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A segmentation method for greenhouse vegetable foliar disease spots images using color information and region growing

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ABSTRACT

This paper presents a novel image processing method using color information and region growing for segmenting greenhouse vegetable foliar disease spots images captured under real field conditions. Disease images captured under real field conditions are suffering from uneven illumination and complicated background, which is a big challenge to achieve robust disease spots segmentation. A disease spots segmentation method consisting of two pipelined procedures is proposed in this paper. Firstly a comprehensive color feature and its detection method are presented. The comprehensive color feature (CCF) consists of three color components, Excess Red Index (*ExR*), *H* component of *HSV* color space and b^* component of $L^*a^*b^*$ color space, which implements powerful discrimination of disease spots and clutter background. Then an interactive region growing method based on the CCF map is used to achieve disease spots segmentation from clutter background. To evaluate the robustness and accuracy, the proposed segmentation method is assessed by cucumber downy mildew images. Results show that the proposed method can achieve accurate and robust segmentation under real field conditions.

1. Introduction

Diseases are one of the main factors decreasing quality of vegetables. The key point of effective identification and diagnosis of diseases is to acquire the disease information accurately (Ma et al., 2015a,b, 2017; Zhang et al., 2017). With the development of computer vision technology, segmenting the disease spots from leaf images is presently considered the main route of disease information acquisition (Ma et al., 2015a,b; Barbedo, 2016). Bai et al. (2017) proposed an improved fuzzy C-means algorithm to improve the extraction of cucumber leaf spot disease under complex backgrounds. The method was composed of two parts: target leaf extraction and disease spots segmentation. Hamuda et al. (2017) proposed an algorithm based on HSV color space and morphological erosion and dilation to discriminate crop, weeds and soil HSV under natural illumination. Zhang et al. (2017) proposed a cucumber disease recognition approach, which used K mean clustering to segment diseased leaf images. Ren et al. (2016) proposed a new segmentation algorithm of cucumber leaf disease image based on saliency detection. The proposed algorithm mainly consists of two produces: saliency detection to get the leaf extraction and image segmentation to get cucumber leaf disease. Zhou et al. (2015) proposed an image segmentation method using template matching and support vector machine for monitoring *Cercospora* leaf spot development on sugar beets under real field conditions, the classifier used a combination of three features of L^*, a^*, Entropy × Density as input, which has strong discrimination power to classify CLS disease from background. Guijarro et al. (2015) proposed a segmentation strategy for agricultural images in order to successfully distinguish soil, weeds and crop plants. This method combined textures features and vegetation indices to improve the segmentation of images weeds and crops plants.

Color is the most direct information to discriminate disease spots and the other parts in a single image captured under real field conditions (Hamuda et al., 2016; Hernández-Hernández et al., 2016). However, segmentation using color information does not perform well on disease images captured under real field conditions, because uneven illumination and clutter field background are unavoidable noises, which has severe influences on color (Barbedo, 2016; Hamuda et al., 2016, 2017; Hernández-Hernández et al., 2016). Therefore, this paper focuses on the need for a robust color based segmentation method for greenhouse vegetable foliar disease spots images captured under real field conditions. Convolutional neural networks (CNN) can cope with input consist of

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images and automatically learn the appropriate features from training set, which is the most popular and best performing classifier for image recognition (Krizhevsky et al., 2012; Ding and Taylor, 2016; Grinblat et al., 2016). As CNN has been extensively applied to agriculture, it is feasible to use CNN as the pattern recognition method for achieving greenhouse vegetable disease classification. In order to guarantee an accurate input to CNN, it is also necessary to research on an accurate segmentation method for greenhouse vegetable foliar disease spots images.

In this study, we propose a two-stage framework for segmenting the greenhouse vegetables foliar disease spots images captured under real field conditions. The first stage involves a comprehensive color feature and its detection method, which combines *ExR*, *H* component of *HSV* color space and b^* component of $L^*a^*b^*$ color space. Because *ExR* is very susceptible to illumination conditions, an *ExR* parameter is adopted to reduce the influences of illumination conditions, which is selected by a new metric of CCF ratio. The second stage employs an interactive region growing segmentation. Disease spots segmentation from clutter background is achieved by interactively selecting growing seeds on the CCF map. Although this method needs human intervention, the ultimate goal of the method is to prepare data input to CNN based disease classification. Considering the characteristics of the data needs, interactive segmentation offers an appropriate way to achieve balance of accuracy and usability of segmentation method.

2. Methodologies

2.1. Data acquisition

About 93 cucumber downy mildew images were acquired from different sources. There were 24 images were downloaded from the Internet and 69 images were captured from greenhouse no. 5 of Agricultural scientific innovation base in Information Institute, Tianjin Academy of Agricultural Sciences, Tianjin, China.

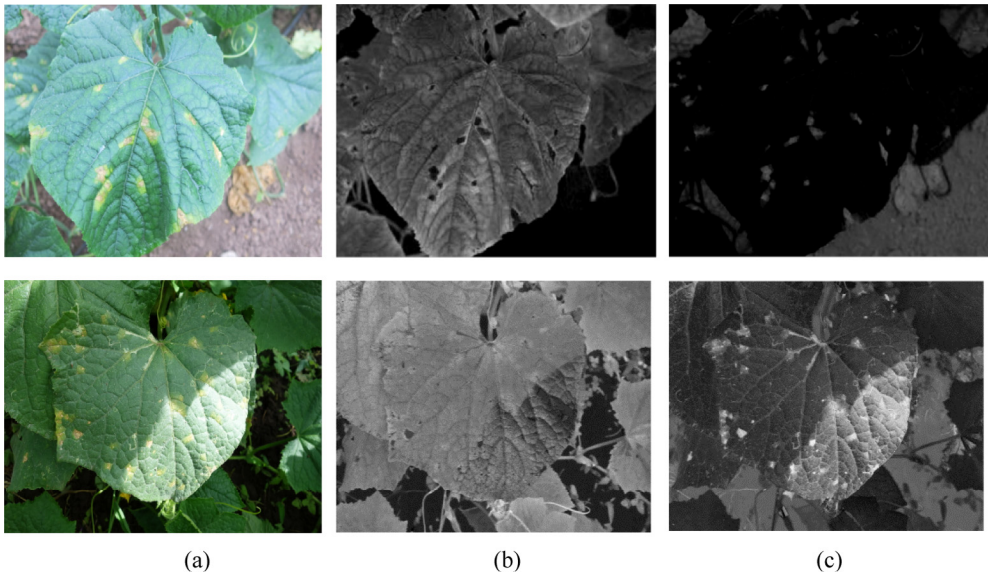

Fig. 1. Color indexes: (a) Original images, (b) Excess Green, (c) Excess Red.

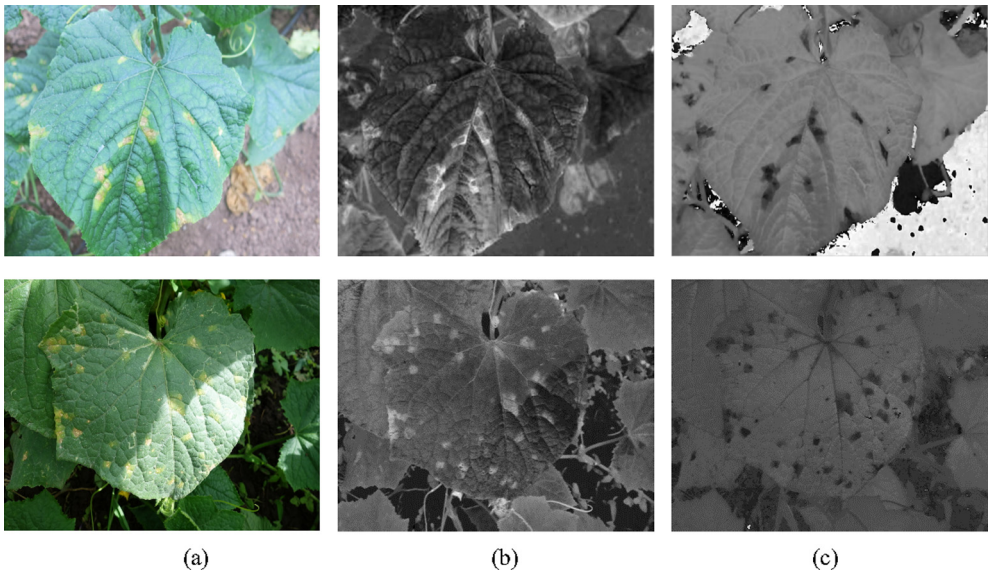

Fig. 2. Color components: (a) original images, (b) b^* component, (c) *H* component.