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A Study on image analysis of Myristica fragrans for Automatic Harvesting

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Abstract: *The traditional method of plucking Myristica fragrans by hand is tiresome and demands huge labour. One of the major tasks in harvesting is to identify matured fruits. This study illuminates the probability of identifying Myristica fragrans by using various Image processing techniques, which include image segmentation, feature extraction & edge detection, to achieve the required classification. The proposed study intends to provide efficient methods that will lead to automatic harvesting.*

Keywords*: *CHT, CIE L*a*b*, Edge detection, Image Processing, Segmentation

I. Introduction

A number of automatic harvesting systems are designed to achieve bulk removal of the fruit during the reaping period. Traditional methods have been practiced using shaker or air blast with chemical mechanics of abscission as pre-harvest agents to loosen the mature fruits. There are some issues in mechanical harvesting system such as the quality and size selection, damage of fruit and trees in some cases. A post selection process can be appended to maintain the aesthetic and value of product for the consumer. However, the mechanical system operates blind when it comes to remove quality ripe fruit.

None of the currently available mechanical harvesting systems have been able to fully replace the flexibility and fruit assortment skills of manual pickers.Despite of the enormous research effort that has been placed on different fruit assortment and exclusion techniques, it is an attempt to identify their effectiveness.This paper endeavors to briefly reviews the main features and achievements of the different methods that have been investigated. We attempted to propose the possible benefit of image data analysis methods that can be used for automatic harvesting of "Myristica fragrans"

Nutmeg is an important spice expansively cultured in the state of Kerala, India. The Fruit of Nutmeg consists of different layers, whose inner part has a dried seed, the nutmeg which is the most useful and marketable component. A thin layer of fine material surrounds the nutmeg. When ripe, the husk splits apart revealing the red colored mace. The mace and the dried seed are sold separately. After plantation, 7 to 9 years are required for the first harvesting of nutmeg trees. The kernel, which is inside the dried fruit is having a wide variety of uses including flavoring dishes and beverages and after suitable processing kernel is used in food & beverage, pharmaceutical, cosmetics, and soap industries.

II. Color Based Analysis

RGB, Normalised RGB,CIE XYZ,CIE YUV,HSI, CIE L*a*b* etc are the commonly-used color spaces in color image processing. Selecting the best color space technique is a major difficulty here. The basic color space is RGB color space and it uses three primary colors namely red, green & blue. Transformation from RGB model to any other color space models can be performed directly or indirectly. HSI color space uses the three components :hue (H), saturation (S),and intensity (I). CIE L*a*b* is one of the most complete color model. CIE L*a*b* color model describe all colors that human eye can see and has three basic coordinate components: the intensity of the color, the position between red and green, and the position between yellow and blue, which are L*, a*, and b* respectively.

In [1] Anmin Zhu et al the CIE L*a*b* color space is selected as the color image segmentation space . Visual sensor generally obtains the image in the RGB model. Therefore it should be transformed into the CIE L*a*b* image before processing.Conversion is generally divided into two steps as follows
Step1 Convert RGB to CIE XYZ,

Step2 Transform CIE XYZ to CIE L*a*b*

III. Image Segmentation

The process of partitioning an image into component regions or objects, so as to change the representation of an image into something that is more easier to analyze in order to get more information in the region of interest in an image which helps in annotation of the object scene is referred to as Image segmentation. Image segmentation is needed in order to identify the content of the image carefully. In this context, edge detection is a fundamental tool for image segmentation.Several general-purpose algorithms and techniques have been developed for image segmentation.

Even though different segmentation techniques are at hand, every method is not equally appropriate for a particular type of image. Thus the algorithm suitable for one class of image may not be suitable for another class of images. Consequently, there is no unanimously supported method for image segmentation for all categories of images and as a result it remains a challenge in image processing and computer vision.

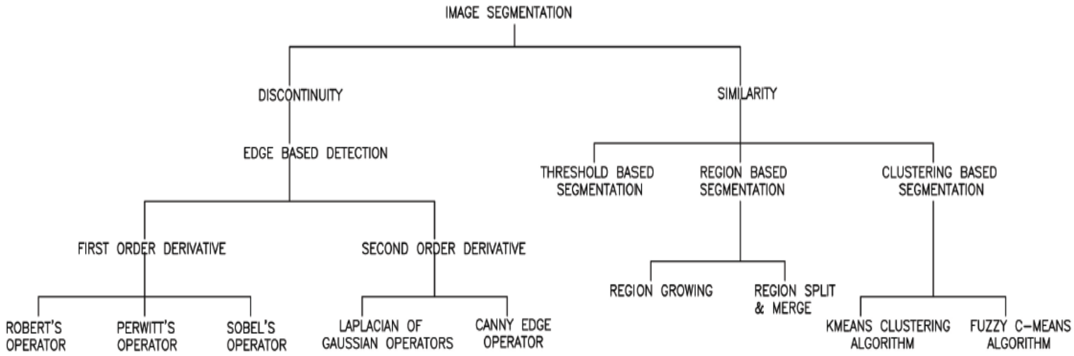


Image segmentation approach can basically be divided into two parts [9], [10].

A. Identifying Discontinuities: The images are subdivided on the basis of sudden changes in the intensity of the gray levels of the image. The idea of division is based on detection of various edges, lines, corners or points in the image that includes image segmentation based on edge detection.

1. Edge based Segmentation

Image segmentation algorithms generally are based on discontinuous intensity values and similar intensity values. In case of discontinuous intensity values, the approach is to partition the image based on abrupt changes in intensity, such as edges in an image.Segmentation based on Edge Detection refers to the boundaries where there is an abrupt change in the intensity or brightness value of the image. Edge detection is the problem of primary value in image analysis. The obtained boundary marks the edges of the desired object. Hence by the detection of its edges, the object can be segmented from the image. The output that is received by applying edge detection algorithm is a binary image.There are three fundamental steps in edge detection o Filtering & Enhancement :In order to facilitate the detection of edges, it is essential to repress as much noise as possible and determine changes in intensity in the neighborhood of a point, without destroying the true edges.

O Detection of edge points:determine which edge pixels should be discarded as noise and which should be retained (usually, thresholding provides the criterion used for detection). o Edge localization: Not all of the points in an image are edges for a particular application. Edge localization determine the exact location of an edge. Edge thinning and linking are usually required in this step.

The edge detection operators can be generally divided into two categories 1) First order derivative operators 2)Second order derivative operators.

i. First order derivative operators

The first order derivative operators generate thicker edges and are sensitive to noise. There are two first order derivative edge detection methods. 1) Evaluating the gradients generated all along two orthogonal directions. 2) Utilizing a set of distinct edge templates with different orientations [11].The first derivative-based edge detection operator to detect image edges by computing the image gradient values, such as Roberts operator, Sobel operator, Prewitt operator.

Robert's Edge Detection operator:

Roberts edge detection method is one of the ancient method and is used often in hardware implementations where simplicity and speed are dominant factors [6].Roberts edge detection operator is based on the principle to approximate the gradient of an image. It is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels through discrete differentiation. Difference between diagonally adjacent pixels is used to process the image [7].The operator consists of two 2×2 convolution kernels. One kernel is simply the other rotated by 90°[12],[18].

$$\begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix}.$$

Let I(x,y) be a point in the original image and by convolving with the first kernel, $G_x(x,y)$ be a point in an image and $G_y(x,y)$ be a point in an image formed by convolving with the second kernel.
The gradient can then be defined as:

$$\nabla I(x,y) = G(x,y) = \sqrt{G_x^2 + G_y^2}.$$

The direction of the gradient can also be defined as follows

$$\Theta(x,y) = \arctan\left(\frac{G_y(x,y)}{G_x(x,y)}\right).$$

Sobel Edge Detection

Sobel operator introduced by Sobel in 1970 is an edge detection technique that is is used in images with high frequency changes. The sobel operator is comparatively cost-effective in terms of computations as it based on convolving the image with a pair of convolution kernels. The sobel operator consists of two 3×3 convolution kernels which are convolved with the original image. one kernel is simply the other rotated by 90°. The Sobel technique performs a 2-D spatial gradient quantity on an image thus highlights regions of high spatial frequency that correspond to edges. The 3X3 convolution mask smoothes the image to some extent and hence it is less prone to noise.

Prewitt operator

Prewitt operator is used for detecting the XY directions in the images by using a 3X3 mask.Here the x -coordinate is the increasing in the right direction, and the y-coordinate is the increasing in the "down" direction.From the resulting gradient approximations at the each point in the image, is combined to get the gradient magnitude.The Prewitt operator is the accurate method to find the magnitude and orientation.The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical directions and is therefore relatively inexpensive in terms of computations[13].

ii. Second order derivative operators

Some of the Edge Detection Operators are based on second order derivative**.** This effectively captures the rate of change in the intensity gradient .It detects better edges , analogous to the minimum details, they also detect and enhance isolated pixels. It includes Canny edge detection operator,Laplacian of Guassian (LoG) Operator, etc.

Canny Edge Detection operator

Canny edge operator is considered as optimal edge detector operator among the available operators. It determines strong and weak edges in the image [11].J.F Canny in [8] has proposed a Computational Approach to Edge Detection algorithm that runs in 6 separate steps:

1. Smoothing: filter out any noise in the original image
2. Finding gradients: By taking the gradient of the image, the edge strength is calculated.
3. Direction calculation: In this step, direction of edge should be calculated.
4. Non maximum suppression: This is done in order to suppress any edge that should not be marked as edges

5. Two times thresholding or hysteresis thresholding: Potential edges are determined by applying thresholding twice.
6. Edge tracking by hysteresis: Finally the algorithm determines the edges by suppressing all edges that are not connected to very certain edge .

Laplacian of Guassian(LoG) Operator

The Laplacian of a Gaussian function is a 2-D isotropic measure of the 2nd spatial derivative of an image and is otherwise referred to as LoG. The filtering process is the application of a smoothing Filter performed by a convolution with a Gaussian function, followed by a 2 nd spatial derivative operation. Smoothing filter is performed in order to reduce its sensitivity to noise. The Laplacian of an image highlights regions of rapid intensity variation and is for that reason frequently used for edge detection.

B. Identifying Similarities: The images are subdivided on the basis of similarity in the intensity of the gray levels of the image. The idea of subdivision is based on identification of various similar edges, lines, corners, or points in the image.

1. Threshold based segmentation

Image segmentation by thresholding is a simple and powerful technique for segmenting images having light objects on shady background. Thresholding operation converts a multi level image into a binary image by choosing an appropriate threshold T and divide image pixels into several regions and separate objects from background.The separation of the objects from the background is generally done by selecting a value T. Depending on the thresholding value there are two techniques described:

If the intensity of any pixel (x,y) is greater than or equal to the threshold value,then it is considered as a part of the object otherwise it belongs to background.Local thresholding and global thresholding are the two types of thresholding methods based on the selection of the threshold value.[16]When T is constant,the approach is called global thresholding otherwise it is called local thresholding.If the background illumination is uneven then the global thresholding method become failed.But these uneven illuminations are compensated in local thresholding method by using multiple thresholds.

Threshold selection is typically done interactively however,it is possible to derive automatic threshold selection algorithms.[20]Limitation of thresholding method is that,only two classes are generated and it cannot be applied to multichannel images.[19]In addition,thresholding does not take into account the spatial characteristics of an image due to this it is sensitive to noise,as both of these artifacts corrupt the histogram of the image,making separation more difficult.

2. Region based segmentation

Region is a group of connected pixels having similar properties.Region based segmentation is a process of partitioning an image into region.Regions are used to interpret images.A region may correspond to particular object or different parts of an object.Region-based techniques are generally better in noisy images (where borders are difficult to detect)

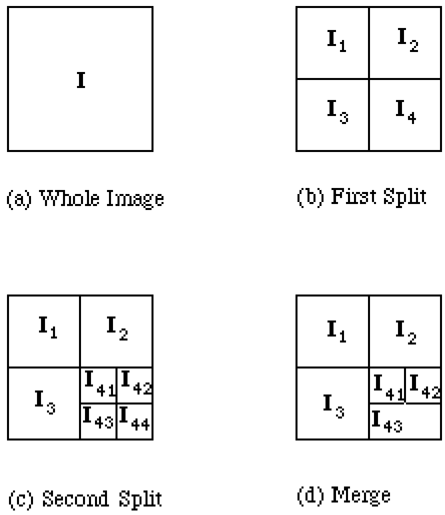
i. Region growing

It is a simple approach to image segmentation which begins from a few pixels (seeds) representing distinct image regions and to grow them, until they cover the whole image .Here a rule describing a growth mechanism and a rule for checking the homogeneity of the regions after each growth step is needed.

ii. Region Split & Merge

It follows top-down approach and begin with the supposition that the whole image is homogeneous . The image is split into four sub images .This splitting process is repeated recursively until the image is split into homogeneous regions.

- Let I denote the whole image
- Not all the pixels in I are similar so the region is splitted.
- It is assumed that all pixels within regions I1 , I2 and I3 ,correspondingly are related but those in I4 are not.
- Therefore I4 is split next
- Again assume that every pixels within each region are related with respect to that region, and after comparing the split regions, regions I41 and I44 are found to be identical.
- These are then merged together



Since the process is recursive, it produces an image representation that can be expressed by a tree whose nodes have four child each .Such a tree is called a Quadtree.

3. Clustering based segmentation

Clustering is the process of grouping together of objects based on some similar properties..So that,each cluster contains similar objects which are dissimilar to the objects of other clusters.Clustering is a process which can be performed by different algorithms using different methods for computing or finding the cluster.The quality of the good clustering methods produces high intra-cluster and low inter-cluster similarities.

A general approach to image clustering involves addressing the following issues:
1. How to represent the image.
2. How to organize the data.
3. How to classify an image to a certain cluster.

The Clustering methods are classified into K mean clustering,Fuzzy C- Means[FCM] Algorithm etc..

i. K mean clustering algorithm

K-means is one of the fast, robust, simplest unsupervised learning algorithms that solve the well known clustering problem. The method is to classify the given data set through a certain number of k clusters that are fixed a priori. Here k centers (centroids) are defined ,one for each cluster. These centroids should be placed in a shrewd way since different location causes different result. So, its better to place them much far as possible from each other. K-means clustering algorithms gives optimal result when data set are dissimilar.

ii. Fuzzy C- Means[FCM] Algorithm

Fuzzy Clustering is a method which allow the objects to belong to more than one cluster with different membership. This is the one of the effective method for pattern recognition.Most commonly used fuzzy clustering algorithms is the Fuzzy-C-Mean.By using FCM we can retain information of the data set than

HCM..In FCM, the data point is assigned membership to each cluster center as a result of which data point may belong to more than one cluster center.

IV. Conclusion & Future Work

The main objective of this study was to attempt to cover the diversity of methods for color based analysis & shape analysis and provide a set of references that can be used for identifying matured Myristica fragrans by using various Image processing techniques, which include image segmentation, feature extraction & edge detection. In this paper, the overview of main image segmentation methodologies applied for digital image processing is explained briefly. Image segmentation has a promising future as the universal segmentation algorithm and has become the focus of contemporary research. The result of image segmentation is affected by some of the factors , such as: homogeneity of images, spatial characteristics of the image continuity, texture and image content and hence there is no universally accepted method for image segmentation. There is not even a single method that can be considered excellent for all type of images. In near future we will propose an image segmentation technique so that it can be used for automatic harvesting of Myristica fragrans.

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