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Color Image Edge Detection Using Fuzzy Membership Functions

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ABSTRACT

Digital image processing is widely used in many research oriented fields. Edge detection method is one of the important techniques in Image Segmentation, which is used to find out the objects in the input image in exact manner. An edge is the boundary between an object and background and it indicates the boundary between overlapping objects. One of the most commonly used operation analysis is edge detection, which is used for enhancing and detecting edges in the image. It removes useless data, noise and frequencies while preserving the important structural properties in an image. Fuzzy Logic techniques have been used in image understanding applications such as detection of edges, feature extraction, classification, and clustering. Fuzzy logic possess the ability to mimic the human mind to employ modes of reasoning that are approximate rather than exact form effectively. This paper discuss about RGB color model and fuzzy membership functions method and particularly explain about the usage of fuzzy membership functions which are used to create different combination of mask with some sort of rules based on RGB channel extraction to scan the separated channel image and include Threshold and filtering concepts for further to produce the output image in well enhanced way.

Keywords : Segmentation, Edge Detection, Color Channel Extraction, Fuzzy Inference System, RGB Color Model, Fuzzy Membership Functions.

I. INTRODUCTION

Edge detection using gray images having lot of methods to locate the edges and it has several set of algorithms to represent it. But the images produce more information in scenes i.e., color images have a few set of methods to detect it. Color provides more powerful information for object detection in color images. In RGB image, each pixel has three color components: red, green, and blue. Amount of mixing of these three colors determines value of pixel. It is difficult to process each pixel; to solve pixel processing problem, need color model for robust edge detection. So, this research work represents color image edge detection method in the literature and detects the edges by extracting the color channels of the RGB image into three separate images with combined form of masking and filtering to enhance the output image if it has any alteration. Fuzzy Membership function is used to frame masks to detect the edges in the given input image.

In this research work, Fuzzy Inference System's Triangular and Trapezoidal membership functions are used with different set of rules. Scanning the image by pixel is a challenging task to obtain the output. Masking is one of the important concepts which are used to scan the input image by pixel by pixel. It is an array based technique contains variables for each array attribute. Two types of masking properties are generated to scan the given input images, such as 2 x 2 and 3 x 3 masks. Both set of masks are used in Triangular and Trapezoidal membership functions and finally trapezoidal membership function using 3 x 3 mask type produces effective results. Variation in masking properties gives different types of results with respect to RGB color model and results proves that increasing window sizes makes images more clear and effective.

Results are obtained by merging the extracted RGB channels into single image and if the image suffers noise will taken further to image enhancement.

II. RELATED WORKS

Md. Habibur Rahman, Md. Rafiqul Islam [2013] proposed a modified version of the watershed algorithm for image segmentation by using adaptive masking and thresholding mechanism over each color channel to overcome over segmentation problem, before combining the segmentation from each channel into the final one. The experimental results are obtained using image quality assessment (IQA) metrics such as PSNR, MSE, PSNRRGB and Color Image Quality Measure (CQM) based on reversible YUV color transformation. Consequently, their proposed modified watershed approach can enhance the image segmentation performance. According to the visual and quantitative verification their proposed algorithm performs better than other algorithms.

K-Means Clustering algorithm which is the popular unsupervised clustering used for dividing the images into multiple regions based on image color property. The major issue of the algorithm is that the user has to specify the number of clusters-K, which is used to split the image into K regions. To overcome the issue, A.Kalaivani, Dr.S.Chitrakala [2014] focused on determining K automatically based on local maxima of gray level co-occurrence matrix. Automatic generated K value is then passed to Fast K-means Clustering algorithm for segmenting color images into multiple regions. They took RGB color model for their clustering process.

Firas Ajil Jassim [2013] proposed a novel algorithm based on combining two existing methods to obtain a significant method to partition the color image into significant regions. On their first phase, the traditional Otsu method for gray channel image segmentation were applied for each of the R,G, and B channels separately to determine the suitable automatic threshold for each channel. After that, the new modified channels are integrated again to formulate a new color image. The resulted image suffers from some kind of distortion. To get rid of those distortion, the second phase is arise which is the median filter to smooth the image and increase the segmented regions. Totally they used seven types of masks sizes to examine their work and conclude 15 x 15 produce clear results.

Rafael Guillermo Gonzalez Acuna [2015] generalizes Otsu's binarization method towards reduction of color levels in color images. Color defines a multi-dimensional property vector at each pixel location, and this can be further generalized towards considering arbitrarily finite-dimensional property vectors at pixel locations. Otsu's binarization method is already briefly discussed by Otsu for multi-Thresholding, was efficiently mapped earlier into a segmentation method for grey-level images by recursively applying the original binarization method. They generalize further by proposing a recursive algorithm for finite dimensional property vectors at pixel locations.

Efficient fuzzy logic based algorithm to detect the edges of an image without determining the threshold value are implemented in simple way by Suryakant, Neetu Kushwaha [2012]. Their proposed approach begins by scanning the images using floating 3 x 3 pixel window. Fuzzy inference system is designed with 8 inputs, which corresponds to 8 pixels of instantaneous scanning matrix, one output that tells whether the pixel under consideration is "black", "white" or "edge" pixel. Rule base comprises of twenty eight rules, which classify the target pixel. The proposed method results for different captured images are compared to those obtained with the linear Sobel operator.

Ajaya Kumar, Banshidhar Majhi stated a new method of image segmentation by histogram thresholding based on the concept of fuzzy measure minimization. The membership function is used to express the unique association between a pixel and its belonging region which is either the object or the background. The optimal threshold can be effectively determined by minimizing the measure of fuzziness of the image. The main criteria for fuzzy based histogram threshoding approach are membership functions and fuzzy measures. While implementation, it has been noticed that bandwidth of s-membership function cannot be determined automatically. Other membership functions like Huang-wang, Gaussian, and Gamma are unable to produce same threshold irrespective of any fuzzy measure. Their membership function has provided consistent results to determine the global threshold in an image with respect to all described fuzzy measures.

III. METHODOLOGY

In this research work, color image is considered for edge detection process by using RGB color model. Initially color model is split into three channels as Red, Green and Blue i.e. RGB. Fuzzy inference is one of the flexible methods with membership function to locate most appropriate pixel values. Work can be proceeding further with triangular and trapezoidal membership functions. To detect the edges, need to frame the mask to scan the image in the form of pixel by pixel. Here membership functions are developed with two different set of masks 2 x 2 and 3 x 3. By using Rule editor 2 x 2 masks are framed with 16 set of rules and 3 x 3 masks are framed with 28 set of rules.

The color image edge detection depends on the color model, and the process based on color component decomposition is given below:
Step1: Decompose color image to R, G, and B components
Step 2: Detect the edge of three components using Membership Functions
Step 3: Compose the component edge to color image edge.

Inference system contains five editor functions as

- Fuzzy Inference System (FIS) Editor
- Membership Function Editor
- Rule Editor
- Rule Viewer
- Surface Viewer

FIS Editor

The FIS Editor opens and displays a diagram of the fuzzy inference system with the names of each input variable on the left, and output variable on the right along with rule editor.

Membership Function Editor

The Membership Function Editor is the tool that display and edit all of the membership functions associated with all input and output variables for the entire fuzzy inference system.

Rule Editor

Constructing rules using the graphical Rule Editor interface is practically self evident. Based on the descriptions of the input and output variables defined with the FIS Editor and the Rule Editor allows to construct the rule statements automatically. Further Rule viewer and Surface Viewer are used as read only tools. Following formula is an adaptive equation with min and max function to calculate triangle membership function.

$$Triangle(x;a,b,c) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$$

The parameters {a, b, c} (with a < b < c) determine the x coordinates of the three corners of the underlying triangular. Simple equation to find min and max values among the membership range using Trapezoidal membership function is given by,

$$Trapezoid(x;a,b,c) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$$

The parameters {a, b, c, d} (with a < b <= c < d) determine the x coordinates of the four corners of the underlying trapezoidal MF. Note that a trapezoidal MF with parameter {a, b, c, d} reduces to a triangular MF when b is equal to c. Due to their simple formulas and computational efficiency; both triangular MFs and trapezoidal MFs have been used extensively, especially in real-time implementations.

2 x 2 masks are in the form of 2 by 2 matrixes contains four input variables (P1, P2, P3 and P4) which form a mask to scan the input image. For 2 x 2 masks, 16 rules are followed and P4 act as output variable. 3 x 3 masks are in the form of 3 by 3 matrices contains eight input variables (P1, P2, P3, P4, P6, P7, P8 and P9) and one output variable (P5). For 3 x 3 masks, 28 rules were followed to scan the input image. Here, P5 act as output variable in the masks. Further masks is slid over the image pixel by pixel row wise and the process continues till the time whole image is scanned for unwanted edge pixels. Based on membership grade, input variables check the pixels of the image which is black, white or edge and output can be fetched with the base of mentioned fuzzy rules.

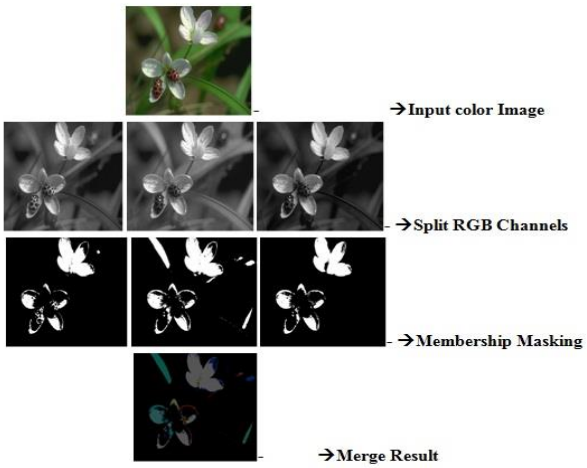

Figure 1: Work flow of Proposed Method

Above figure shows the work flow of proposed method with image results obtained in step by step phases.

Table 1: Results of PSNR

PSNR	LENA	VEG	FLAG	PAINT	HAT
SOBEL	52.582	54.485	56.531	55.324	52.017
PREWIT	52.351	53.261	54.266	53.587	51.754
TRI 3 M	52.208	54.893	56.373	55.212	52.079
TRAP 3 M	53.912	55.044	56.081	55.596	52.207

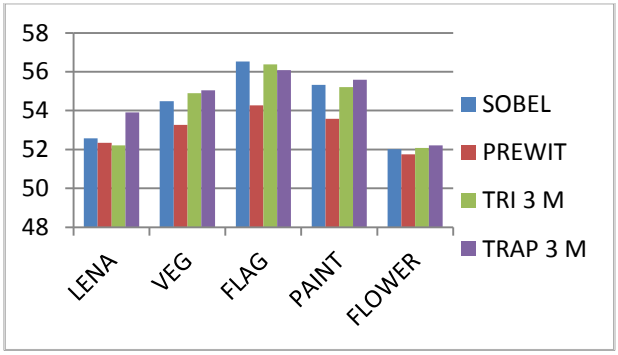

Chart 1: Values of PSNR

Edge percentages are calculated with the help of picture quality measures to show which method outperforms well. Peak signal-to-noise ratio, often abbreviated PSNR, is used to measure the image quality in this work. Table 1 shows the results obtained in edge detection on grey level process by four methods with five different image sets. Chart 1 displays the result range of PSNR with different image sets. The qualitative results show that Trapezoidal membership function produces high edge rate when compared to existing methods and this method has the advantage of keeping the more edge details than the other ways. Because the algorithm is an improved method of pixel processing using Membership functions based on three components of RGB color model and it compose the component edge to color image edge.

IV. CONCLUSION

Segmentation techniques used in image edge detection especially on color image using RGB model have been represented in this paper. Here color image can be extracted into three channels to perform targeted operations. Each technique described in this work has its own advantage and disadvantage based on their parameter properties chosen. Many authors stated that combining two or more methods will produce effective edge results while applying to color images. On calculating the performance analysis, masking methods produce much better results with accuracy while comparing to other techniques in the literature. Variation in masking properties gives different types of results with respect to the RGB color model and results proves that increasing window sizes makes images more clear on measures. This paper concludes that color image segmentation using Trapezoidal membership function with the mask range of 2x2 and 3x3 produce better results in starting level window sizes by using Fuzzy rule based Inference system. Mainly input image is extracted into three channels and further implementation process can be done through in two entirely different phases. On the first phase, the fuzzy membership function based edge detection for gray channel image segmentation were applied for each of the R,G, and B channels separately to determine the suitable automatic threshold for each channel. After that, the new modified channels are included with channel wise and again to form a resultant color image. The resultant image suffers from some kind of alteration. So the second phase is arising to smooth the image with the help of filtering and increase the edge regions according to proposed method.

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