Comparison of Edge Detection Techniques in context of Area calculation of Turmeric rhizomes for Grading

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Abstract: Edge detection is an important approach in Segmentation of Digital Image Processing (DIP) and Computer Vision. Edge can be a border between the blocks or a boundary between the regions with relatively different Gray levels. Turmeric is a most well-known, widely researched rhizomatous herb cultivated in most of states in India. It is mainly used in medicines, culinary, cosmetics etc. Grading plays an important role in turmeric marketing. Size is one of the main aspects in separating and classifying dried rhizomes for Grading. Color, Texture and Size are the main physical parameters for grading. In extracting the size of the rhizome, area has to be calculated using different Edge Detection Techniques. This paper provides the comparison of some commonly used edge detection techniques in context of calculating the area of rhizomes for grading.

Index Terms: Filters, Segmentation, Edge Detection, Saturation, Threshold, moisture content

Introduction: Turmeric, A golden spice is herbaceous perennial plant belongs to the family of Zingiberacea. Its botanical name is Curcumin Longa. Turmeric is rich in anti-inflammatory, anti-aging, and Antioxidant properties. Curcumin, a bio-active phytochemical compound present in turmeric, has a very high therapeutic value in medicines. Edge detection method is of high importance in object recognition and size identification. It detects the discontinuities and the boundaries of an input image through the change in threshold value. Object recognition and area measurement can be achieved by edge detection. Every region of an image or an object is assumed uniform until the separation or discontinuity. Gray image is best suitable for edge detection as it provides the monochromatic shades of only black to white. It contains the gray shades and color information is removed from the image. The luminance of the image pixel is retained in gray image There are two types of Edge detection techniques:1. Gradient based search method is one where the first order derivative is used to compute the gradient magnitude by determining the local directional maxima of an input image. 2. Laplacian based zero crossing method the one where the second order derivatives are computed for extracting the edges from the image by using linear operators. In this paper six edge detecting algorithms, Canny, Sobel, Prewitt, Homogeneity, LOG and Robert are applied to images of turmeric rhizome and compared.

Related background Work:

Researchers have worked on various edge detecting algorithms on images. [1] The algorithms are the mathematical methods that target the classification of points/pixels of an image where the image intensity discontinues or varies sharply. Thresholding the direct method in edge detection but it works well with straightforward domains. Xin Chen and Houjin Chen [2] used Sobel mask to develop an algorithm for colored images. Single pixel on an image is identified and thresholding scheme is used to detect a pixel as an edge. Soumya Dutta and Bidyut Chaudhuri,[3] developed a system where input image is converted into gray image and for each pixel a maximum directional LOG of the sum of gray values is calculated by extracting each component of the image separately. The ideal threshold value is selected to generate the edges. Edge map is prepared with the transformation Technique.

P.V. Arun et al., have worked on comparative analysis of common edge detecting algorithms in context of object extraction.[4] They have used five satellite images of different spatial resolutions for their study. They worked on six edge detecting techniques and comparative analysis is done with respect to Threshold and Distinguished features from the image. Chen et al [5] proposed the improvement in Kuhawara filter to improve the resolution of an original image. In RGB color space each edge is detected independently with optimum threshold value. The efficiency and the performance in edge detecting algorithms are improved by applying thinning algorithm. Thinning algorithm ends up with the smooth and thin edge. R.Jothilakshmi and R Rajeswari, [6] studied a different approach, ant colony optimization on gray scale images to detect the edges in the input image. Wang et al., [7] have proposed the new edge detection approach on color image processing based on vector morphological operators. The noise is an unwanted signal that contaminates the image. A new vector ordering process in they used RGB color space and defined the vector of an image and ordering is done to analyse the noise in the image. The vector morphological operators are used in detecting the edges present in the input image.

Lei et al., have proposed color edge detection method considering the HSI component of an image and Principal Component Analysis (PCA). Hue LOG is computed and is applied to classical gradient operators and edges for hue component are obtained. [8] Complete object edges can be obtained by using the edge fusion of the first principal component and hue component of color image. The computational complexity is low in the proposed method. Xin et al., have proposed an improvement in canny edge detecting algorithm to detect edges in color image. [9] They adopted methods of quaternion weighted average filter, vector Sobel gradient computation; Interpolation based non-maxima suppression for edge detection and connecting edge in the input image. B O. Sadiq et al., have proposed the novel pixel-based approach for colored images. They used Pratt Figure of Merit (PFOM) for quantitative comparison between the existing edge detection algorithms with their new approach of multi pixel collection. [10] The algorithm is used to generate two masks that are applied to input image for calculating the gradient. Euclidian distance between the pixels is found and thinning algorithm is used to suppress the thick edges.

Simranjit Singh Walia,and Gagandeep Singh have studied and reviewed different edge detecting methods. The gaps or the limitations of existing method are noted. [11] They found the limitations in processing the color images and the complex background images. They concentrated on Hue factor in Human Visual System (HSV). Muthukrishnan and M.Radha, have discussed the different edge detection techniques Segmentation is a process that separates an image into its component objects. [12] Discontinuity approach is used to partition an image based on intensity values, similarity measures, according to set of pre-defined criteria. They explained eight algorithms in detail and compared the results. They found that Canny edge detecting algorithm is best suitable for many applications. Abdel Karim M et al have discussed Sobel, Prewitt and Homogeneity algorithms on city image, spider image and village image. [21] They evaluated each algorithm and compared the results. They found that the performance of homogeneity and Prewitt is better than the Sobel edge detectors.

Edge Detection Methodology: Edge detection is fundamental tool in in computing the area of turmeric rhizomes. The basic methods used is as shown in Figure 1.

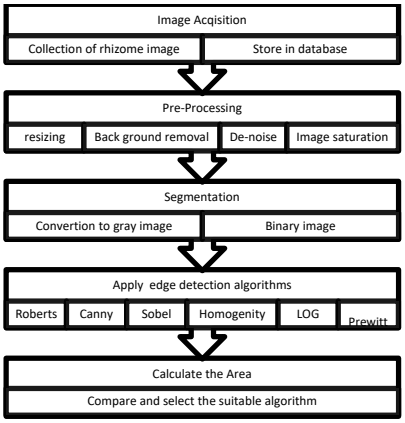


Figure 1. Block diagram of methodology

Image Acquisition: The different images of turmeric rhizomes belonging to the different varieties are collected using high resolution camera. Each variety of turmeric rhizomes have different specifications with respect to color, size ans curcumin content.

Pre-Processing: The image is resized to a standard size of 256X256 to reduce the space and time for analysis. The back ground is removed using subtraction method. The image is denoised using the median filter. The final images are saturated so as to get the clear high contrast image for analysis and stored in database. Saturation describes the color intensity of the input image to get the clear color. It represents the amount of gray in proportion to the hue of an image

Segmentation: The input image is segmented into regions and original RGB image is converted into grayscale and Binary images before applying various edge detection methods.

Edge Detection Algorithms: Several varieties of turmeric grown in India and each variety has its own specification with respect to color, size, aroma, curcumin level, moisture content etc. The size of the rhizomes helps in classification and grading. The edge detection algorithms help in finding the area of the rhizomes. The important factors considered in edge detection are threshold value and intensity interpolation. In Image Processing the thresholding is the segmentation technique where the grayscale image is converted into binary image. The intensity (I) is less than a constant T, a maximum brightness represented by $0<I_{ij}<T$. The second order derivative methods are more sensitive to noise. It is observed that some algorithms detect better edge detection for computing the area so as to find the size of the rhizome Edge detection method is followed by Edge linking and thinning. The following Figure 2 depicts the relation between edge detection, edge linking and thinning.

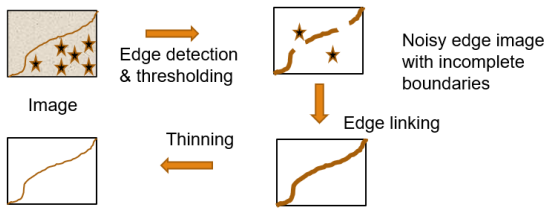


Figure 2. Edge detection, edge linking and Thinning process

(a) Canny edge detection: This algorithm is standard and computationally more expensive. It is proposed by John Canny. The algorithm involves the following steps

1.Image convolution to get smooth image
2. Computation of edge magnitude, strength and direction.
3. Application of critical suppression to gradient magnitudes.
4. Selection of proper threshold values to highlight the edges.

The convolution mask for Canny Edge detection is as shown below.

-1	0	+1
-2	0	+1
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

(b) Sobel Edge Detection: This is the most popular, very simple yet effective edge detection method introduced by Sobel in the year 1970 [1]. 2D spatial gradient convolution operation is done on an input image to detect the edges. Two convolution masks Gx and Gy. are computes as shown below. The detected edges are thick but suitable for applications in which the detection of the outer most contour of an object is necessary and needs to be thinned for further calculations.

-1	-2	-1
0	0	0
+1	+2	+1

Gx

-1	0	-1
-2	0	+2
-1	0	+1

Gy

(c) Prewitt's Edge Detection: This is the gradient based edge detection method proposed by Prewitt in 1970, [1] It is mainly used for detecting smooth, vertical and horizontal edges in image. It uses the three by three (3X3) convolution mask, Gx and Gy computed as below for estimation of magnitude and orientation of an edge.

-1	-1	-1
0	0	0
+1	+1	+1

Gx

-1	0	-1
-1	0	+1
-1	0	+1

Gy

(d) Robert's Edge Detection: This is a simple and fast method, introduced by Lawrence Roberts in 1965.[1]It uses Robert's cross 2x2 convolutions mask, Gx and Gy. The input image is in gray scale, Pixel value of each point in the output image is 2-D spatial gradient measurement of input image. Convolution masks are as shown below.

-1	0
0	+1

Gx

0	-1
+1	0

Gy

(8)

(d) Homogeneity Edge Detection: This method is proposed by Marr and Heldrith in 1980.This edge detection algorithm iterates through the image directly, compares each pixel with the neighbouring pixel and feeds to the convolution filter. The similarity of eight neighbouring pixels is considered It uses 3X3# mask and the manual threshold is selected to identify edge pixels and non-edge pixels

(e) Laplacian of Gaussian (LoG) Edge Detection: It is a 2D measure of second order derivatives. The Laplacian of an input image detects regions where the rapid change in intensity values exists. Laplacian is applied to get smooth and noise free images.

Convolution mask Gx and Gy used are as shown below.

0	-1	0
-1	4	-1
0	-1	0

Gx

-1	-1	-1
-1	8	-1
-1	-1	-1

Gy

Area calculation: Area in the image processing is the total number of pixels inside the boundary/edges. The edges are extracted and the resultant image is converted into binary image and area is calculated in MATLAB by calling the bwarea() or sum() functions. Area is a scalar value corresponding to the total number of pixels in the binary image. The computed values are tabulated and depending on the pixel count the rhizomes are classified in the basis of size.

Performance Evaluation: Performance of edge detecting algorithms are measured by the mathematical equation below [10]. Performance measures the value of detected edges, N_D between 0 and 1. The resultant value, *P* closer to 1 gives the better edges from the input image [11].

Performance = $P = \frac{1}{Max(N_A,N_D)} + \sum_{k=1}^{N_D} \frac{1}{1+cd^2(m)}$ ----------1

N_A= Number of Actual edges

N_D=Number of detected edges

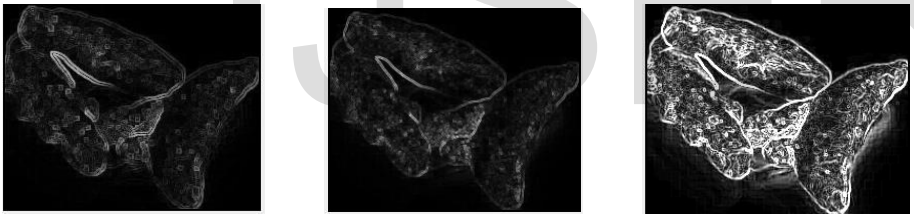
m= constant set to 1/9

d (m)= Distance between actual edge to detected edge

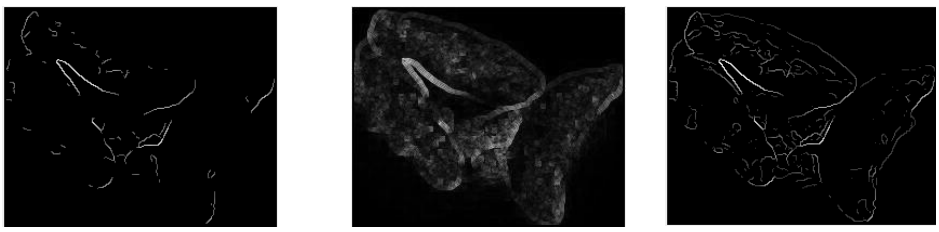
Experimental Results

(a) Original image (b) gray image (c) Saturated Image

Figure 3: Sample images (a) original image, (b) gray image and (c) Saturated image



(a) (b) (c)



(d) (e) (f)

Figure 4: Output Result of applying different edge detecting algorithms

The outputs of all existing edge detection algorithms are as shown in figure. The Figures (a) (b) (c) (d) (e) and (f) are the resultant image of Canny, Homogeneity, Sobel, LOG, Robert and Prewitt respectively.

The Comparison of these algorithms with respect to their performance is as shown in Table below

Table 1: Comparative analysis of traditional edge detecting algorithms and Performance.

Sl.no	Edge detecting	Threshold	Noise sensitivity	Space	Performance

	technique			Complexity	
1	Canny	0.8	Least	High	0.81
2	LOG	0.23	More	Low	0.63
3	Homogeneity	0.2	Moderate	Low	0.70
4	Sobel	0.3	Less	High	0.41
5	Robert	0.34	Least	High	0.41
6	Prewitt	0.6	Least	Low	0.42

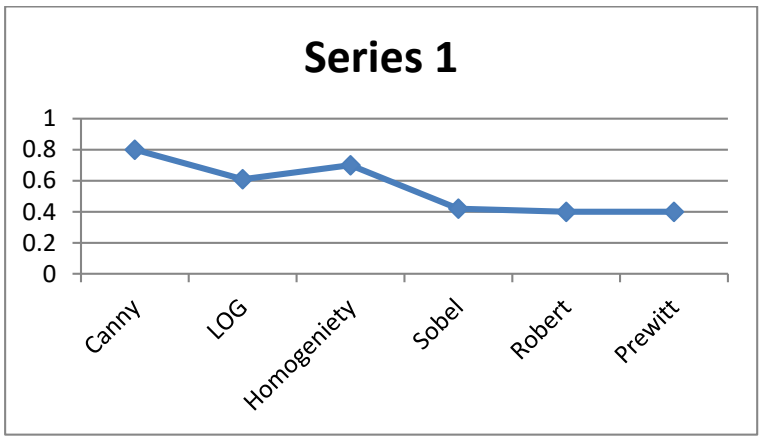


Figure 5. Performance of different edge detecting algorithms

Summary of Analysis

Each method or a filter extracts the different edges from the input image. Combing the edges extracted by filter in both the directions x and y provides the entire boundary of an image. Threshold values are adjusted to get the desired output.

The resultant image is a set of connected points and curves indicating the object or an image. Edge detection makes the object recognition, data interpretation process simple and faster.

Canny Edge detecting method extracts a lot of inner details of an image. Space and Time complexity of this algorithm is more as it is computationally complex. Canny edge detection method depends on σ, standard deviation (SD) for the Gaussian filter, and threshold values, 'T1' and 'T2'.

Sobel Edge Detecting filter extracts more boundaries and is computationally more efficient than other but number of false edges are more. This method detects the edges for the points whose gradient of image intensity is maximum.

Prewitt, the Gradient-based edge detection method is very sensitive to noise. Image smoothening is done with this method.

Conclusion

Turmeric is an important commercial crop in India. Grading is an important factor and turmeric rhizomes are mainly graded on the basis of size, color and curcumin content and moisture content. This method of classifying the rhizomes provides the farmer's crop a grade remotely so as to fix the rate in the commercial market. Comparison of different edge detection technique helped to select the best suitable one for detecting the edges and boundaries of turmeric rhizome so as to calculate the area and categorise them. Canny Edge detection algorithm proved better as compared to other algorithms. Further the texture analysis can help for classification may add up for better performance.

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