A Counting Algorithm for Tangerine Yield Estimation

Ulzii-Orshikh Dorj[1], Malrey Lee*[1], and Sangsub Han[2]

[1]Center for Advanced Image and Information Technology,
School of Electronics & Information Engineering,
Chon Buk National University, 664-14, 1Ga, Deokjin-Dong,
Jeonju, Chon Buk, 561-756, South Korea(*corresponding author)
[2]Department of Forest Environmental Sciences, Chonbuk National University, Jeonbuk 561-756, South Korea

Abstract. In this present paper, a new counting algorithm for tangerine yield estimation is adapted to obtain better results with respect to partially / semi partially occluded tangerine and its clusters. To optimize tangerine counting, and to minimize typical background noises from orchards (i.e. bare soil, weeds, and man-made objects), a tangerine fruit counting algorithm is implemented, and compared between before harvesting, after harvesting tangerine fruits, and results of yield estimation through tangerine flower recognition. Under natural lighting conditions prediction of the tangerine fruits from the orchards is computed and compared based on observers, and with tangerine counting algorithm. The simulation outputs show that new counting algorithm is found to be suitable, and effective.

Keywords: Counting algorithm, tangerine fruit, yield estimation, thresholding.

1 Introduction

The problem of identifying the total number of fruits / vegetables on trees / plants has long been of interest in agricultural crop estimation work. Yield prediction of fruits and vegetables in practical environment is one of the hard and significant tasks to obtain better results in crop management system to achieve more productivity with regard to moderate cost. Palaniappan et al. [1] utilized color vision in machine vision system to identify citrus fruits, and estimated yield information of the citrus grove in-real time. Radnaabazar et al. [2] presented an automatic machine vision system, and estimated citrus yield. Rong [3] et al. presented new apple fruit recognition algorithms based on color features to estimate the number of fruits and developed models for early prediction of apple yield. Stajnko et al. [4] described a new, computerized vision-based model to estimate the diameter and number of apple fruit on a tree and hence its yield autonomously under natural weather conditions in fruit orchard.

[1,2] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

Jadhav et al. [5] developed a technique to monitor yield, by correlating the volume of the harvested fruits to its mass. Zaman et al [6] presented tree canopy mapping with an automated ultrasonic system for using to estimate fruit yield within a grove to plan site-specific management practices. However, all these methods demonstrated yield estimation just before fruit harvesting or during harvesting time. But, current efforts on tangerine yield estimation using computer vision can be classified into two categories: 1) Yield estimation by detecting tangerine flowers. 2) Yield estimation by counting number of tangerine from orchards. Yield estimation by detecting tangerine flowers developed in [7, 8]. Since there is no research report leading to satisfactory yield estimation for tangerine therefore, in this present paper a new computer vision algorithm is proposed. For convenience, a sample of 2 tangerine tree images was taken on November during tangerine harvesting season. Images were taken from four sides of each tree in stationary mode under natural outdoor illumination conditions. Also, collection of total number of tangerine fruit images was taken after harvesting. The paper is arranged as follows. Section 2 explains about the objectives and newly proposed methodology in detail. Section 3 shows experimental outputs using newly proposed algorithm in comparison with others methods. In section 4 conclusions is presented.

2 Objectives and Methodology

The overall goal is to develop a real time yield estimation system capable of determining tangerines from natural tangerine tree. The system will estimate tangerine yield for a single tree. A detailed schematic representation of the proposed method is presented as a flowchart which is shown in figure 1.

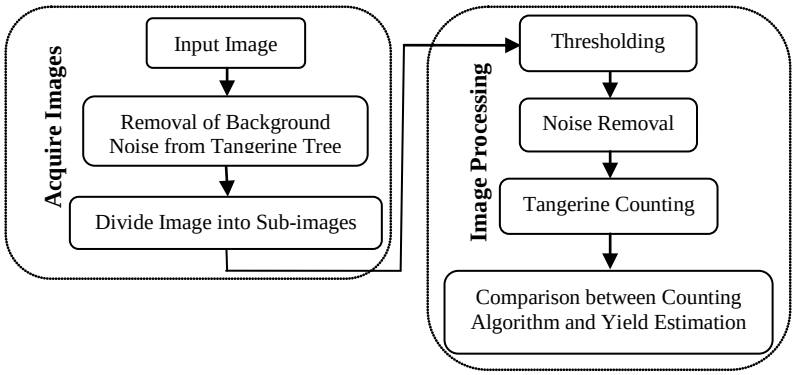


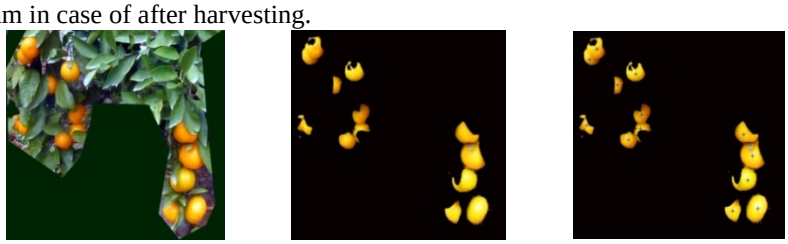
Fig. 1. Flowchart of a proposed method

For developing the tangerine recognition and counting algorithm, images were taken through camera in the tangerine field in Jeju Island of South Korea. It is significant to point out that, image processing operation is carried out using sub 72 images. The class of objects of original RGB image of tangerine tree consists of green tangerine, yellow tangerine, mature tangerine, rotten tangerine, light green leaf, dark green leaf,

grass, soil, tree, twig etc. Following are the steps such as thresholding, noise removal and counting are involved and executed to perform counting algorithm. In brief: 1). Perform histogram of color component Cb in YCbCr, and thresholding in Cb component, 2). Erasing small pixels, 3). Counting number of connected objects.

3 Performance Evaluation and Discussion on Results

The main goal of this paper was to develop tangerine fruit detection and counting algorithm of the tangerine under various natural lighting conditions and estimate yield of tangerine fruits using Matlab program, and compared yield estimation result in [8]. As a result, total of 72 sub images of tangerine were detected by this algorithm. The following figure 2 shows the results of tangerine fruit counting algorithm in case of before harvesting sub image. Similarly, figure 3 shows the tangerine fruit counting algorithm in case of after harvesting.



Input sub image | Result of Thesholding in Cb | Number of matured tangerine fruits are 13

Fig. 2. Tangerine fruit counting algorithm steps (before harvesting)

Input sub image | Result of Thesholding in Cb | Total Number of matured tangerine fruits are 22

Fig. 3. Tangerine fruit counting algorithm steps (after harvesting)

Figures 2 and 3 reveal that, two different cases are considered in order to show that the results obtained are not exactly equal. This is due to partially / semi partially occluded tangerine and its clusters. It is apparent that results obtained after harvesting is more suitable for yield estimation but on the other side the user has to consider the results before harvesting thereby it can be used to determine number of tangerine flowers turned out to be tangerine fruits (for statistical purpose). Result of tangerine detection and new counting algorithm for two different trees in case of before and after harvesting, and yield estimations of tangerines between 10%-20% (obtained based on data [8]) is shown in table 1.

Table 1. Result of tangerine detection and counting algorithm for two sample trees

Number of Trees	Before harvesting (On the tree)		After harvesting (Out of the tree)		Yield estimation (10%) [15]		Yield estimation (15%)		Yield estimation (20%)	
	Mean value of observers	Counting Algorithm	Mean value of observers	Counting Algorithm	Mean value of observers	Counting Algorithm	Mean value of observers	Counting Algorithm	Mean value of observers	Counting Algorithm
#1	708	689	758	755	338	338	506	507	675	676
#6	733	708	803	801	367	355	551	533	734	710

4 Conclusions and Future Work

In order to obtain better yield management a new counting algorithm for tangerine yield estimation is adapted to yield better results with respect to partially / semi partially occluded tangerine and its clusters. To optimize tangerine counting, and to minimize typical background noises from orchards, a counting algorithm is implemented, and compared between before harvesting, and after harvesting which is closer to 20% of yield estimation result. The simulation outputs show that new counting algorithm is found to be suitable, and effective.

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