Grower Summary

CP 060a

Combined thermal and visual image analysis for crop scanning and crop disease monitoring

Final 2014

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Further information

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HDC
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

HDC is a division of the Agriculture and Horticulture Development Board.

Project Number:	CP 060a
Project Title:	Combined thermal and visual image analysis for crop scanning and crop disease monitoring
Project Leader:	Dr Nasir Rajpoot, University of Warwick
Contractor:	University of Warwick
Industry Representative:	Alan Davis
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GROWER SUMMARY

Headline

The project successfully developed fast techniques for capturing changes in the thermal profile of plant canopies under variable environmental conditions with an average accuracy of more than 95% providing the potential for early diagnosis of water stress and disease outbreaks using combination of thermal and stereo 3D imaging.

Background

It has been shown by researchers that thermal imaging can be used for stress detection and early detection of disease in plants. In a recent study, it has been shown that image analysis can be used to provide a consistent, accurate and reliable method to estimate disease severity (Sun, Wei, Zhang, & Yang, 2014). Multi-modal imaging has been used by researchers in the past for determining the quality of crop. Among various imaging techniques, thermal imaging has been shown to be a powerful technique for detection of diseased regions in plants (Belin, Rousseau, Boureau, & Caffier, 2013). One of the major problems associated with thermal imaging in plants is temperature variation due to canopy architecture, leaf angles, sunlit and shaded regions, environmental conditions and the depth (distance) of plant regions from the camera (Jones, 2002). We aimed to combine information of stereo visible light images with thermal images to overcome these problems and present a method for automatic detection of disease in plants using machine learning techniques. Our results show that the proposed technique can be applied for fast and accurate scanning of a crop for detection of diseased plants.

Summary

An experimental setup was designed and developed at the Department of Computer Science, University of Warwick, UK, to simultaneously acquire visual and thermal images of diseased/healthy plants. The imaging setup consisted of two visible light imaging cameras (Canon Powershot S100), and a thermal imaging camera (Cedip Titanium). The experiment was carried out on tomato plants (cultivar Espero) in a controlled environment. Of 71 plants, 54 plants were artificially inoculated on day 0 with the fungus *Oidium neolycopersici* which causes powdery mildew disease, whereas the remaining 17 plants were not inoculated. The disease symptoms that developed consisted of white powdery spots (first appearing after approx. 7 days) that expanded over time and eventually caused chlorosis and leaf die-back. As part of pre-processing work, we have introduced a novel technique for alignment of thermal and visible light images of diseased plants.

(a) (b) (c)

(a) Visible light image. (b) Thermal image. (c) Overlay of thermal image and the corresponding visible image after alignment.

We also present technique for 3D modelling of diseased plants and compare it with the existing state of the art methods. After pre-processing, we use machine learning techniques and combine thermal and visible light image data with depth information to detect plants infected with the tomato powdery mildew fungus *Oidium neolycopersici*. We present a technique which can detect diseased plants using thermal and visible light imagery with an average accuracy of detection more than 95%. In addition, we show that our method is capable of identifying plants which were not originally inoculated with the fungus at the start of the experiment but which subsequently developed disease through natural transmission.

Plant #p47 shown for illustrative purpose the plant was not inoculated with any disease but later showed symptoms of the disease and was successfully captured by our algorithm.

Although we can use the same technique across different crops, our technique will need further development on different plants and different diseases since different plants may respond differently in terms of thermal signature to the same disease and therefore further testing is necessary before application. The approaches presented in this work have been

tested on spinach crop in real world environment and tomato plants in a controlled environment. However, these approaches can be extended to different type of crop but need to be tested on multiple types of disease with multiple control treatments at a larger scale before they can be employed in a real world setting.

Financial Benefits

Early and accurate detection of stress and disease regions in a crop can help growers take timely action against the disease/stress. In the previous report (CP60a, Year 2 report, 2013) we had shown that we can efficiently and accurately identify stress regions in a crop with the help of thermal imaging. Good irrigation strategies in turn can help the grower to get optimal crop yield i.e., little or no loss of plants through over or under watering. In this report, we have shown the strength of thermal and stereo visible light imaging systems for early disease detection. In this report, we have shown that we can detect the onset of powdery mildew disease before the visible symptoms appear, a disease which can cause 60% yield loss in extreme cases during epidemic onset[1]. Early disease detection can help to avoid any possible crop yield loss. Thermal imaging can also be used for more efficient use of fungicides by optimising spray quantity and timing or it can be used to spray only 'disease hotspots' in glasshouse. The additional information which comes from 3D map has been shown to increase the accuracy of disease detection and will definitely bring more financial benefits to the grower. A good thermal imaging camera is available in the price range of £15000 to £30000, with high end cameras having the ability to remotely transfer live images, thermal and colour, via Wi-Fi networks on computer screens or tablet (e.g. iPad). A camera can be mounted on a rig on moving boom e.g. on a water boom in Venlo type glasshouses to scan the crop regions.

Action Points

Glasshouse businesses should consider options for installing an overhead system for monitoring their crop with the help of a mounted thermal and colour imaging camera. The cost of the imaging system is negligible compared to the financial benefits which can be obtained using such kind of systems.

[1] http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=22075