Fusion on Citrus Image Data from Cold Mirror Acquisition System

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ABSTRACT

In this paper, an image fusion is presented to improve the citrus identification by filtering the incoming data from two cameras. The citrus image data has been photographed by using a portable bi-camera cold mirror acquisition system. The prototype of the customized fixture has been manufactured to position and align a classical cold mirror with two CCD cameras in relative kinematic position. The algorithmic registration on the pairwise images has been bypassed by both the spatial alignment of two cameras with recourse of software calibration and the triggering synchronization in temporal during the photographing. The pairwise frames have been fused by using the Daubechies wavelets decomposition filters. The pixel level fusion index rule is proposed to combine the low pass coefficients of the visible image and the low pass coefficients of the near-infrared image convoluted by the complementary of entropy filter from the visible low pass coefficients. In the study, the fused artifact color image and the non-fused color image have been processed and compared by some classification methods such as low dimensional projection, self-organizing map and the support vector machine.

Keywords: Bi-Camera Imaging, Classification, Cold Mirror, Discrete Wavelet Transform (DWT), Image Fusion

1. INTRODUCTION

1.1. Background

From the historical background in horticultural industry, the vision system used in the automatic harvester aims to detect the fruits with the information of the location and the depth estimation for the robot controller. In vision system, vision cameras are mainly the solution to communicate with the environment. The major achievements of vision systems and the performance of the various sensors in the harvesting agricultural automation have been reviewed by Jimenez et al (2000). The practice has covered three main categories: intensity, spectral and laser range
finder. In most literatures, the successful fruit identification rate is averagely around 70% and up to 90% with variations in some cases. Some issues still barrier the commercial use of the automatic harvesting system. In practice, the imaging sensors have certain physical limitation. Therefore the image data acquired by the single sensor are degraded. From the open uncontrollable dynamic, the spectra is affected by potential multi-factors (Kane & Lee, 2006). By using hyperspectral technique, the certain wide range of spectra can be acquired within the resolution capability. The statistical study on segments of all wavebands can provide the feature reference in machine vision system development. However the waveband selected based on the study could be fuzzy conditionally. The scanning time depends primarily on the area to be scanned and the sensor resolution (Okamoto & Lee, 2009). Alternatively the multispectral imaging has been proposed to capture and combine more information at the same time with capability of acquiring more wavebands and a smarter image processing technique to improve the detection (Edan, 1995; Kane & Lee, 2006). Instead of dispersing spectrum into the discrete numerous wavebands, multispectral image capture the specific range of wavelength across in spectral space. The early multispectral scheme was presented by Rabatel (1988). The custom built camera consisted of three CCD micro cameras side by side with three different optical waveband filters in terms of 550nm, 650nm, and 950nm wavelength respectively. Two ratios by using 550 and 650nm intensity to 950nm intensity were calculated to classify the fruit apple and background. The detection of fruit was about 75% when the sky was overcast. This scheme initially gave the implication to possibly detect immature green fruits by combining different waveband spectra. However the failures were detected and the system was not absolutely insensitive to illumination changes. Kane and Lee (2007) used a monochromatic near infrared camera equipped with multi waveband pass filters to capture citrus fruit tree images. This work was an extension (Kane & Lee, 2006) after the measurements done on the green leaves and the green types of citrus fruits through seasons. Three waveband filters were attached to the camera respectively to catch waveband spectral area images. The reference index of band intensity was used followed by the Otsu’s threshold to classify the citrus from the background. Averagely 84.5% correct citrus pixels were identified. However the resultant multispectral images were not well synchronized and aligned in dynamic scenes. Another issue was the saturation part and the dark area on the image. The reason that the number of leaves caused the diffuse reflectance was theoretically studied by Kane and Lee (2006). It was proposed that the multispectral images should be captured at the same time with capability of acquiring more wavebands and a smarter image processing technique. On top of that, the multispectral scheme has been broadly designed and practiced in research such as in inspection analysis. Various sensors are selected and practiced depending on the application case (Aleixos et al., 2002; Lu, 2004). In literature, the multispectral can be achieved by multisensor shooting the same channel (Aleixos et al., 2002) or a single sensor shooting the channel by interchanging (Lu, 2004) certain filters. Basically the certain spectral regions and the ratio combination of the spectral regions components are used to contrast the image for classification process. The fusion on the information from different sensors still has space to be extended. The multisensor fusion technique is a synergistic combination of different sensor information. The idea of fusion technique has been broadly researched for various applications such as medical diagnostic learning purpose or surveillance and inspection purpose (Blum & Liu, 2006; Wyawahare, Patil, & Abhyanker, 2009). The main information can possibly be maintained in the fused data source by combining the quality of the data from each other complementarily. Use of image fusion technique needs to solve two issues (Blum & Liu, 2006) namely the registration and the fusion of the data. The issue of registration has been practiced recently by developing two types
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