ENHANCED EDGE DETECTION FOR DISCONTINUITY ISSUE USING MORPHOLOGICAL OPERATIONS

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ABSTRACT

Classification of banana fruit based on its quality and maturity is an interesting application of image processing in agricultural sector for enhancing banana export. Complete automation of this system leads various challenges for researcher in computer vision. Isolating banana fruit from the background image using efficient method is an initial phase of this system. Edge detection using image segmentation is a conventional method used for identifying edges of banana image from entire scene. Major problem in most of the edge detection method is discontinuity of edge which records its higher influence on banana segregation phase. Hence development of better segmentation method helps to resolve discontinuity issue which has higher impact on automation system for banana fruit industry. This paper proposes an efficient and simple edge detection method using convolution and morphological operations. Performance of the proposed method has been compared with the existing first order derivative methods using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). The result shows significant enhancement in the results by proposed methods compare with existing methods.

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I. INTRODUCTION

Isolating desired object from an image is a significant task of image segmentation which forms the basis for image analysis and interpretation. Results derived from image segmentation determine the performance accuracy of a computer vision system. Most of the image segmentation methods are application specific hence more emphasis is needed in selecting appropriate segmentation method based on application. This paper focuses role of image segmentation in banana fruit quality analysis as part of agricultural research. Increased alertness of consumers in the consumption of qualitative food products from market require fully automated system for quality assessment [1]. Banana is a major fruit crop for consumption and having demand all over the year. Due to its importance throughout the world, automated system for quality analysis is a prerequisite for traders and consumers [2]. This requirement offers challenges for researchers in computer vision for the development of complete system. Image acquisition is the basic step to capture banana image using digital camera. As a primary step in image analysis, banana region is required to be segregated from the image background [3]. Image segmentation plays an important role in segregating banana from the background image. Two basic

classifications of image segmentation are edge based and region based segmentation methods [4]. Edge based methods are based on the discontinuity property of pixels. Rapid and unexpected changes in pixel values are the basic criteria for pixel selection. Point, line and edge detection methods belong to edge based segmentation method. Region based segmentation methods are based on the similarity property of pixels. Pixels with similar intensity values are the basic criteria for pixel selection. Region growing, region split and merge belong to region based segmentation methods [5]. Edge detection methods decide the boundary of banana region in an image. Existing edge detection methods suffer from a major drawback of providing enhanced and accurate edges of banana in an image. Another major problem faced in edge detection method is the noise which also has unexpected change in pixel values like edge. This paper proposes a simple but efficient edge detection method to overcome existing drawbacks and to avoid discontinuity of edges.

II. Materials and Methods

A. Existing Edge Detection methods

Edge detection method is much useful for boundary detection of banana fruit based on shape and size features. Recognition of discontinuity and marking the location of discontinuity forms edges. Numerous edge detection operators are available for extracting edges. Gradient with its magnitude calculation and use of convolution mask are the base for calculating edges. Edge based methods are broadly classified into gradient based and laplacian based methods. Gradient based methods are dependent on the first order derivatives in an image. Laplacian based methods are based on the second order derivatives in an image.

Gradient based method calculates the maximum and minimum value derived from the first order derivatives in an image [6]. A simple, faster and easier 2 - D gradient measurement is carried out by Roberts operator for edge detection. 2 × 2 convolution kernel pair is used by this operator for manipulation in which one kernel is the 90° rotation of other kernel. This method is very much related to sobel operator which uses 3 × 3 convolution kernel [7]. Prewitt operator is similar to sobel operator which uses 3 × 3 convolution kernel for detecting horizontal and vertical edges in an image. These three edge operators are approximately similar as in Fig. 1a, b and c.

Laplacian based method uses second order derivatives to find edges in an image. Second order derivative value is zero when first order derivative reaches the maximum value [8]. Rapid change in intensity value can be easily identified using Laplacian of Gauss (LoG) method as in Fig. 1d. Laplacian operator uses the concept of Gaussian smoothing for detecting edges. Zero crossing method is similar to LoG method except that the edges are located by using the value zero in second order derivatives as in Fig. 1e. Canny's edge detection is a popular method which is capable of locating small change in intensity values. This method is capable of identifying edges that are thin with weak edges [9]. Major disadvantage of this method is that there are more possibilities for false edges as in Fig. 1f.

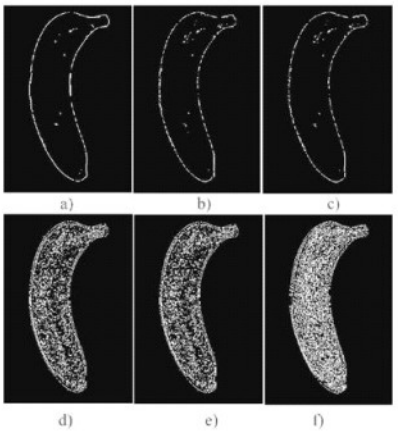

Figure 1: Output of edge operators a) Roberts method, b) Sobel method, c) Prewitt method, d) LoG method, e) Zero- cross method, and f) Canny method.

B. Proposed Edge based Segmentation Algorithm

Feature extraction is an essential task in banana fruit quality analysis to obtain fruit quality characteristics such as size, shape, color, texture and appearance. Image segmentation is used for extracting banana fruit and also to assist in identifying different quality characteristics of banana fruit. Edge based segmentation is used to identify edges of banana fruit. But it suffers from a disadvantage of discontinuity of edges, influence of noise and improper detection of boundaries in an image. Proposed method based on convolution and morphological operations have been developed to solve the disadvantages of edge based segmentation method. The steps involved in proposed algorithm are developed using Matlab are depicted in Fig. 2.

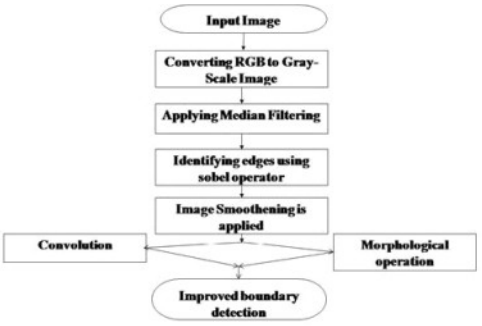

Figure 2: Steps involved in proposed algorithm

a) Median Filtering: Image enhancement is a preprocessing step to be performed in an image. The input image in RGB color space model is converted into Gray scale image for image analysis and manipulations as in Fig. 3a and b. Histogram equalization is applied for the uniform distribution of pixel intensities in an image [10]. After enhancing the image, filtering operation is performed to reduce noise in an image.

Filtering is used to smooth, de-blur and to restore the image for an enhanced form. In proposed algorithm, median filtering has been applied to the histogram equalized image of banana samples to reduce noise in an image as in Fig. 3c since median filter is very much capable of reducing noise in an image.

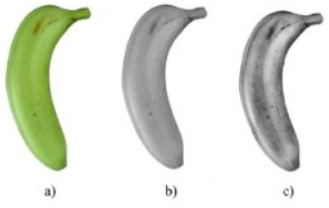

Figure 3: a) Input image, b) Gray scale image, and c) Median filtered image.

It is order static filter used to substitute the pixel values in an image by median intensity values calculated using the neighborhood pixals [11] as follows;

$$\hat{f}(x,y) = \underset{(s,t)\,ES_{xy}}{median}\{ g(s,t) \} \qquad (1)$$

b) Edge detection : Mask models such as LoG operator, Roberts operator, Sobel operator, prewitt operator are used for edge detection technique. Sobel operator has been applied to the median filtered image for detecting edges of banana as in Fig. 4a. The operator consists of a pair of 3×3 convolution kernels for both horizontal and vertical direction [12]. One kernel is just arrived by rotating the other kernel by 90°. Sobel operator performs a 2 - D spatial gradient measurement on an image and it gives importance to regions of high spatial frequency which correspond to edges [13]. It is used to find an absolute gradient magnitude at each point in an image. Calculating the 2-D gradient for a function f(x,y) is defined by,

$$\nabla f \equiv grad(f) = |g_x| + |g_y| \qquad (2)$$

where, 'f' is a function and 'x' and 'y' are the coordinate values of 'f', 'g_x' and 'g_y' are the gradient in 'x' and 'y' direction. The resultant image has value zero for constant intensity regions. Edge strength estimation is more reliable using sobel operator.

c) Image smoothing: In order to enhance detection of edges accurately, it is essential to identify the changes in neighborhood intensity. Enhancement emphasizes pixels relationships along with its neighboring elements [14]. Image Smoothing for enhancement can be performed either through convolution mask or through morphological operation such as dilation. Image convolution operation is used widely for enhancing effects (like blurring, edge sharpening etc.) in an image. To enhance the resultant banana image obtained from sobel operator, convolution task is performed over an image as in Fig. 4b. Image obtained after performing convolution is much better and enhanced compare with existing methods. Noises are reduced to the great extent with continuous edges. Morphological operation is another enhancement method performed on an image to thicken the edges. Dilation operation of morphology is performed to thicken the edges of an image [15, 17]. Definition of morphological operation is expressed as a set operation $X \oplus Y$

$$X \oplus Y = \{z \mid (Y)_z \cap X \neq \emptyset\} \qquad (3)$$

where, 'X' is the binary input image, 'Y' is the structuring element and 'Ø' is the empty set. Result of the morphological operation produces an efficient edge detected image without any discontinuity as in Fig. 4c.

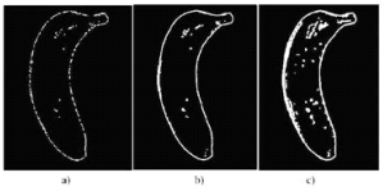

Figure 4: a) Sobel operator output for median filtered image, b) Output of convolution operation, and c) Output of morphological dilation operation.

d) Statistical evaluation of the proposed method: Mean Square Error (MSE) and Peak signal to noise ratio (PSNR) were evaluated for comparing the performance of proposed method with existing first order derivatives edge detection method. Mean square error has been calculated by taking average of squares of error [16]. Measurement unit of mean square error is same as that of quantity being evaluated.

Mean square error is calculated by,

$$MSE(A,B) = \frac{1}{XY}\sum_{m=1}^{X}\sum_{n=1}^{Y}(A_{mn} - B_{mn})^2 \qquad (4)$$

where, 'A' is the reference image and 'B' is the test image with similar image size X × Y, 'm' and 'n' as their respective rows and columns. Peak signal to noise ratio has been calculated from mean square error to measure the quality of the reconstructed image as follows.

$$PSNR(A,B) = 10\log_{10}\left(\frac{255^2}{MSE(A,B)}\right) \qquad (5)$$

III. Results and Discussion

The efficient algorithm based on convolution and morphological operations has been implemented and tested for 60 banana images consist of three groups such as Matured, Non-Matured and banana with disease/damage. Each group consists of 20 images where results of 10 images have been focused in this paper. Banana images along with their output of proposed method and existing edge detection techniques are shown in Fig. 5a, b, c, d and e for performance comparison. Comparative result shows that discontinuity of edges in edge detection techniques of first order derivative has been solved in enhanced method. Mean square error and peak signal to noise ratio are graphically represented in Fig. 6 and Fig. 7.

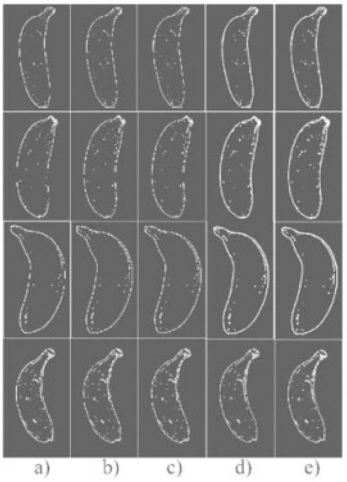

Figure 5: Comparative view of edge detection methods

a) Roberts method, b) Sobel, c) prewitt method, d) Proposed method I performs convolution operation on enhanced edges, and e) Proposed method II performs dilation operation on enhances edges.

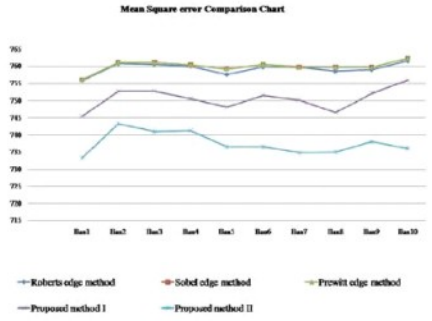

Figure 6: Chart depicting comparison of edge detection methods based on mean square(MSE).

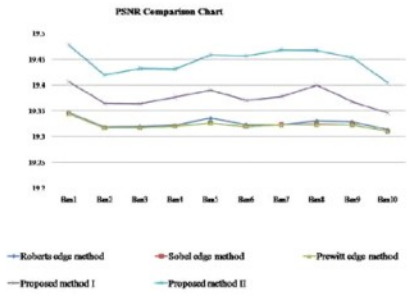

Figure 7 : Chart depicting the PSNR comparison between edge detection methods.

In proposed method, there is no discontinuity of edges in the boundary of banana region. Further, proposed algorithm has also able to identify dark spots, dots or scratch in the banana area. The proposed methods were compared with Roberts, sobel and prewitt edge detection methods of first order derivatives. In comparison, it was noted that sobel and prewitt methods have almost similar result. Enhanced edge detection method based on convolution and morphological operations gives better results than existing first order derivatives method. Image quality metrics have widely been used to retrieve statistical information about the reliability of resultant image obtained from different analysis and manipulations [18].

The results of MSE and PSNR confirms that proposed method - I using convolution gives better MSE and PSNR when compared with other first order derivative edge detection methods. Enhanced method – II gives bit more better MSE and PSNR than enhanced method – I.

IV. Conclusion

An efficient and better edge based segmentation method with continuity of an edge in banana region has been introduced in this paper. Proposed methods based on convolution and morphological operations have been compared with existing first order derivatives edge detection techniques. The comparison and performance evaluation has been done using image quality metrics such as mean square error and peak signal to noise ratio. Proposed work shows better accuracy in MSE and PSNR when compared with the existing methods.

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