspectral cameras to develop algorithms that detect changes in leaf reflectance.

Leaf imaging trials

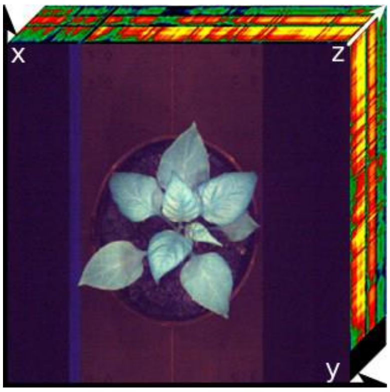
The first three trials were based on cutting leaves from plants, scanning individual leaves, assessing leaves for symptoms visually to ground-truth imaging data then processing the data to develop machine learning models that could discriminate between healthy leaves and leaves with disease symptoms.

In this first round of trials, the CSIRO algorithms could detect leaves with symptoms at greater than 85% accuracy.

Whole plant trials

Cutting leaves from plants prior to scanning gives a snapshot of symptoms but doesn't allow for tracking of symptoms as they develop over time.

To overcome this limitation, CSIRO designed and built an experimental multi-camera scanning set-up to scan whole capsicum plants in pots for TSWV symptoms under controlled lighting conditions.



This image shows a hyperspectral hypercube taken by CSIRO's whole plant scanning system. *It shows its three dimensional aspects: the two spatial dimensions X and Y and the spectral dimension Z which is made up of many spectral bands.*

The set-up allows more frequent scanning of plants so increasing the probability of picking up very early changes in leaf reflectance, possibly before an experienced plant pathologist can pick up virus symptoms by visual observation alone.

Researchers ran two whole plant scanning trials in 2018. Capsicum plants in pots were scanned and visually assessed for virus symptoms every 2 days from 3 days after virus inoculation onwards.

The CSIRO team achieved a greater than 90% accuracy by applying machine learning techniques to construct classifiers that could discriminate between plants with virus symptoms and plants without symptoms.

Plant disease prediction per pixel. *Pixels coloured green were classified as control and those coloured red were classified as diseased. This image is an inoculated plant with visual symptoms from the last day of Trial 5.*

In addition, these classifiers could leverage information from beyond the visible light spectrum (on which human symptom observation is based) to correctly predict plant infection 5 to 7 days earlier than human observation.

CSIRO also compared the hyperspectral data (many spectral bands) against NDVI (ratio between two spectral bands – red and near infrared). NDVI gave an overall accuracy of 45% as it is less sensitive to changes in plant reflectance as other parts of the light spectrum are ignored. NDVI disease detection is based on an arbitrary threshold which is sensitive to 'background noise' such as reflectance from soil.

These limitations also apply to other vegetation indices. Hyperspectral imaging uses the full light spectrum and so is less sensitive to 'noise'.

Results in a nutshell:

Can hyperspectral imaging combined with machine learning detect plant disease?

Yes, at higher than 90% accuracy.

How did hyperspectral imaging compare with NDVI?

NDVI accuracy was low at 45% as this vegetation index is based on red and infrared wavelengths only.

Can hyperspectral imaging combined with machine learning detect plant disease before the human eye?

Based on trial 5 results, the CSIRO machine learning model could detect disease in individual plants 5 to 7 days before symptoms were visible to an experienced DAF plant pathologist.

What next?

To move this research forward, the next steps are:

- test if the proposed algorithms can be applied to other crop-problem scenarios (scalability).
- investigate if algorithms for TSWV detection in capsicum are robust in field settings.

Challenges of running field experiments include cross-contamination of disease to adjacent plots, other crops and farms. This is a tricky problem which needs to be addressed first.

The aim is to work towards a modular solution for early disease detection that could be mounted on a robot or other platforms for field deployment.

To find out more, please contact:

At DAF:

Sue Heisswolf – Bowen 07 4797 9744

David Carey – Gatton 0467 746 302

At CSIRO DATA61:

Peyman Moghadam – Brisbane 07 3327 4601

https://research.csiro.au/robotics/our-work/solutions/agtech/

This project has been funded by Hort Innovation using the vegetable research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au