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SEGMENTATION USING FUZZY LOGIC IN COLOR IMAGES BASED ON MEMBERSHIP FUNCTIONS

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ABSTRACT

Color Image Segmentation is the high level image description in terms of objects, scenes, and features separates the image into distinct regions of similar pixels based on pixel property. The success of image analysis depends on segmentation reliability. This article presents a novel approach for color image segmentation using two different algorithms with respect to color features. Here presented an adaptive masking method based on fuzzy membership functions and a thresholding mechanism over each color channel to overcome over segmentation problem, before combining the segmentation from each channel into the final one. Our proposed method ensures accuracy and quality of different kinds of color images. Consequently, the proposed modified fuzzy approach can enhance the image segmentation performance by use of its membership functions. Similarly, it is worth noticing that our proposed approach is faster than many other segmentation algorithms, which makes it appropriate for real-time application. According to the visual and quantitative authentication, the proposed algorithm is performing better than existing algorithms.

KEYWORDS: Color Segmentation, Fuzzy Membership Functions, Edge Detection, Region Growing

INTRODUCTION

Image segmentation 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. 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. In computer vision, Segmentation is the process of partitioning a digital image into multiple segments. Color images can convey more information compared to gray scale images. Color image segmentation follows discontinuity principles to extract the regions based on color as its property. It is a method of mining one or more integrated regions that are homogenous. There are a large number of color image segmentation techniques based on segment properties. Segmentation properties can be classified into four general categories such as pixel-based, edge-based, region-based, and model-based techniques. Image segmentation 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. 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. In computer vision, segmentation is the process of partitioning a digital image into multiple segments which gives more meaning and easier to analyze and is to 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

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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

Generally, the basic behavior of these techniques can be divided into three major concepts which are shown in above figure. The first concept is the similarity concept 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. 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 such as RGB, CMY, and HSV etc, which are considered to examine color segmentation process.

RELATED WORKS

A.Borji & M.Hamidi proposed a new method for color image segmentation using fuzzy logic membership functions. Sugeno type fuzzy inference system is used. Trapezoidal, Gaussian and bell shaped membership functions are investigated in their work and the results are compared. Trapezoidal membership function quotes better results among other functions. Md. Abul Hasnat, Olivier Alata and Alain Tremeau proposed an unsupervised method for indoor RGB-D image segmentation and analysis. Worked a statistical image generation model based on the color and geometry of the scene and it consists of a joint color-spatial-directional clustering method followed by a statistical planar region merging method. Evaluate their method on the NYU depth database and compare it with existing unsupervised RGB-D segmentation methods.

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.

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.

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.

Navkirat 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

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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.

MATERIALS AND METHODS

Color is perceived by humans as a combination of tristimuli Red, Green, and Blue (RGB) which are usually called three primary colors. From *R,G, B* representation, we can derive other kinds of color representations (spaces) by using either linear or nonlinear transformations. Several color spaces, such as RGB, HSI, CIE are utilized in color image segmentation, but none of them can dominate the others for all kinds of color images. Selecting the best color space still is one of the difficulties in color image segmentation. Red, green, and blue components can be represented by the brightness values of the scene obtained through three separate filters (red, green, and blue) based on the variables present in the membership functions. Fuzzy logic membership functions such as triangular and trapezoidal were proposed to segment the grey level images. Here there are some difficulties with trapezoidal membership function i.e. it have four variables to represent their own capability. In color images there are number of color spaces which contain three color properties. In such case triangular membership function is much suitable function because of having three variables formula. For example, if we take RGB color space means three colors are included in triangular membership variable XYZ.

Figure 1: Result image with grey levels

Figure 1 represents the results obtained through trapezoidal membership function in grey level images. Here four variables are taken through membership functions for implementation. This membership function doesn't suits for color image segmentation. In this case triangular membership function is proposed with suitable variable declaration. Fuzzy inference system editor contains different input and output variable which is based on masks types. Two fuzzy sets are used for the input i.e. Black & White and three fuzzy sets are used for the output i.e. Black, White and Edge. For 2*2 masks, P4 variable is chosen for output and for 3*3 masks p5 variable is chosen for output. 2*2 masks contain 16 fuzzy rules and 3*3 masks contain 28 fuzzy set rules. The results are based upon fuzzy rules. In membership function editor, the value and degree of membership is denoted and the function trapmf is Chosen.

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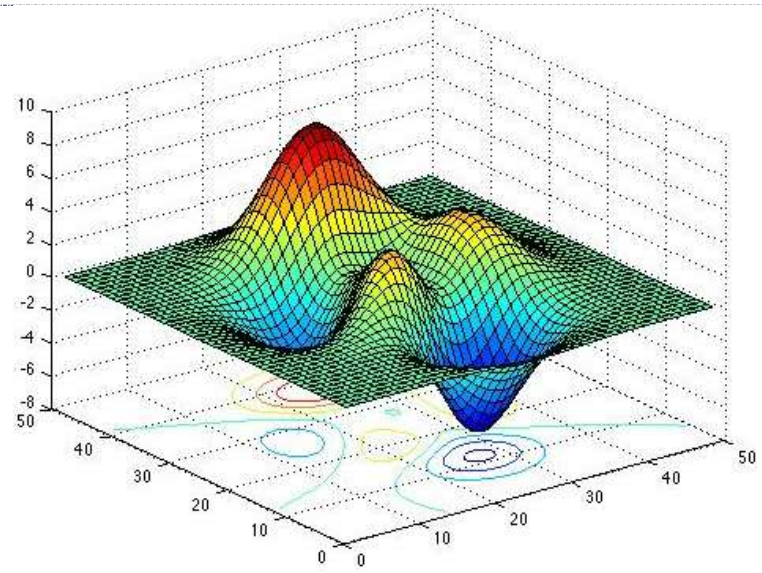

Figure 2: Surface Viewer

Above figure is the surface viewer of resultant image which is represented in figure 1. It is a read only option in the fuzzy inference system which shows the surface occupation of input image. Surface viewer and rule viewer are read only tools given by inference system to check rule properties and surface occupation in the given input.

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 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 (universes of discourse) 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.

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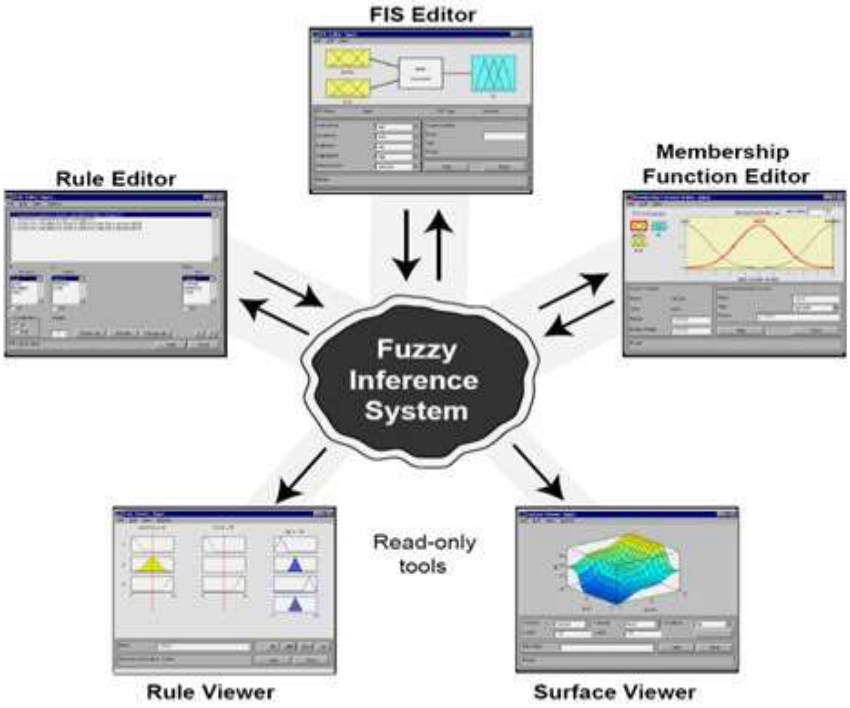

Figure 3: Fuzzy Inference System Tools

Figure 3 point out the fuzzy inference system properties in the form of tools namely Fuzzy Inference System Editor, Membership Function Editor, Rule Editor, Rule Viewer, and Surface Viewer. Membership Function Editor is used to define the shapes of all the membership functions associated with each variable. Rule Editor is used to edit the list of rules that defines the behavior of the system. Rule Viewer to view the fuzzy inference diagram based on given input. Use this viewer as a diagnostic to see, for example, which rules are active, or how individual membership function shapes influence the results. Surface Viewer to view the dependency of one of the outputs on any one or two of the inputs i.e. it generates and plots an output surface map for the system. Generally, Membership function is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1. It provides a measure for the degree of an element to a fuzzy set. It fully defines fuzzy set and it can take any form, but there are some common examples that appear in real applications. There are different shapes of membership functions; triangular, trapezoidal, piecewise-linear, Gaussian, bell-shaped, and so on. In most of the literature, triangular membership functions are used due to having flexible formula to calculate. Choosing of membership function is based on problem taken.

RESULTS AND DISCUSSION

Parameters of triangular membership function are denoted as a, b, c where b is peak point. Here 2*2 masks are used in this algorithm, input pixels are divided into Black and White i.e. two fuzzy sets while the output pixel is divided into three fuzzy sets i.e. Black, Edge and White. For 2*2 masks, rule base of 16 rules is set for various conditions that can occur. The result of proposed method was compared to existing operators and it was suggested to 3*3 dimension window.

A Triangular Membership Function is specified by three parameters {a, b, c} as follows:

$$\mathbf{triangle}(x; a, b, c) = \begin{cases} 0, & x \leq a. \\ \frac{x-a}{b-a}, & a \leq x \leq b. \\ \frac{c-x}{c-b}, & b \leq x \leq c. \\ 0, & c \leq x. \end{cases}$$

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By using min and max, we have an alternative expression for the preceding equation:

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

The parameters {a, b, c} (with a < b < c) determine the x coordinates of the three corners of the underlying triangular. Trapezoidal is one of the types of fuzzy membership function having flat top and really is just a truncated triangle curve. It fully depends on four scalar parameters such as a, b, c and d given by,

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

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

An alternative concise expression using min and max is:

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

The parameters {a, b, c, d} (with a < b <= c < d) determine the x coordinates of the four corners of the underlying Trapezoidal 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. Due to their simple formulas and computational efficiency; both Triangular Membership Functions and Trapezoidal Membership Functions have been used extensively, especially in real-time implementations. However, since the Membership Functions are composed of straight line segments, they are not smooth at the corner points specified by the parameters.

The parameters a and d locate the "feet" of the trapezoid and the parameters *b* and *c* locate the "shoulders." In this paper, mamdani's fuzzy inference method is implemented with the help of flexible trapezoidal formula. Fuzzy inference system editor contains four input variables p1, p2, p3, p4 and one output variable. Two fuzzy sets are used for the input i.e. Black & White and three fuzzy sets are used for the output. It is a 2*2 mask scanning process which is done by using those four input variables. P4 variable is chosen for output where the results are based upon fuzzy rules. In membership function editor, the value and degree of membership is denoted and the function trapmf is Chosen. The mask moved over an area of the input image, changes the P4 pixels value and then shifts one pixel to the right and continues to the right until it reaches the end of a row. It then starts at the beginning of the next row & process continues till the whole image is scanned. When this mask is made to scan over the image, the output is generated by the fuzzy inference system based upon the rules and the value of the pixels P1, P2, P3 and P4. In fuzzy inference system editor, input variables such as P1, P2, P3 and P4 notify input and output type of the pixels which are find out at image scanning section.

CONCLUSION

Segmentation algorithms for color images based on Edge detection are described in this paper. Additionally, fuzzy logic membership function's masking methods were proposed which is based on IF-THEN rules and the output gives some likely results. A brief introduction to color image segmentation and fuzzy segmentation approach is discussed. The development based on IF-THEN rules is predicted as a promising research area in

the near future. Suitable membership functions are chosen based on the parameters likely to assign for the variables and it finally concludes that triangular membership function must satisfy all the conditions which suits for implementation. Generally, implementation process can be done through two 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 new color image. The resulted image suffers from some kind of alteration. To get rid of this warp, the second phase is arise which is the median filter to smooth the image and increase the projection on segmented regions. Experimental results were presented on a variety of test images to support the proposed algorithm.

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