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Detecting corn tassels using computer vision and support vector machines

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ABSTRACT

An automated solution for maize detasseling is very important for maize growers who want to reduce production costs. Quality assurance of maize requires constantly monitoring production fields to ensure that only hybrid seed is produced. To achieve this cross-pollination, tassels of female plants have to be removed for ensuring all the pollen for producing the seed crop comes from the male rows. This removal process is called detasseling. Computer vision methods could help positioning the cutting locations of tassels to achieve a more precise detasseling process in a row. In this study, a computer vision algorithm was developed to detect cutting locations of corn tassels in natural outdoor maize canopy using conventional color images and computer vision with a minimum number of false positives. Proposed algorithm used color informations with a support vector classifier for image binarization. A number of morphological operations were implemented to determine potential tassel locations. Shape and texture features were used to reduce false positives. A hierarchical clustering method was utilized to merge multiple detections for the same tassel and to determine the final locations of tassels. Proposed algorithm performed with a correct detection rate of 81.6% for the test set. Detection of maize tassels in natural canopy images is a quite difficult task due to various backgrounds, different illuminations, occlusions, shadowed regions, and color similarities. The results of the study indicated that detecting cut location of corn tassels is feasible using regular color images.

1. Introduction

There have been many applications in agricultural tasks where expert systems have been studied; plant recognition is one of them. In addition, use of expert systems in agriculture has not been as straightforward as it was in industrial applications due to the lack of a fixed template to take into consideration. Rather, experts systems used for automated purposes in agriculture have to deal with biological materials which have vast morphological diversities (Blackmore & Steinhauser, 1993). However, expert systems that target crop-plant recognition as in robotics in agriculture or other automated systems provide enormous potential to speed and ease agricultural tasks.

Maize (*Zea Mays L.*) production in the World is about 875 Mt, and harvested area of maize is 18 Mha in Europe (FAO, 2014). Cultivation of maize is possible in almost any climate. Agricultural importance of maize arises from its intense usage in human and livestock nutrition. In industry, maize is also used for producing various materials such as ethanol and fibre. Seed purity plays an important role on maize yield. Maize plants are able to pollinate themselves naturally. However, self-pollination is not a desired situation. Quality assurance of maize requires constantly monitoring production fields to ensure that only hybrid seed is produced. Corn seed which has commercial value is hybrid between two inbred parents. Producers allow only the pollination between the two varieties of corn seeds selected for their field. This hybridization is provided by cultivating both 'male' and 'female' plants in the same field. While a male plant responsible for producing pollen, a female plant produces the hybrid seed. To achieve this cross-pollination, tassels (male flowers on the top most part of a maize plant) of female plants have to be removed for ensuring all the pollen for producing the seed crop comes from the male rows. This removal process called detasseling.

Detasseling process can be carried out manually by human experts or with the help of a detasseling machine. Although seed producers have been started to use these machinery contemporarily, detasseling success of these machinery varies between 60% and 90%. However, desired goal of detasseling is over 99% in most producing applications. To meet this requirement, the detasseling

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Nomenclature

b_i	background pixel	Mha	million hectare
C	regularization parameter of the SVM	Mt	million ton
DoG	difference-of-Gaussian function	RBF	radial basis function
f_i	blob pixel	$p(i, j)$	co-occurrence probability
FAO	food and agriculture organization of the united nations	RGB	Red–Green–Blue
γ	kernel coefficient	ROI	region-of-interest
$G(x, y, \sigma)$	Gaussian function	SE	structuring element
GLCM	grey level co-occurrence matrix	SIFT	scale-invariant feature transform
HSI	Hue-Saturation-Intensity	SVM	support vector machine
$I(x, y)$	image representation	σ	scale parameter
k	number of dimensions	YCbCr	luminance–chrominance in blue-chrominance in red
$L(x, y, \sigma)$	scale-space		

process still relies on extra human labor as the second process after using detasseling machinery which increases the total production cost. Most of these machines conduct cutting operation with a fixed height. Even though some detasseling machines have optical head sensors that allow determining height of the plant, more precise tassel locating has not been available yet. In a maize row, plant heights are unsteady, and height-based approaches are not adequate to locate tassel locations correctly. An expert system for automated tassel detection can reduce labor costs and increase accuracy. Computer vision methods could help positioning cutting location of the tassel to achieve a more precise detasseling process on the row.

In-field computer vision methods have been investigated in numerous studies to predict crop yield, to locate crops, and weeds. In an early study, spherical object detection was conducted using an artificial light source, and detection method was tested for citrus fruit at the initial stages of maturity (Pla, Juste, & Ferri, 1993). A survey about on-tree fruit detection techniques was reported up to year 2000 (Jimenez, Ceres, & Pons, 2000). This research outlined many of those studies using different image analysis methods and imaging systems. A study was conducted to investigate feasibility of discriminating between weed and sunflower using color imaging and artificial neural networks (Kavdir, 2004). A machine vision system was developed using color information for detecting mature oranges (Regunathan & Lee, 2005). Using hue and saturation, they performed Fisher's discriminant analysis, neural networks, and Bayesian classification to find fruit pixels. A system was presented to estimate the green citrus yield using color images and Fourier transform (Bansal, Lee, & Satish, 2013). A computer vision algorithm was proposed to detect immature peach fruits in natural orchard conditions (Kurtulmuş et al., 2014). To the best of authors' knowledge, there was only one study related to corn tassel detection using computer vision (Wenbing, Yane, Dongxing, Wei, & Minzan, 2012). Basic image processing techniques such as histogram-based thresholding were used, and researchers provided, unfortunately, neither detailed information about imaging conditions nor any quantitative success rate for their detection method.

The purpose of this study was to explore the feasibility of detecting cutting location of corn tassel in natural outdoor maize canopy using conventional color images and computer vision with a minimum number of false positives. An affordable solution is very important for maize growers who want to reduce production costs. This technique can be adapted to an expert and automated tassel cutting system enabling the system's ability to detect tassels in various locations and backgrounds. Also, proposed technique may be used as a separate system to locate tassels easing the labor devoted for this task. Proposed algorithm used features such as color, shape, and texture. Two support vector machines (SVM) were used as classifiers.

2. Material and method

2.1. Image acquisition

Image acquisition was carried out in a maize field located in Uludag University Research Farm, near Bursa (40° 11′North, 29° 04′East), Turkey. A total of 46 maize canopy images were taken in July 20, 2013. Using a regular color camera (Nikon Coolpix L22), maize canopy images were captured randomly in the grove at various times in daytime. Using these images, training and validation image sets were constituted by randomly selecting the images for training and testing detection algorithm. The training set consisted of 12 maize canopy images, and a total of 34 images were used to create a validation image set. Image resolution was 1024×768 pixels.

2.2. Software

The software was programmed in Python 2.7 programming language using the Scipy and Numpy scientific computing libraries (Oliphant, 2007). Scikit-image image processing library was used for the basic image processing steps such as reading images, color space conversions, region analysis, and textural feature extraction (Scikit-image, 2014). OpenCV in python was used for scale invariant feature transform (OpenCV, 2014). To construct a SVM classifier, scikit-learn machine learning library was also utilized (Scikit-learn, 2014). The algorithm development and the experiments were conducted in a personal computer (Intel core 2 Duo 2.26 GHz with 3 Gb of RAM).

2.3. Color based image binarization with a support vector machine classifier

To extract potential maize locations, a machine learning based approach was followed using color information. In computer vision, histogram-based thresholding is the first approach to consider for segmenting the target objects. However, colors of the background and the target objects are mostly similar in outdoor images. For this reason, a machine learning based approach was followed for image binarization. In a maize canopy image, it can be observed that major pixels are of leaves, sky, soil, and tassel. With this assumption, these pixel groups were manually marked in the training images. These manually created masks at the four classes were used for sampling of the pixels from different color components. Colour information was extracted using three different color space: Red–Green–Blue (RGB), Hue-Saturation-Intensity (HSI), and luminance–chrominance in blue-chrominance in red (YCbCr). To obtain R, G, and B color components separately,