ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Machine Vision Based Automatic Segmentation and Yield Counting Of Fruits By Color And Shape Features

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ABSTRACT

Locating the fruits on the tree and counting them becomes an issue in the fruit harvesting system. Instead of the manual task of identifying and counting the fruits, the machine vision methods support the fruit yielding system which segments and count the fruits on the trees automatically. In this paper, an intelligent counting system is proposed based on the color and shape analysis of the fruits. Initially the preprocessing is done on input fruit images to remove the noise. The Graph cut algorithm is used to suppress the background to extract the salient foreground image. The foreground image is then converted from RGB to HSV color space which ensures the segmentation process easier. Segmentation process of the converted image is carried out using the Color Thresholding (CT) technique. The fruit region is extracted from the segmented image using the Connected Component Labeling (CCL) by which the objects (fruits) in the image are identified and extracted. The edge detection utilizing Canny Edge Detection Algorithm (CEDA) is used for the purpose of identifying and detecting the edge points of the objects and the circular fitting algorithm utilizes those edge points to fit in a circular shape to find the fruit count for an image.

Keywords: Edge detection, circular fitting, Image Processing, HSV color space, Color thresholding.

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INTRODUCTION

Automatic counting of fruits in practical environment is one of the most difficult and significant task which helps in crop management and fruit harvesting system to increase the productivity with low cost. There are many algorithms used in practical environment for automatic segmentation and counting of objects in an image. In order to automate this segmentation and counting process, [1] various proposed different optimization and computer vision techniques which utilized the intensity, color, orientation and edge feature vectors of the input image [2]. The machine vision applications were developed instead of human operators who failed to identify and count the objects from the images. It starts with identification of fruits with different colors [3] brings the hybrid method of combining the texture and color features. This method is implemented to identify the red and green color apples. The spherical shape fruits are recognized by the combination of various novel methods [4] with different difficulties. The recognition of orange fruit using the machine vision algorithm is proposed and comprises of region labeling, perimeter extraction, segmentation, size filtering and perimeter based segmentation [5]. Numerous fruit detection processes are reviewed and a new automated fruit recognition system [6] is introduced where the segmentation is based on the shape based analysis and is capable of detecting the fruits at different maturity level. Initially the input image is preprocessed and the existing noises are removed. Then the Graph Cut Algorithm [7] suppresses the background from the image. The foreground is usually in the RGB color space from which the HSV is extracted that gives the color information for the later steps [8]. The segmentation process of the foreground images is done using the color thresholding [9] where the objects are extracted by utilizing the color information acquired from the previous steps. This color thresholding is used to mask the desired color on the image. The object extraction is done using the Connected Component Labeling (CCL) by which the fruits are identified [10] and the Canny Edge detection algorithm is used to find the edges of the identified fruits by using its five conventional steps [11]. Finally the Circular Fitting Algorithm [12] makes use of those strong edges and makes the object to fit into a circle. This process makes the counting process simple. The number of circles occurs in the processed input image is the number of fruits. The figure.1 depicts the work flow of the proposed fruit counting system.

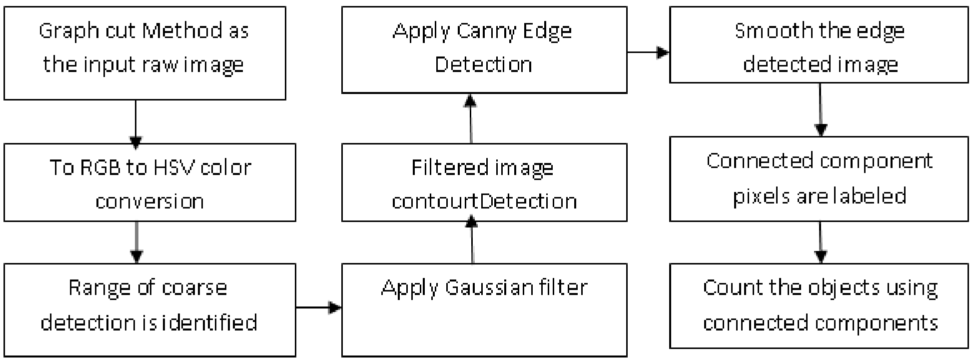

Figure 1. Block diagram of the proposed technique

RELATED WORK

In paper [13],the combination of color image segmentation and the fuzzy logic technique is used for checking the ripeness stage of the fruit without seeing and touching and this paper reviewed the color and shape extraction techniques which identifies the disease and ripeness of the fruits. In paper[14] &[15] the author detected the fruit features based on fruit size detection and grading system. The fruit features are extracted by detection algorithms. The grading system providing accurate, consistent, reliable and quantitative information apart from handling huge volume of images. In paper[16],the author utilised conventional RGB camera with making use of machine learning technique to detect immature, mature, and young fruits on the plant. The threshold values are used for fruit detection. The segmentation is based on classification models according to shape, color, size, texture of the image. The performance results shows the high precision.

a) Image Preprocessing and Background Suppression

The input images are taken form the internet and are preprocessed using Gaussian denoising filter where the existing noise are removed with more attention. Then the de-noised image is given to the background subtraction session where the foreground (salient images portion) is retrieved from de-noised image. This background suppression process makes use of the Graph Cut Algorithm [7] which uses the traditional inbuilt steps to extract the foreground portion with the user defined image area. The raw input image and the foreground extracted image are shown in the figure.2 and figure.3.

Figure.2: Input image

Figure.3: Background subtraction

b) Hue Saturation Value (HSV) Color Space Extraction

The foreground image is taken for extracting the HSV value. The images are usually in the RGB color space which is not having sufficient information to represent the features of the image. Hence it is essential to transform the RGB color space of the original foreground extracted image into the HSV color space image which changes the saturation and hue value of the image [8]. The HSV is capable of decomposing the image into several meaningful parts which are used for the segmentation process. The fig.4.shows the RGB to HSV converted image This process avoids the brightness variation in the image and that leads to discovering the number of colors in the image visually.

c) Segmentation Using Color Thresholding

The image segmentation is a process of partitioning the image into different regions where an individual region is having the homogenous pixels. The segmentation process in this paper is combined with the color thresholding technique [9]. The color thresholding technique is performed using the color information of the objects in the image. The intensity range of the particular color is specified and considered as threshold value. The objects that appear out of the specified intensity range are removed. Hence the color range is necessary to specify otherwise the algorithm will find the objects in the image non-satisfactory. The objects that are to be extracted have the range of intensity in terms of RGB. The Figure.5 shows the segmented image.

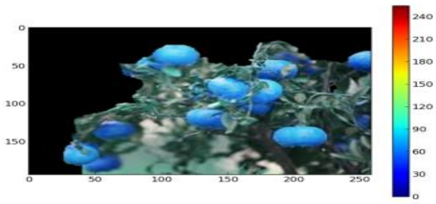

Figure 4. HSV image

Figure 5 . Segmented image

d) Canny Edge Detection Algorithm

Canny Edge Detection Algorithm (CEDA) is one of the optimal edge detection techniques with good localization and clear response. The CEDA is a combination of four inbuilt process such as smoothing, gradients computation, Non-Maximum Suppression and finally thresholding. The result of the final thresholding step gives the optimal edges of the extracted objects in the image [11]. Even though the image is preprocessed in the initial stage, after the object extraction stage the existing noises may spoil the image. Hence the Gaussian filter is used to de-noise the image. Finally the detected strong edges are collected and marked in the image to display the contour of the objects in the image. This is shown in Figure 6.

e) Connected Component Labeling Object Extraction

Labeling is a method of extracting the object region using the connected components and is applied to the image after the thresholding process [10]. The Connected Component Labeling normally identifies the groups and labels the connected pixels. The images after thresholding are taken for the object extraction process. If the pixels are connected vertically or horizontally or diagonally, then the pixels are assumed to be connected.

This process can also be applied for high dimensionality data or image. The fruit can be filtered, counted or even tracked using region labeling which is done by blob extraction process. This is shown in figure .7

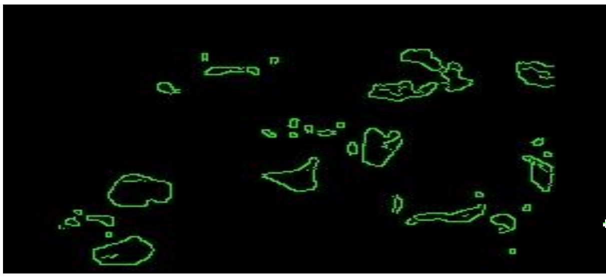

Figure 6. Canny Edge detection **Figure 7. Region Labeling**

f) Fruit Counting Using Circular Fitting Algorithm

The automatic counting of fruits is performed using the Circular Fitting Algorithm where detected strong edges are allowed to fit in a circle [12]. Finally the number of fruits is determined by counting the fitted circles on the input image which makes the process of fruit counting automatic.

g)Yield estimation and quality Parameter

This paper utilizes the shape analysis concept for the process of yield measurement which finds the total number of fruits in a tree with minimized time. The mean yield estimated error is calculated by the quality parameters. Percentage accuracy and mean absolute percentage error (MAPE) are quality parameters which are defined as

$$\%ofaccuracy = \frac{\mathrm{Alg}\,orithamicallycount}{Manualcount} X100\% \quad (1)$$

The mean absolute Percentage error

$$MAPE = \frac{1}{N}\frac{|Mi - Ai|}{|Ai|} X100\% \quad (2)$$

Here, N – total number of fruits, i= 1 to N,M- Manual counting, A-Algorithmic count

RESULTS AND DISCUSSION

The process of edge detection of the extracted objects plays a significant role in counting the fruits. This edge detection detection process is accomplished by using the Canny Edge Detection Algorithm. Different types of fruits are identified and counted using the proposed system such as cherry, orange, lemon, pomegranate and mango.

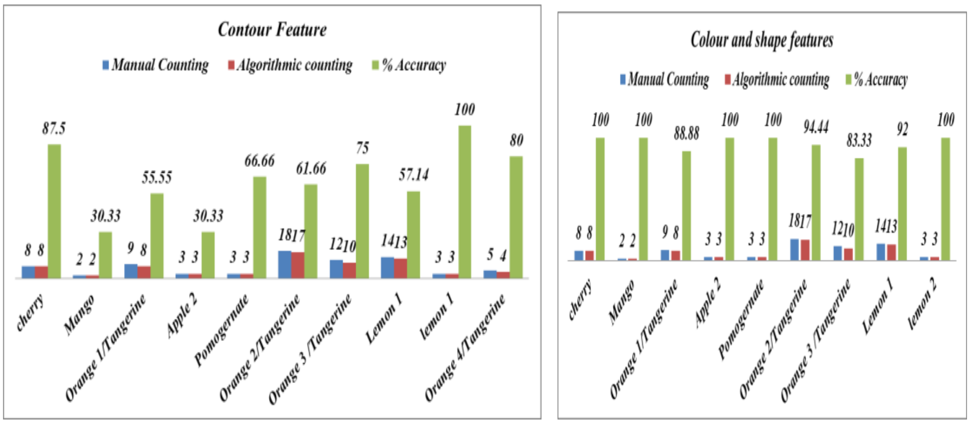

Figure 6. Comparison of Algorithmic and Manual Counting

The figure 6 shows the comparison in terms of graph. This figure conveys that the proposed machine vision based automatic counting of fruits detect the fruits better than the manual counting and bring better accuracy. Hence this proposed method of colour feature providing better accuracy than the contour feature.

CONCLUSION

In this paper, the automatic system is developed for the purpose of fruit counting. The algorithm was composed of different subsections and they are edge detection, connected region labeling and finally circle fitting based detection. Accommodating a reliable counting technique facilitates a fast, consistent, automatic and convenient way of identifying and counting fruits. In addition, this proposed system reduces the cost spend on the manual process of counting the fruits and also reduces the false estimation. The implemented results are discussed and compared to the manual counting process.

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