Detecting Edges in RGB Color Channels: A Segmentation Approach

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Abstract

Image segmentation is an important technique in image processing and it is the process of grouping an image into units that are consistent with respect to one or more features. Segmentation using gray images has lots of methods to segment and it has several set of algorithms to represent it. But the images produce more information in scenes i.e., color images have few set of methods to segment it. So, this paper represent color image segmentation methods in the literature and getting to prepare novel segmentation method by extracting the color channels of the RGB image into three parts with combined form of masking, filtering and Thresholding methods. Otsu method is one of the best and famous Thresholding method used in color image segmentation and it uses various combinations of masks to scan over the image to detect the correct boundary. Otsu method divides the segmentation tasks in two or more phases and provides the results better along with different phases. In the same way this paper discusses about RGB color model and fuzzy membership functions method and particularly about the usage of fuzzy membership functions which are used to create mask with some sort of rules based on RGB channel extraction to scan the separated channel image with few combinations and include Threshold method and filtering for further to produce the output image in well enhanced manner.

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

1. INTRODUCTION

Segmentation is an image processing method, which divides the image into several regions with their own characteristic for the sake of extracting useful target, and it is a key step from the image processing to image analysis. It is one of the most important steps leading to the analysis of processed image data, which refers to grouping of similar pixels together and separating the particular portion of the image for the purpose of identification [1]. Its main goal is to divide an image into parts that have strong correlation with objects or areas of the real world contained in the image. Generally, Segmentation is the process of partitioning a digital image into multiple segments which gives more meaning and easier to analyze and cluster pixels into prominent image regions, i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Image segmentation algorithms are based on either discontinuity principle or similarity principle. The idea behind the discontinuity principle is to extract regions that differ in properties such as intensity, color, texture, or any other image statistics and the similarity principle is to group pixels based on common properties [2]. Basically Color is perceived by humans as a combination of tristimuli $R$ (red), $G$ (green), and $B$ (blue) which is usually called three primary colors [3]. From $R, G, B$ representation, we can derive other kinds of color model representations by using either linear or nonlinear type of transformations.

Basically, 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. Image is a collection of pixels; each pixel is a combination of red, green, and blue colors for RGB image. So it is difficult to process each pixel; so, we need color model for robust detection. In HSV image, each pixel has only one color which is represented by Hue component, Saturation and value components determine how much amount of black and white color is added into that color; it helps to differentiate object with other color so we use HSV color model for object detection. Here RGB color model is taken for research and process is carrying out through the same.
The paper is organized into five sections as follows: Section 2 discusses the related works carried out in the field of color image segmentation and Edge detection. Section 3 discusses about the modules to be proposed for color channel extraction and segmentation based on Fuzzy logic Trapezoidal Membership Functions. Section 4 highlights discussion on the experiments to be done through Trapezoidal Membership Function by 3*3 masks and channel separation. Section 5 finally concludes the paper with future enhancement.

2. RELATED WORKS

Firas Ajil Jassim 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 15x15 produce clear results [4].

A.Kalaivani, Dr.S.Chitrakala represented 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, they 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 [5].

Navkritar Kaur presented color image segmentation algorithm in the form of color conversion. They convert RGB image to HSV because it gives the color according to human perception. Further three matrixes are made by three different planes. Firstly, a single new matrix is formed so as to see values of RGB at each pixel. If two rows are equal in a single new matrix then combine those rows. After that total number of colors existing in an original image is calculated. To see the exact color enter the number of colors wants to see and finally processed image is converted from HSV to RGB color space [7].

Rafael Guillermo Gonzalez Acuna 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, originally 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 [8].

Suryakant, Neetu Kushwaha proposed the implementation of a very simple but efficient fuzzy logic based algorithm to detect the edges of an image without determining the threshold value. Their proposed approach begins by scanning the images using floating 3x3 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 [9].

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 thresholding 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 [17].

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Huang-Chia Shih, En-Rui Liu proposed a novel Automatic Reference Color Selection scheme for the adaptive Mathematical Morphology method, and that is specifically designed for color image segmentation applications. However, the Mathematical Morphology process typically neglects the details of reference color determination. Their proposed ARCS scheme is used for determining the ideal reference color for Mathematical Morphology and for color image segmentation application. In addition, they use both 1D histogram based modeling scheme binning from 3D color spaces such as red, green, blue and hue, saturation, intensity, and 2D color models such as (H, S), (Cb, Cr), and (I, By). By quartile analysis, the threshold determination reacts with less sensitivity to the context variations of the images tested. To evaluate the system, four quantitative indices were utilized for an Automatic Reference Color Selection comparison using advanced segmentation methods in their experiments [21].

Chaohui Lü, Xingyun Yang and Sha Qi implements a system of applying ant colony algorithm to image segmentation, which is based on the aspects of the discreteness of digital image and the fuzzy clustering ability of ant colony algorithm. There are mainly three contents in the algorithm. The first part is to extract the features of an image including the RGB values, the gradient, and the neighborhood. The second part is to set the clustering center with the method of a combination of statistics and artificial selection. And the third part is to apply the ant colony algorithm to segment a color image and they introduced a method based on the statistics and the artificial participation to find clustering centers [22].

Er. Manpreet Kaur, Ms. Sumeet Kaur represented a modified rule based fuzzy logic technique, because fuzzy logic is desirable to convert the uncertainties that exist in many aspects of image processing. Firstly the gradient and standard deviation is calculated and used as input for fuzzy system. The standard deviation and gradient values are used as input for fuzzy system using membership function. Fuzzy if-then else rules are applied to modify the membership to one of Low, medium and high classes. Finally defuzzification is performed. The three edge strength values used as fuzzy system inputs were fuzzified using Gaussian membership functions. Fuzzy if then rules are applied to modify the membership to one of low, medium, or high classes. The traditional algorithm like Sobel, Prewitt, LoG are implemented and then the results are compared with modified algorithm and concluded that the proposed technique is to find the more fine edges and reduce the pixels that are not belonging to the edge [27].

3. METHODOLOGY

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. In previous work, 2*2 and 3*3 masks are used based on different set of rule format. 2*2 masks are in the form of 2 by 2 matrices contains four input variables P1, P2, P3 and P4 which form a mask to scan the input image [10]. For 2*2 masks, 16 rules are followed and P4 act as output variable. 3*3 masks are in the form of 3 by 3 matrices having eight input variables such as P1, P2, P3, P4, P6, P7, P8 & P9 and one output variable P5. Here P5 act as output variable which gives resultant pixel of the mask scan [11].

For 3*3 masks, 28 rules were followed to scan the input image. Masks is slid over the whole image pixel by pixel row wise and the process continues till the time whole image is scanned for unwanted edge pixels. A Membership Function is a curve that defines how each point in the input space is mapped to a membership degree or value between 0 and 1. 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. Rules are feed in rule editor of fuzzy inference system engine which works on the concept of if else. User can add more number of variables which are suitable for problem of selection.

A triangular MF is specified by three parameters \{a, b, c\} as follows:

\[
\text{triangle}(x; a, b, c) = \begin{cases} 
0, & x \leq a, \\
\frac{x - a}{b - a}, & a \leq x \leq b, \\
\frac{c - x}{c - b}, & b \leq x \leq c, \\
0, & c \leq x.
\end{cases}
\]
By using min and max function, we have an alternative expression for the preceding equation:

\[
\text{triangle}(x; a, b, c) = \max \left( \min \left( \frac{x - a}{b - a}, c - x \right), 0 \right)
\]

The parameters \{a, b, c\} (with \(a < b < c\)) determine the x coordinates of the three corners of the underlying triangular. It can be further fed in membership function editor of inference system.

A Trapezoidal Membership Function is specified by four parameters \{a, b, c, d\} as follows:

\[
\text{Trapezoid}(x; a, b, c, d) = \begin{cases} 
0, & x \leq a. \\
\frac{x - a}{b - a}, & a \leq x \leq b. \\
1, & b \leq x \leq c. \\
\frac{d - x}{d - c}, & c \leq x \leq d \\
0, & d \leq x
\end{cases}
\]

By using min and max in the inference system variables declared are calculated in between parameter range. In scenes, it can be altered in inference system based on the parameters range to be selected. We have an alternative expression for the preceding equation as follows.

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

The parameters \{a, b, c, d\} (with \(a < b \leq c < d\)) determine the x coordinates of the four corners of the underlying Trapezoidal Membership Function. Note that a Trapezoidal Membership Function with parameter \{a, b, c, d\} reduces to a Triangular Membership Function when \(b\) is equal to \(c\). In this paper, mamdani’s fuzzy inference method is implemented with the help of flexible Trapezoidal Membership Function formula.

Likewise, this concept is taken further to process color image on the basis of color image segmentation. Here RGB color model is taken for research by extracting the image channels into three separate images. After separation all the three images are included for edge detection by using fuzzy membership functions. Following is an algorithm to perform extraction of the channels in given input image into three separate RGB channels.

**Color Separation Algorithm**

```matlab
pic = imread('paint.jpg');
for mm = 1 : size(pic, 1)
    for nn = 1 : size(pic, 2)
        if pic(mm, nn, 1) < 80 && pic(mm, nn, 2) > 80 && pic(mm, nn, 3) > 100
            gsc = 0.3 * pic(mm, nn, 1) + 0.59 * pic(mm, nn, 2) + 0.11 * pic(mm, nn, 3);
            pic(mm, nn, :) = [gsc gsc gsc];
        end
    end
end
```

After extraction each image is taken further to include masking process through Mamdani inference system using membership functions. There are several kinds of membership functions present; they are Triangle, Trapezoidal, Gaussian, Bell, Sigmoid, Piecewise Linear, etc. Like grey process here too same membership (Triangle & Trapezoidal) functions are planned to use.
If-Then Rules

Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. These if-then rule statements are used to formulate the conditional statements that comprise the fuzzy logic. A single fuzzy if-then rule assumes the form if x is A then y is B where A and B are linguistic values defined by fuzzy sets on the ranges X and Y, respectively. The if-part of the rule “x is A” is called the antecedent or premise, while the then-part of the rule “y is B” is called the consequent or conclusion. An example of such a rule might be

If ‘service’ is ‘good’ then ‘tip’ is ‘average’

The concept good is represented as a number between 0 and 1, and so the antecedent is an interpretation that returns a single number between 0 and 1. Conversely, average is represented as a fuzzy set, and so the consequent is an assignment that assigns the entire fuzzy set B to the output variable y. Likewise, for grey level images 0 and 1 denotes black and white in the form of pixel values. Edge can be found out through whether the pixel is black or white. To detect edges several set of rules are framed and implemented through inference systems’ rule editor. Rules can be varied based on size of the masks. Two different set of masks are developed to scan the image with the implementation of two different set of rules format.

Rules formation for 3*3 masks can be framed by following way.
If (P1 is White) and (P2 is White) and (P3 is White) and (P4 is White) and (P6 is White) and (P7 is Black) and (P8 is Black) and (P9 is Black) then (P5 is Edge)

This is formulated for grey images with the use of 3*3 masks to scan the input image. Likewise it can be further implemented to extracted channels of RGB images.

4. RESULTS & DISCUSSION

Color images express more information while compared to gray scale images. Basically, Color image segmentation follows discontinuity principles to extract the regions based on color as its property. There is large number of color image segmentation techniques based on segment properties which are demonstrated earlier. Segmentation properties can be classified into four general categories such as pixel-based, edge-based, region-based, and model-based techniques.

Actually, the basic behavior of these techniques can be divided into three major concepts. The first concept is the similarity concept which is like edge-based techniques which involves edge detection in image. Alternatively, the second concept is based on the discontinuity of pixel values as same as pixel-based and region-based techniques. It is an effective concept which is accepted overall by all categories of applications in literature. Finally, a complete different approach is the third concept which is based on a statistical approach like Model-based techniques. This technique provides approximate mathematical calculation in order of statistical way. There are various color models present such as RGB, CMY, and HSV etc, which are considered to examine color segmentation process. In this research work RGB color model is taken for execution. Below figure is an example of color channel extraction which is used to extract the color channels from the image. Here RGB color model is chosen, so, three channels such as red, green and blue channels are extracted separately and all of them are included for edge detection technique to detect the edges present.

![Figure 5: RGB Channel Extracted Image](image-url)
Above figure is an example of color channel extraction of RGB color model. All the three extracted images are included for edge detection technique by means of membership functions. Likewise grey images same procedure will be followed for these extracted images. Here scanning concept of pixel identification are done through 3*3 mask of triangular membership function. Same kind of rules is implemented through the rule editor. 28 set of rules which is used to identify the resultant pixel can be fixed as either black or RGB. This is totally different from several set of algorithms in literature.

5. Conclusion

Segmentation techniques used in image segmentation especially on color image using RGB model have been represented in this paper. Here color image can be extracted into their own channels to perform targeted operations. Each technique described in this work has its own advantage and disadvantage based on their parameter properties. Many researchers stated that combining two or more methods will produce effective segmentation results while applying to color images. On calculating the performance analysis, masking methods produce much better results with respect to RGB color model and results proves that increasing window sizes makes images more clear. 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 segmented regions.

References


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