Grower Summary

CP 060a

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

Annual 2013

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Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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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 (HDC STUDENTSHIP)
Project Leader:	Dr Nasir Rajpoot
Contractor:	University of Warwick
Industry Representative:	Alan Davis
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Start Date:	01 April 2011
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Project Cost:	£64,650

Headline

Thermal images combined with visible light images have successfully identified stressed regions of a plant canopy with high accuracy.

Background

Thermal imaging has been shown to be suitable for stress and early disease detection in plants. However, there are problems associated with thermal imaging because of variation in the perceived temperature caused by various environmental factors. These include structure of the canopy, sunlit and shaded regions, leaf angles and the distance of imaging device from the plant. The major aim of the project is to combine information from colour and thermal images to model these variations as a function of leaf angles, light intensity and 3D depth information. Results to date have shown that, with the help of statistical parameters and classification algorithms, water stressed and well watered canopies can be successfully distinguished. . Thermal and stereo colour images have been collected from powdery mildew inoculated tomato plants and these are now being processed. This will include developing algorithms for accurate alignment of the thermal and colour images to create a depth map of the plant for analysis. The aim is to develop a 3D thermal profile of a crop to account for noise introduced due to the structure of canopy and develop new methods for early disease detection.

Summary

1. Thermal and stereo colour images were taken for 15 consecutive days from a tomato powdery mildew trial underway at Warwick Crop Centre (courtesy of Gillian Prince). Manual measurements of leaf temperature were also taken for two days. An algorithm has been developed for image rectification which is a pre-processing step before 3-D depth estimation. The process consists of aligning the same features from stereo image pair along a set horizontal line. Before analysis the images must be aligned in such a way that the same pixel location in both the images corresponds to the same physical location on the plants. Figure 1 shows a 3D profile of a tomato plant on day1 and day14 of inoculation with powdery mildew. Corresponding thermal images overlaid on the 3D profiles are also shown. On day1, leaves look more regular in shape and they appear to be at cooler temperature than the environment at about 18-20˚C, whereas on day14 leaves are more irregular in shape and their temperature is about 21-23˚C. Algorithms for accurate alignment of these images need to be finalised, before analysis of disease progress can be undertaken.

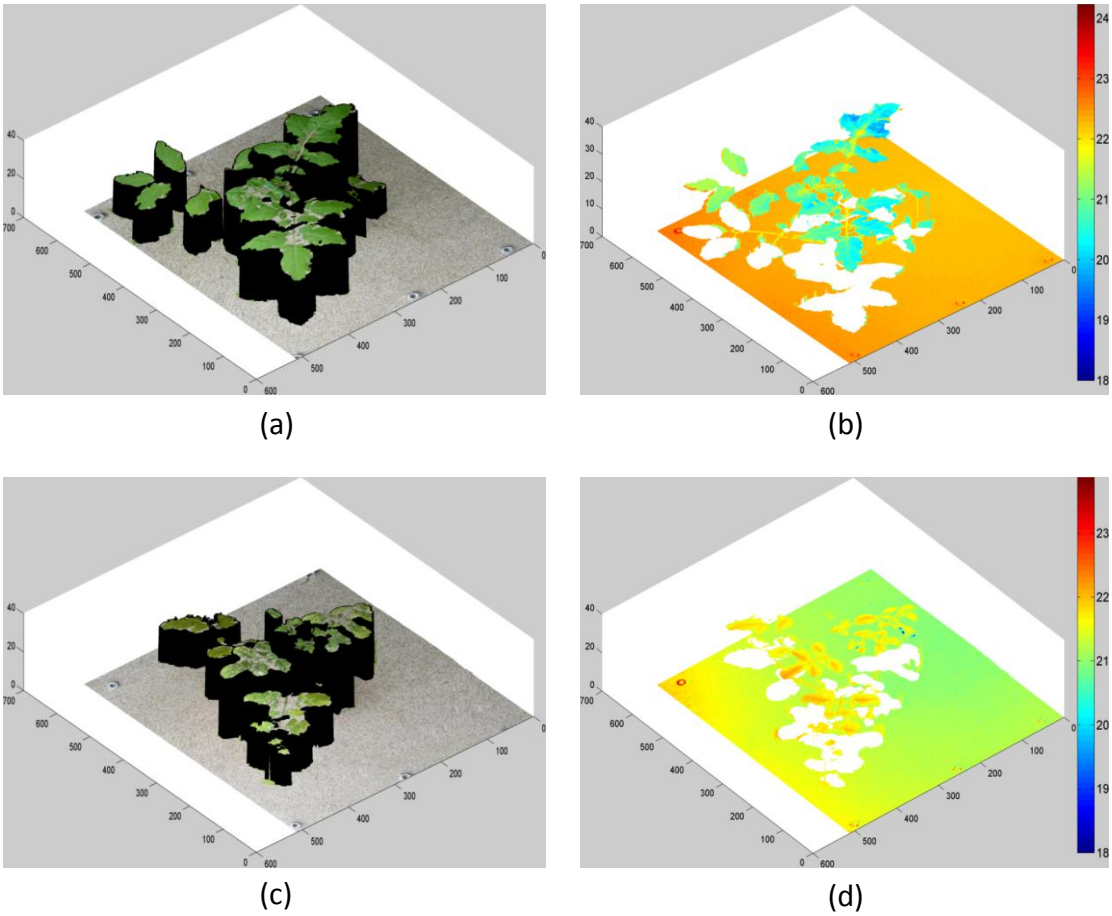

Figure 1: (a) & (c) 3D profile of a tomato plant on day1 & day14 of inoculation with powdery mildew. (b) & (d) show corresponding thermal image overlaid on 3D profile. On day1, leaves look more regular in shape and their temperature is about 18-20˚C, whereas on day14 leaves are more irregular in shape and their temperature is about 21-23˚C.

2. Thermal and colour images were obtained from a stress experiment carried out by Prof. Gail Taylor's group at the University of Southampton. 108 images of a spinach canopy were provided in total, 54 images were taken from a drought canopy and 54 images were from well-watered plants. Information from thermal and colour images was combined and machine learning techniques were used to distinguish between the two groups of plants. Results indicate that water stressed and well watered plants can be classified with an average accuracy of around 97.12%. Figure 2 shows the result of the probability of an image showing stress given by the classifier against manually measured soil moisture values for images collected from Prof. Taylor's experiment.

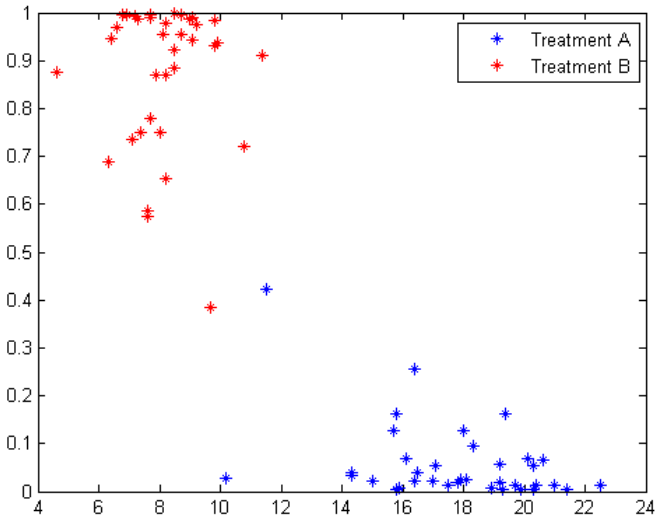

Figure 2: Probability of image showing drought-stressed plants vs soil moisture values (correlation value = - 0.89, High moisture means less probability of stress) (%Volume) as given by our classifier. Classification accuracy for this particular set of training and testing data was 98.62%.

Financial Benefits

Financial assessment is premature at this stage, although it is anticipated that stress detection in different parts of the crop could help growers to water crops more efficiently and detect disease at an early stage facilitating timely action which would mitigate against crop losses and some of the costs associated with treatment.

Action point for growers

Glasshouse growers could consider options for installing an overhead system for monitoring their crop, pending further developments as this project progresses.