Hybrid Segmentation of Peel Abnormalities in Banana Fruit

D.Surya Prabha
Research Scholar
Department of Computer Applications
School of Computer Science and Engineering
Bharathiar University, Coimbatore. 641 046

J.Satheesh Kumar
Assistant Professor
Department of Computer Applications
School of Computer Science and Engineering
Bharathiar University, Coimbatore. 641 046

ABSTRACT:

Classification and categorization of banana fruit is an interesting application of image processing. Automation of banana fruit analysis based on morphological features will help banana industries for better quality analysis. Segmentation will play an important role in banana image analysis for accurate analysis and categorization. This paper proposes a new method for better segmentation and categorization of banana fruits. Features including Mean Square Error (MSE) and Similarity Measure (SSIM) have been calculated for various banana images. Result shows better accuracy of proposed algorithm compared to other segmentation methods.

Keywords:

Banana, Region based, color gradient, segmentation.

1. Introduction

The role of image segmentation is primary and important phase in areas related to object recognition, image processing and image analysis [1]. The edge based methods and region based methods are most commonly used methods of image segmentation. These methods play a major role in various image analysis and image interpretation applications. These methods though widely used, they also come across certain problems in separating region of interest in an image. The major problem faced in edge based segmentation method is selection of threshold value. Improper selection of threshold value for binary conversion of image produce disconnected edges that lead to poor segmentation of image. In region based segmentation, the major problem is the selection of appropriate seed point pixel to obtain the region of interest. Improper selection of seed point may lead to over segmentation of image. Image segmentation has a special characteristic of being specific to certain application. Image segmentation producing higher accuracy to one application may be inaccurate or predict incorrect result in another application. Selection of appropriate segmentation method is essential to have a greater accuracy in image analysis interpretation. This paper proposes a segmentation method which is more appropriate and suitable for the application of banana fruit quality analysis [2] [3]. The automated quality analysis of banana fruit would be a great support for the traders and marketers to distribute qualitative fruit in the market as well as for exporting [4].

To increase the performance of image segmentation, a hybrid algorithm has been proposed to get higher accuracy in output which will work better than color gradient based edge detection and region growing algorithm. The results of segmented images from each method are compared using image quality metrics from the original image. Image quality metrics have been used for the purpose of evaluating the quality between two images. There are various image quality metrics such as Structural Content (SC), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalised Cross-Correlation (NCC), Average Difference (AD), Maximum Difference (MD) and Normalised Absolute Error (NAE). The image quality metrics used for comparison are Mean Square Error and Structural Similarity. The output of each individual method and hybrid method are tested with MSE and SSIM, and showed a higher accuracy of result for hybrid algorithm. In this paper, various image segmentation techniques and development of hybrid algorithm for better performance has been discussed in detail and the developed algorithm was also evaluated using the image quality metrics.

This paper is organized as follows. Section 2 deals various Image Segmentation techniques in image processing. Section 3 focuses on the proposed hybrid Image Segmentation method for banana fruit quality analysis and Section 4 presents the performance evaluation of the proposed method with existing methods. Section 5 presents conclusion.

2. EXISTING SEGMENTATION METHODS

Mathematically, Segmentation is performed based on pixels relationship with their nearby neighborhood in an image. Basically, segmentation methods are classified based on the pixel relationship properties into two broad categories such as boundary based methods and region based methods [5]. Methods based on discontinuity property of pixels are referred as boundary based methods and the methods based on similarity property of pixels are referred as region based method. In edge based segmentation, the rapid and unexpected change in intensity values of the features in an image forms the basic criteria for partition. In region based segmentation, intensities with similar values of the features in an image forms the basic criteria for partition. Thresholding, region growing, region split and merge are the methods which belong to region based segmentation. Point, line and edge detection are the methods that belong to edge based segmentation. Other segmentation methods such as histogram based segmentation, watershed based segmentation, clustering based segmentation, graph based segmentation and color based segmentation methods are also in use. Some of these image segmentation methods are discussed in the following section.

2.1. Thresholding

Thresholding based segmentation method is considered to be the core of image segmentation. Thresholding is used in most

of the methods for determining a threshold value as a criterion to select required region of interest. This method is simple and quick when compared with other segmentation methods [6]. Threshold value for an image is selected based on the required region of interest. Different regions are obtained for varied threshold value. Selection of threshold value manually requires trial and error method and is time consuming and chances of bias is also possible. Popular and most commonly used Otsu's threshold method is adapted for global thresholding in an image [7] [8] as in Figure 1. The main aim of Otsu's automatic threshold is to select an optimum threshold value.

(a) (b)

Figure 1. (a) Original input image (b) Threshold segmented image of Original input image

2.2. Clustering methods

Clustering based segmentation is an unsupervised method used for classifying images into different clusters based on pixel characteristics [9]. The characteristic of pixel determines number of clusters that can be formed in an image. Similarity and dissimilarity are the main characteristic features of pixel in an image. Based on these features, images are clustered into groups. Each cluster is unique from other but pixels within the clusters are similar. The similarity measure for a cluster is decided based on the application and data set [10]. Examples of similarity measure are intensity value of pixel and connection regions of pixel with its neighborhood. Hard means and Fuzzy means are popular clustering method used for segmenting images [11]. Hard means clustering is a traditional method used in unsupervised classification of objects into groups. In an image, pixels are considered as objects and they are grouped into clusters. According to the selection of number of clusters, the cluster groups are formed in an image. Different cluster label index can be formed for an image based on the number of clusters as in Figure 2.

(a) (b)

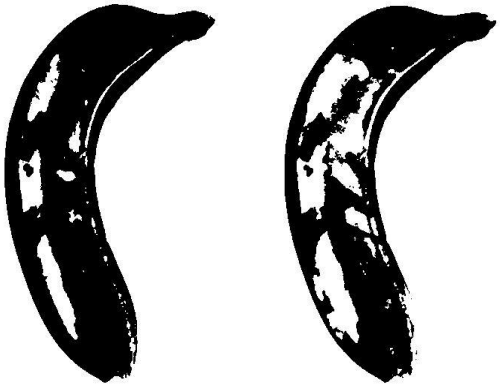
Figure 2. K-Means clustering based segmentation from Original input image. (a) Number of clusters as 8 (b) Number of clusters as 2

2.3. Color image segmentation:

Image segmentation techniques are not restricted only to the monochrome images. It is also possible to segment image on the basis of color. Locating of object based on color in an image is possible. Analysis of true image can be performed either directly on the true image or either through individual color plane of the image [8]. RGB color model is suggested for performing the segmentation task due to its simplicity and processing speed [6]. A threshold value is set on the basis of intensity value of color to segment the image because intensity values are constant in similar color region. Object with specific color range can be easily detected from the entire image. The mean value of required color is calculated and is compared with the each RGB pixel values of an image using either Euclidean or Mahalanobis distance measure [8]. Threshold value selection is also important as the result varies for different threshold values as in Figure 3.

3. PROPOSED SEGMENTATION METHOD

The important task in banana fruit quality analysis is to extract the exact quality characteristics such as size, shape, color, texture and appearance. These characteristics are analyzed through image processing method which is automatic, cost effective and efficient method [3]. Image segmentation is used in this basic process of separating the banana fruit from the background and also to identify the quality of banana fruit [2]. The segmentation method proposed in this paper improves the segmentation accuracy by combining the edge based and region based segmentation techniques.



(a) (b)

Figure 3. Color Segmentation method applied on Original input image (a) with threshold value as 75%. (b) with threshold value as 100%

The steps involved in the development of the proposed segmentation method as in Figure 4 are discussed in this section. The proposed method has been developed using MATLAB.

3.1. Edge detection using Vector based color gradient:

As edge detection is an important module in image segmentation, it is computed directly on RGB color space model. In monochrome images, the scalar function is used for gradient calculation. In color images, the vector function is used for gradient calculation [8]. The gradient, in general, is defined as two-dimensional function with a significant property of identifying the greatest magnitude direction in a function. The magnitude of vector based color gradient is used to compute the first-order derivatives. First order derivatives are used for deriving the edges in an image. The square root of largest Eigen value in a vector based color gradient is considered as its magnitude value [12]. A gradient image is derived using the magnitude and direction of gradient. Another approach to obtain the edges is to manipulate the gradient in individual color components (red, green and blue) and then adding these individual color component gradients into a single color gradient image. Output of these two approaches might have slight differences. Either of these methods can be applied as input for further process. Adaptive histogram equalization is applied to color gradient image to enhance the image.

3.2 Region growing method

In region-based segmentation, images are partitioned into various regions. This technique assumes that adjacent pixels in the same region have similar features like grey level, color value, or texture. This region based segmentation is classified into two methods as region growing and region split and merge. In region growing method, it integrates sub-regions of pixels into larger regions based on some predefined conditions for growth. The selection of set of seeds is the complicated job. From this seed grows region appends with other seeds which are similar. However, SRG suffers from automatic selection of initial seeds to attain more accurate segmented images [12].

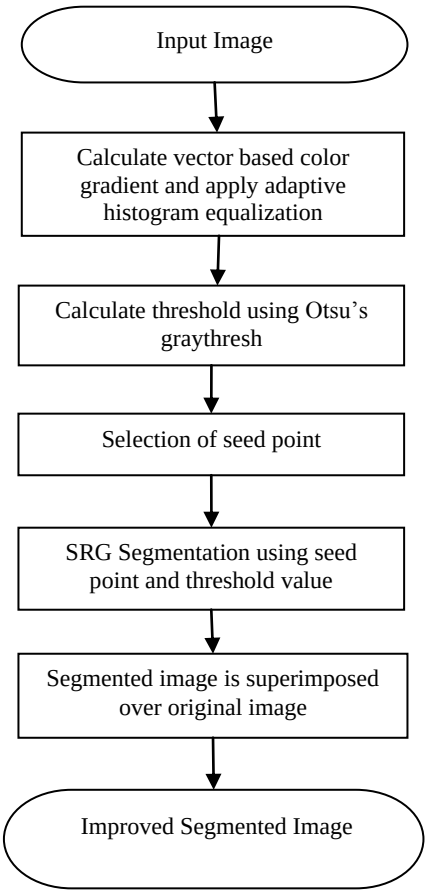
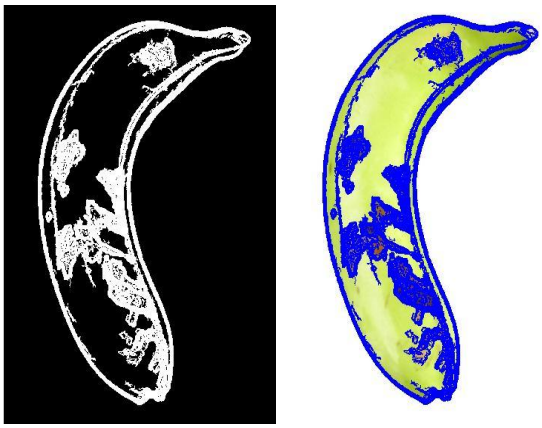


Figure 4. Steps involved in the proposed segmentation method

The seed value can be either a single seed value or an array. If the seed value is an array, then it contains the value 1 at the coordinates of similar seed points and contains the value zero in rest of the region. If the seed value is scalar, then the seed value is either 0 or 1. The seed value is selected on the basis of edges of the gradient image. The threshold value can also be either an array with similar image size or a single global threshold value ranging within 0 to 1. This value is calculated using Otsu's graythresh method [8]. The threshold value selected by Otsu's graythresh method and the seed point determined manually is used to segment the histogram equalized color gradient image based on region growing method. Selected seed point is grown towards the entire image with threshold value as its criterion. Resultant segmentation method has detected edges with a greater accuracy as in Figure 5(a). Segmented image is imposed over the original image as in Figure 5(b) for much better segmentation result [8]. Final segmentation result on banana fruit helps to identify abnormalities in the peel of banana. The proposed segmentation method is applied to a large number of data sets containing banana image with peel abnormalities and the performance is evaluated.



(a) **(b)**

Figure 5. (a) Proposed segmentation method output from Original input image. (b) Resultant image of Superimposing the segmented image over original image.

4. PERFORMANCE EVALUATION

Image quality metrics have been used for the purpose of evaluating the quality between two images [13]. The image quality metrics used for comparison are Mean Square Error (MSE) and Structural Similarity (SSIM). Graphical User Interface Development Environment of Matlab has been developed as in Figure 6 for evaluating the performance of segmentation methods.

Figure 6. The GUIDE of Matlab used for evaluating the performance of segmentation methods.

MSE is used to measure the difference between actual image and manipulated image [14]. The MSE is less for the lesser distorted image and high for distorted images. SSIM is used to measure the similarity between the actual and manipulated image [14]. The SSIM index value ranges within 0 to 1 [15]. Similar images have a higher index value. The output of each individual method and hybrid method are tested with these techniques and showed a higher accuracy of result in the hybrid algorithm from Table 1 and Table 2. The line with marker chart type is used to diagrammatically depict the Structural Similarity index value tabulated in Table 2. Figure 7 charts the better performance of the hybrid segmentation method than other existing methods based on structural similarity index.

Table 1. Mean Square Error calculated for different segmentation method

Samples	Otsu's Thresholding segmentation	K-Means clustering based segmentation	Proposed segmentation method
Ban1	277.341	484.414	70.131
Ban2	271.366	272.853	38.1897
Ban3	218.326	507.946	62.159
Ban4	173.743	558.419	100.115
Ban5	145.348	566.909	31.464
Ban6	119.832	481.840	82.137
Ban7	130.216	522.395	103.704
Ban8	175.810	575.449	77.622
Ban9	214.671	221.161	92.482
Ban10	192.982	558.845	60.870

Table 2. Structural Similarity calculated for different segmentation method

Samples	Otsu's Thresholding segmentation	K-Means clustering based segmentation	Proposed segmentation method
Ban1	0.624	0.087	0.796
Ban2	0.617	0.620	0.859
Ban3	0.672	0.113	0.790
Ban4	0.719	0.011	0.723
Ban5	0.778	0.194	0.870
Ban6	0.738	0.090	0.766
Ban7	0.636	0.044	0.699
Ban8	0.733	0.072	0.763
Ban9	0.680	0.687	0.751
Ban10	0.725	0.060	0.826

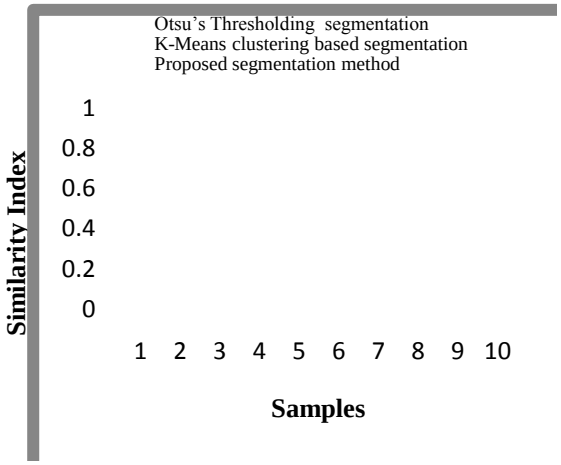


Figure 7. Line with markers chart depicting the SSIM index of different segmentation method.

5. CONCLUSION

The proposed algorithm of image segmentation for banana fruit quality analysis is a hybrid method by combining the edge based and region based methods. The accuracy of segmentation is better than existing methods. This algorithm reduces the drawback of other methods and increases the performance of segmentation with higher accuracy and reliability. Results have been compared based on features such as MSE and SSIM.

6. ACKNOWLEDGMENT

The authors are thankful to the Department of Computer Applications, School of Computer Science and Engineering, Bharathiar University for providing a suitable research environment.

REFERENCES

[1] Juneja, M. and Sandhu, P.S. 2009. Image Segmentation based Quality Analysis of Agricultural Products using Emboss Filter and Hough Transform in Spatial Domain. Researcher, 1 (5), 62-68.

[2] Mustafa, N.B.A., Fuad, N,A., Ahmed, S.K., Azwin, A., Abidin, Z., Ali, Z., Yit, W.B. and Sharrif, Z.A.M. 2008. Image Processing of an Agriculture Produce: Determination of Size and Ripeness of a Banana. IEEE, 978-1-4244-2328-6/08.

[3] Gao, H., Zhu, F., and Cai, J. 2010. A review of Non-destructive Detection for Fruit Quality. IFIP Advances in Information and Communication Technology, 317, 133-140.

[4] Brosnan, T. and Sun, D.W. 2004. Improving quality inspection of food products by computer vision - a review. Journal of Food Engineering, 61, 3–16.

[5] Gonzalez, C.R. and Woods, R.E. 2011. *Digital image processing*. Dorling Kindersley (India) Pvt Lt, New Delhi. p 954.

[6] Gay, P., Berruto, R. and Piccarolo, P. 2002. Fruit Color Assessment for Quality Grading Purposes. Paper presented in ASAE Annual International Meeting/ CIGR XVth World Congress, held at Chicago, Illinois , USA during July 28-July 31, 2002. pp 1- 9.

[7] Riyadi, S., Rahni, A.A.A., Mustafa,M.M., and Hussain, A. 2007. Shape Characteristics Analysis for Papaya Size Classification. Paper presented in The 5th Student Conference on Research and Development –SCOReD held at Malaysia during 11-12 December 2007. pp. 1-9.

[8] Gonzalez, C.R., Woods, R.E., and Eddins, S.L. 2011. *Digital image processing using MATLAB*. Tata McGraw-Hill, India. p 738.

[9] Zhang, Y., Zhao, D., and Kong, D. 2010. Application of Image Segmentation Algorithm Based on Entropy Clustering in Apple Harvesting Robot. IEEE, 978-1-4244-5539-3/10

[10] Palus, H., and Bogda, M. 2003. Clustering techniques in colour image segmentation. Artificial Intelligence Methods, 11 (5), 223-226.

[11] Oliver, A., Munoz, X., Batlle, J., Pacheco, L., and Freixenet, J. 2006. Improving Clustering Algorithms for Image Segmentation using Contour and Region Information., paper presented at International Conference on Automation, Quality and Testing, Robotics, IEEE , 2, 315 – 320

[12] Balasubramanian, G. P, Saber, E., Misic,, V., Peskin, E., and Shaw, M. 2008. Unsupervised color image segmentation using a dynamic color gradient thresholding algorithm. Proc. of SPIE-IS&T Electronic Imaging, SPIE Vol. 6806, 68061H

[13] Chen, G. H., Yang, C. L., Po, L. M.,, and Xie., S. L. Edge-Based Structural Similarity For Image Quality Assessment, 2006, Presented paper at *ICASSP 2006*, IEEE, 933-936

[14] Alain, H. and Djemel Z. 2010. Image quality metrics: PSNR vs. SSIM., 2010 International Conference on Pattern Recognition, 2366-2369.

[15] Wang, z., Bovik, A. C., Sheikh, H. R., and Simoncelli, E. P. (2004). Image quality assessment: From error visibility to structural similarity. IEEE Transactions on Image Processing, 13 (4), 600-612.