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A new portable application for automatic segmentation of plants in agriculture

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ABSTRACT

The achievement of the objectives of precision agriculture requires not only the development of new technologies, but also the availability of portable tools that can be used in the field. This paper describes the creation of a novel application for mobile devices called pCAPS (portable classification application for plants and soil) that integrates several computer vision techniques for plant segmentation and analysis in crop pictures. This tool allows monitoring of agricultural crops in real time, providing information that can be used to automate and optimize the calculation of water needs. The three main modules of pCAPS are: capture and cropping, image analysis, and historical record. First, a robust algorithm to detect rectangular markers located in the field is proposed; images are trimmed accordingly, in order to achieve a uniform analysis over long periods of time. Then color segmentation is applied using a probabilistic approach based on histograms in the optimum color space. Finally, an object counting process is performed on the binarized images, which is useful in applications that require the number of objects and their average size. Using pCAPS, the user can go with a portable device to a crop field, take a picture with the camera, automatically cut out the image, and perform on the ground an analysis of the vegetation, obtaining the percentage of green cover (PGC), number of plants, date, time, and GPS coordinates. This information can be sent by email to the central offices of the agricultural business, where appropriate decisions on fertirrigation needs would be taken. pCAPS is intuitive, user-friendly and has been developed for use by farm managers, requiring minimal skills in the use of mobile devices.

1. Introduction

Nowadays, in the context of computer science applied in agronomic engineering, efforts are being directed towards the development of applications for mobile devices (Picco et al., 2014; Delgado et al., 2013), also known as apps. This trend first emerged over two decades ago, for example in the work by Ketchpel et al. (1996) it was recommended that these tools should be designed to be compact, require little memory for execution, use little storage for the results, and adapt to the small screen of the user interface. The new generation of smartphones and tablets are equipped with powerful modern browsers, reliable Internet connection, high resolution cameras, precise GPS positioning, and other kinds of sensors that are suitable for agriculture (Hemel and Visser, 2011; Wasserman, 2010). Besides, the ability to be interconnected through wireless technologies provides communication with applications in the cloud, thus creating programs that can smartly adapt to their environment and be used centrally or remotely (Willig et al., 2005).

However, the availability of these devices is not enough by itself, and adequate apps are needed to harness their full power, allowing communication at field level between farmers, nutrient managers and others business professionals (Delgado et al., 2013). Every day new advanced applications appear, fostering progress in the agricultural domain, especially in less developed countries (Qiang et al., 2011). For example, there are apps to help farmers with timely decision making on the application of pesticides (Lomotey et al., 2013), to estimate the level of nitrogen in rice leaf by image analysis (Intaravanne and Sumriddetchkajorn, 2012), or to compute

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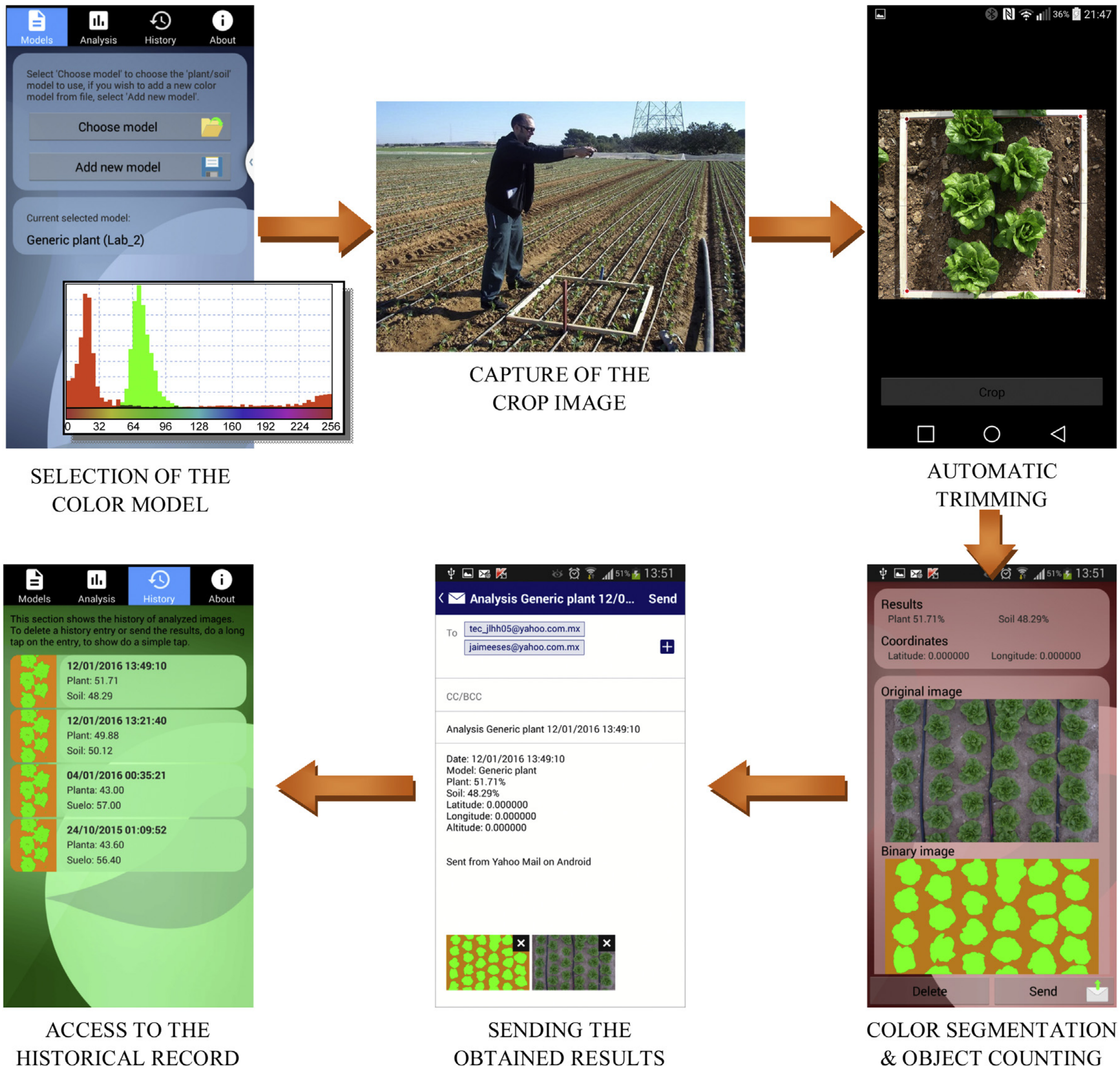

Fig. 1. An overview of the use of the proposed app in the agricultural crop. The user can capture, analyze and send the obtained results on the ground using a portable device. GPS location and date/time are included together with the results.

the solar radiation received in a crop field (Molina-Martínez et al., 2011).

Visual monitoring of crops consists in periodic capture of images of the areas of interest, which are analyzed to measure the growth of plants. These images should be consistent along time, in the sense that all of them should correspond to the same positions of the culture. The essential problem to be tackled is the segmentation of plants and soil, by classifying image pixels in vegetation or background elements, such as soil, stones, hoses, drip or any object, as quoted by McCarthy et al. (2010). This process results in the estimation of the percentage of green cover (PGC), which is defined as the percentage of land covered by the plant canopy in a top view of the crop (Fernández-Pacheco et al., 2014). Other parameters could be interesting in some applications, such as the number of existing plants, their average area, the date and time of capture, and GPS location coordinates. Additional data can be estimated from the previous values, such as the plant height (Fernández-Pacheco et al., 2014; Xu et al., 2010), the depth of the root system (Escarabajal-Henarejos et al., 2015b), and the crop coefficient Kc (López-Urrea et al., 2009; Allen and Pereira, 2009). These values are used to estimate crop evapotranspiration, which is an essential component in water balance used to estimate irrigation needs of the plants.

This paper describes the design and development of a new software tool that has been created to automate monitoring, segmentation and analysis of agricultural images, obtaining the PGC and other interesting information of the crop. Color processing techniques are based in the research described in (García-Mateos et al., 2015), where a novel algorithm for optimal color space selection and model training and was proposed for the problem of plant/soil segmentation in irrigation management applications. The app pCAPS consists of three main modules: image capture and automatic cropping; plant segmentation and analysis; and record of historical data. The system has been developed for easy use by non-expert users, and allows sending the results by email or any other means available in the device. Therefore, this data could be received in the offices of the company, where calculations of the optimal irrigation needs for the crop could be done according to a predefined methodology (Escarabajal-Henarejos et al., 2015a).

The rest of the paper is organized as follows. Section 2 describes the underlying computer vision techniques that are proposed to perform crop image analysis. Then, Section 3 presents the experimental results of the proposed method, along with a sample usage of the program. Finally, the most relevant conclusions and future research lines are drawn in Section 4.

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