A preliminary evaluation of machine vision sensing of cotton nodes for automated irrigation control

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Introduction

Real-time sensing of crop water stress is required to implement site-specific irrigation that responds to crop water needs. Large mobile irrigation machines (LMIMs) are potentially amenable to real-time sensing and control due to the method's ability to apply water directly to crop plants at high temporal frequency. This project aims to develop a real-time, plant-based sensor for cotton water stress that has potential use on a variable-rate LMIM which adjusts water application in response to real-time irrigation requirement.

A number of plant attributes may be used to infer water stress in cotton. Nodes above white flower and distance between the fourth and fifth mainstem nodes are being targeted in this project because these attributes indicate the balance between vegetative and reproductive growth that is required during crop flowering to optimise yield for cotton.

Use of Machine Vision to Measure Plant Structure

The desire for on-the-go measurement of physical plant characteristics particularly engages machine vision as a potential sensing technology for cotton plant water stress. Physical plant attributes which have been successfully measured on-the-go using machine vision in the literature include plant height and biomass. These attributes require discrimination of plant and non-plant elements but not specifically plant structures such as stems, petioles and leaves.

A machine vision solution for measurement of internode length and nodes above white flower requires image processing algorithms to identify cotton plant features (such as the mainstem and node positions), and a suitable camera platform to collect imagery of cotton plants in the field. By mounting the camera behind a fixed transparent window which moves through crop foliage, reliable geometrical data is derived without the need for binocular vision.

Equipment

Two vision systems were designed and trialed on four varieties of cotton (Sicot 80B, Sicot 71B, Sicot 289B and DP 408B) during crop flowering in the 2005/2006 cotton growing season. Video footage of cotton plants was collected using a Prosilica EC750C machine vision camera and also a Sony DCR-TRV19E camcorder, with up to 25 frames per second being captured by each camera. The Prosilica camera was fitted with a varifocal, manual iris Tamron lens which allowed for adjustment of optical parameters such as depth of field. The two cameras were used for relative performance comparison and were mounted in a fiberglass box which traversed the crop canopy and featured a glass front panel. Three replicates of multiple orientations and approach angles of the camera platform were conducted to test the repeatability of the vision systems (Figure 1). Different approach speeds and illumination conditions were also tested.

For each of the plants targeted by the camera platform, manual measurements were made of the top five internode lengths, plant height, stem diameters of the top five internodes, nodes above white flower, retention of first-position fruit on the top five nodes, number of fruiting branches and plant spacing.

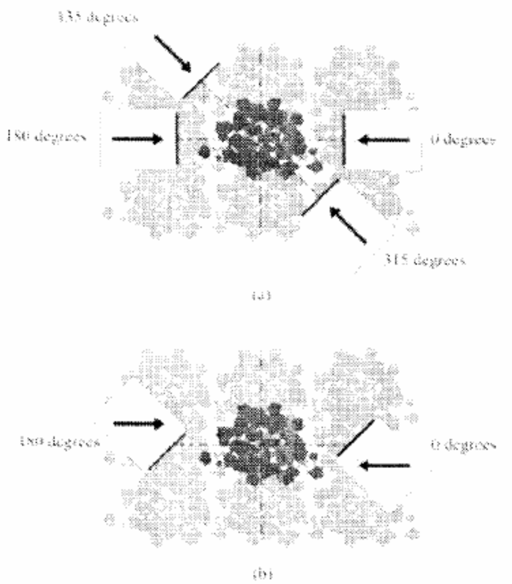

Figure 1. Approach angle of camera platform with yaw angle of (a) 0° (b) 45°

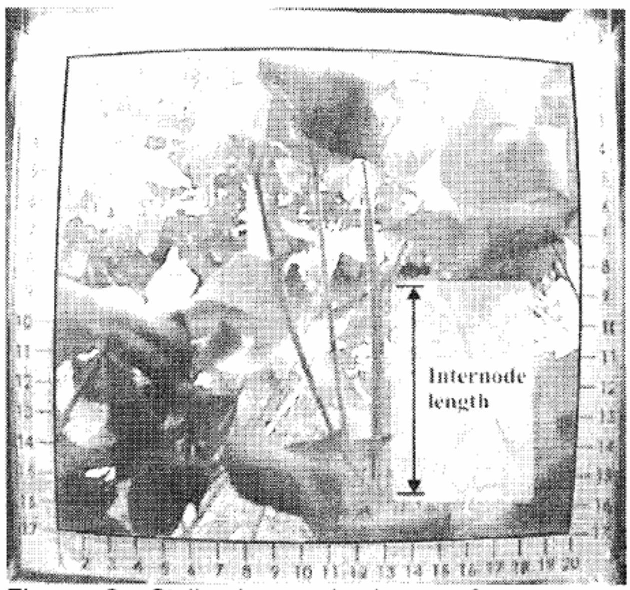

Figure 2. Stylised sample image from camera platform

Major Findings to Date

A stylised sample image from the Sony camcorder is shown in Figure 2. By visual inspection of acquired imagery, the camera platform effectively isolates the target plant attributes and enables distance measurements of plant features. Corresponding image processing algorithms, based on edge detection and plant feature geometry, have been applied to the video to determine plant attributes for comparison with the manual measurements taken. As expected, the orientation of leaves obscured essential points of geometry within some images such that the required measurements could not be deduced. This problem is overcome due to the multiple images available (up to 25 per second).

Conclusion

A single-camera machine vision system incorporating an enclosure that moves within the crop canopy may be used to automatically and accurately measure cotton plant attributes, particularly the top five internode lengths, during the crop flowering stage.
Further work includes testing of the image processing algorithm robustness, adaptation of the camera platform for LMIM mounting and integration of the sensor with an overhead irrigation machine that modifies irrigation amount in real-time.