OPEN COTTON BOLL DETECTION METHODOLOGY USING UNMANNED AERIAL SYSTEM (UAS) IMAGERY

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Abstract

Unmanned Aerial System (UAS) images have great potential for agriculture and can be used for various applications. Especially in case of agricultural researchers, UAS images facilitate precise data collection in crop fields for detailed analysis. Additionally, crops can be monitored with short time intervals using UASs, unlike most other remote sensing platforms. In this study, an open cotton boll detection methodology using UAS imagery is proposed. A Phantom 4 platform was used with its standard integrated sensor. Raw oblique imagery was used to detect cotton bolls not shown in orthomosaic image. Random seed distribution and region growing methods were adopted to detect homogeneous regions of cotton bolls. Open cotton boll spatial characteristics including size and roundness were then analyzed to acquire meaningful spectral information of optimal cotton boll candidates. Finally, multispectral threshold values of candidate bolls were derived from the Otsu method and a combination of thresholding was applied to the image. The proposed method shows acceptable results when compared to visual analysis of the original image. Most of all, the proposed method can contribute to automated cotton boll detection and aid crop yield estimation.

Introduction

Unmanned Aerial Systems (UAS) have evolved rapidly introducing great potential for various agriculture applications. UASs facilitate precise data collection in crop fields for detailed analysis. In addition, crops can be monitored with short time intervals using UASs unlike most other remote sensing data such as aerial photos and satellite imagery. Cotton production is an important economic factor in the United States as the country is the worldwide cotton export leader. Texas produces more cotton than any other state in the United States. Cotton is Texas' leading cash crop and corresponds to 25% of the country's cotton production. Cotton bolls in UAS images have different spectral values based on to UAS sensors, weather, and time of flight. Therefore, adaptive and automatic cotton boll extraction is required for increasing applicability of UASs for boll estimation.

Data and Methods

A DJI Phantom 4 platform and its standard integrated sensor including red, green, and blue bands were used. UAS data were acquired on August 18, 2016 and the study site was located at the Texas A&M AgriLife Research center at Corpus Christi, TX, United States. The flight conditions were 15m altitude and 85% overlap. Orthorectification was performed and final spatial resolution was 0.6cm. The orthomosaic image was superimposed with 490 Geographic Information System (GIS) boundary rows (Fig. 1).

Subset images and random seeds in those images were used for computation efficiency. Based on random seeds, the region growing algorithm was conducted to generate homogeneous segments. Spatial characteristics regarding size and roundness were analyzed to detect small and round segments, which are the initial steps to finding open bolls (Fig. 2). Then, Otsu thresholding was applied to determine threshold value dividing segments into bright or dark segments. A derived threshold value was used for detecting open cotton bolls in the orthomosaic image. Finally, binary thresholding results were then refined using size constraint to remove noise. For the additional analysis, the results of binary cotton boll detection were clipped using cotton boundary GIS data and cotton boll area per row was estimated.

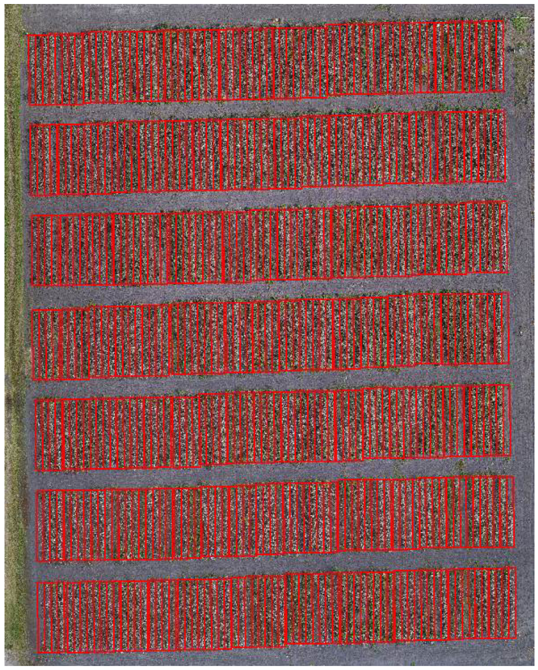

Figure 1. Orthomosaic image and GIS boundary rows.

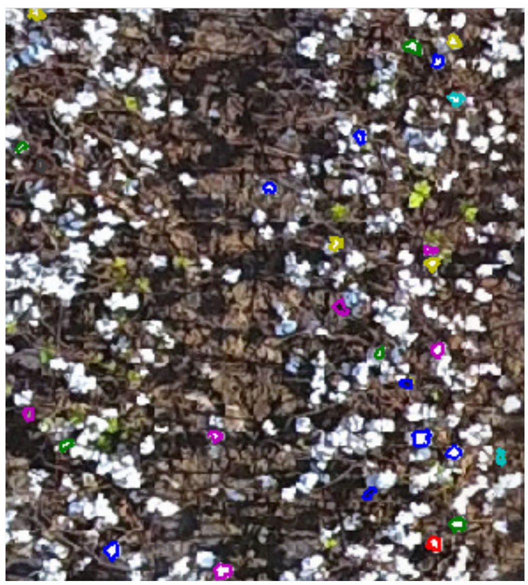

Figure 2. Open boll candidate segments.

Results and Discussion

Final cotton boll extraction results showed high accuracy for extraction and detection (Fig. 3). Evaluation pixels were randomly extracted and then visually compared with the orthomosaic image to verify their actual classes. Based on the accuracy assessment, the proposed method had of boll extraction and detection had a 90% accuracy. In addition, total cotton boll area on each row was estimated and integrated with cotton spatial yield data to analyze the relationship between yield and cotton boll area. Linear regression between yield and cotton boll area was performed and showed a positive correlation (Fig. 4). The R square value was about 0.6. For future studies, objective parameter values and sophisticated methodology will be studied to improve the proposed methodology.

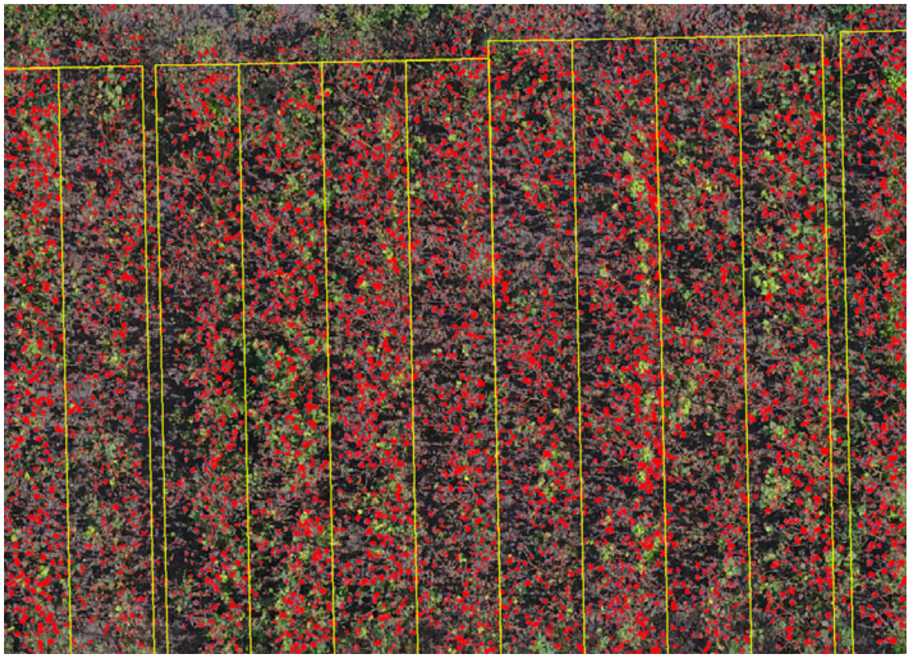

Figure 3. Final cotton boll extraction results and GIS boundary rows.

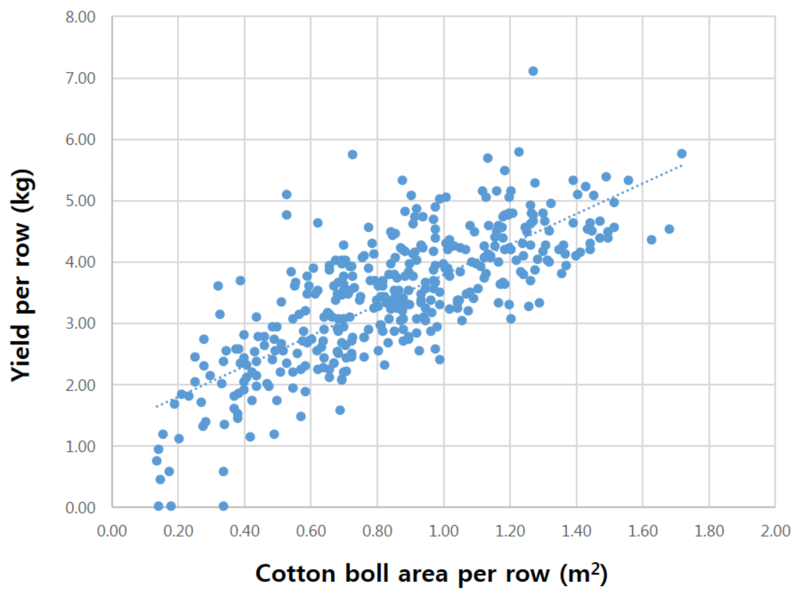

Figure 4. Linear regression analysis.