Middle-East Journal of Scientific Research 19 (6): 799-803, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.19.6.1471

Multi Class Image Segmenation Using Bottom-Up Approach

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Abstract: Multi-class image segmentation is one of the recent research areain image editing and content-based image retrieval. In this paper we are proposing a bottom up approach using JSEG, to segment an input image. It heuristically groups the pixels in the input image according to their spatial adjacency, feature proximity, boundary continuity, etc., However, as it focuses directly on the pixel or region it can obtain highly accurate region boundaries. But classical JSEG does not produce high quality segmentation for some class of images. Hence in this paper an approach of using I-FRAC and FRACTAL JSEG is proposed.

Key words: JSEG · J-value · Fractal dimension · I-FRAC · Luv color space etc

INTRODUCTION

Content-based image retrieval (CBIR) is the application of computer vision techniques to the image retrieval problem, it is the problem of searching the digital images in large databases."Content-based" means that the search will analyze the contents of the image instead of metadata such as keywords, tags and/or descriptions associated with the image [1].

An Image Contains Rich Set of Information like: Color,Texture,Contour etc.In the bottom up approach using JSEG, To segment an input image, it heuristically groups the pixels in the input image according to their spatial adjacency, feature proximity, boundary continuity, etc. and thus have no knowledge about the correspondence between pixels or regions to semantic categories. However, as it focuses directly on the pixel or region inter-dependence inside the input image, it can obtain highly accurate region boundaries.

In JSEG First, Colors in the Image Are: Quantized to differentiate regions in the image. Then, image pixel colors are replaced by their corresponding color class labels, thus forming a class-map of the image. Applying the criterion to local windows in the class-map results in the "J-mage", in which high and low values correspond to possible region boundaries and region centers, respectively. Experiments show that JSEG provides good segmentation results on a variety of images.

However JSEG having some disadvantages, several limitations are found for the algorithm.

We can improve this by using modified versions of JSEG called fractal JSEG. An improved version for the JSEG color image segmentation algorithm, combining the classical JSEG algorithm and a local fractal operatorl, thus improving the boundary detection in the J-map. which show improved results in comparison with the classical JSEG algorithm.

Previous Research: In paper [2] a new approach to fully automatic color image segmentation, called JSEG, is presented. First, colors in the image are quantized to several representing classes that can be used to differentiate regions in the image. Then, image pixel colors are replaced by their corresponding color class labels, thus forming a class-map of the image. Applying the criterion to local windows in the class-map results in the "J-image", in which high and low values correspond to possible region boundaries and region centers, respectively. A region growing method is then used to segment the image based on the multi-scale J-images. Experiments show that JSEG provides good segmentation results on a variety of images. But several limitations are found for the algorithm. An alternative to solve these limitations leads to paper [3], this paper proposes an improved JSEG color image segmentation algorithm, combining the classical JSEG algorithm and a local fractal operator that measures the fractal dimension of each pixel. Paper [4] proposes an improved version I-FRAC.

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The proposed I-FRAC segmentation algorithm showing better result than JSEG and same result as Fractal JSEG but its faster than FRACTAL JSEG [5-7].

Proposed System: Proposed system is a region based segmentation using bottom up approach. In order to solve the limitations of JSEG an algorithm which is based on fractal dimension calculation of a single pixel called FRACTAL JSEG and I-FRAC is implemented. The performance of algorithms compared using some standard measures.

Color Quantization: The concept of the JSEG algorithm is to separate the segmentation into two portions, color quantization and spatial segmentation. The color quantization quantizes colors in image into several classes that can differentiate regions in the image [8], the corresponding color class labels replace the original pixel values and then create a class-map of the image. Color quantization is the process that reduces the number of distinct colors used in an in image; in such a way that new image should be visually as similar to the original image. Various algorithms can be used for color quantization.In this paper our aim is to reduce the number of colors into 24 classes without losing visual quality significantly. So that further analysis become simpler, for that a k-means based color reduction algorithm is used also a color palette indicating which are the colors used for quantization also shown.

KMEANS Algorithm:

Step 1: Initially Choose K pixel points (centroids) in space and form k clusters having centroids only.
Step 2: Assign each input pixel to the nearest centroid forming k clusters with added pixels.
Step 3: Recalculate positions of all centroids,
Step 4: Go to step 2 until the positions of centroids no longer move.

Luv Color Space Creation: To utilize color as a visual cue in multimedia,image processing and in computer vision applications an appropriate method for representing the color signal is needed. The different color specification system or color models adress this need. Color space provides a method to specify,order,manipulate and effectively display an objects colors taken into consideration. For example a color space can define the range of theoretical values for representing a color, how many color component needed and so on. This points out the 'choice of color space' is very important decision which can influence the result of processing. Alot of color models are developed by various scientific communities, of which the most important one is RGB color mode [9]l.

RGB Color Model: The most commonly used color model is RGB color model [10], the RGB color model is a color model in which red, green and blue light are added together in various ways to reproduce a broad array of colors. Representing image using RGB color model:

Each pixel is defined by using a combination of R component (ranging from 0-256 values), G component (ranging from 0-256 values) and B component (ranging from 0-256 values).

Disadvantage:

RGB Is a Device-dependent Color Model: different devices detect or reproduce a given RGB value differently, since the color elements and their response to the individual R, G and B levels vary from manufacturer to manufacturer, or even in the same device over time. Thus an RGB value does not define the same color across devices.

Perceptual non Uniformity: A system is perceptually uniform if a small perturbation to a component value is approximately equally perceptible across the range of that value. since RGB is not uniform while working with RGB components during scientific applications where the accuracy is most important small errors may affect the result.So its better to work with uniform color spaces detailed below.

CIE XYZ System: An important color space, defined by the International Commission on Illumination is the CIE XYZ color space.We can think CIE XYZ as an intrmediate color space which allows the transformation between various color spaces. That is most commonly the transform is given in two steps, first a transform from the "source" color space to the CIE XYZ color space and then a transform from the CIE XYZ color space to the "destination" color space.

CIE LUV and CIE Lab: small changes in XYZ color components will result in large or small perceptual changes. This may affect the computation result. Solution is to create a perceptually uniform color space.CIE in 1976 proposed to color models: CIELab and CIELuv. The CIELab and CIELuv color space was intended for equal perceptual differences for equal changes in the coordinates L, a and b.

Where,
luminance L,
chrominance u, v, a and b

Matrix transformation to convert XYZ to CIELuv:

Where,

$$\upsilon' = \frac{9Y}{X + 15Y + 3Z}$$

J-image Calculation Module: Since we are using a region based segmentation technique with seed growing we want to find out best set of seed points among a large set.A homogenity measure call J-value is calculated for this purpose.The class-map can be viewed as a set of spatial data points in a 2-D plane. The value of each point is the image pixel position, a 2-D vector *(x, y)*. In the following, a criterion for "good" segmentation using these spatial data points is proposed.

Defining J:
The measure J is defined as follows,

$$J = S_B / S_W = (S_T - S_W) / S_W$$

Where,

$$S_B = \sum_{i=1}^{c} N_i(\mu_i - \mu)(\mu_i - \mu)^T$$

The value is called between class scatter matrix, that is it measures the distance between different classes.

Where,

Ni-number of elements in class i
μ_i -mean of elements in class i
-is the total mean of all points in the given 2D space.

A higher value of J indicates that the classes are more seperated from each other and members with in each class are closer to each other and vice versa. When an image consists of several homogeneous color regions, the color classes are more separated from each other and the value of *J* is large. On the other hand, if all color classes are uniformly distributed over the entire image, the value of *J* tends to be small.

The J-image is a gray-scale image whose pixel values are the J values calculated over local windows centered on these pixels. For each pixel we need to calculate the J-value by placing an imaginary window surrounding it and the window size will vary according to the user given parameteres to the JSEG algorithm.

Calculation of Fractal Image Module: Fractal dimension (FD) is one of the feature for segmentation, shape classification and graphic analysis in many fields [11], the box-counting approach is used to estimate the FD of an image.. Fractal geometry provides a mathematical model for many com plex objects found in nature such as coastlines, mountains and clouds. Self-similarity is an essential property of fractal in nature and may be quantified by a fractal dimension (FD). The FD has been applied in texture analysis and segmentation, shape measurement and classification, image and graphic analysis in other fields.

Method to Calculate Fractal Dimension of a Pixel: Various methods are available for calculating the fractal dimension of a single pixel of which the differential box counting method (DBC) is adopted here.

Seed Determination Module: Before operating seed growing, we must determine the initial seed areas. These areas correspond to minima of local *J* values. The steps of seed determination method are shown as below.

Step 1: Compute the average and the standard deviation of the local J values in the region, denoted as *ìJ* and *TJ*, respectively.
Step 2: Define a threshold *TJ*

$$T_J = \mu_J + \alpha\sigma_J$$

where α is selected from several preset values that will result in the most number of seeds.

Then we set the pixels with local *J* values less than *TJ* as candidate seed points and connect the candidate seed points based on the 4-connectivity and obtain the candidate seed areas.

Seed Growing: Once the seed points are determined a seed growing algorithm based on 4-neighbourhood can apply to form a region and that region contains neighbours having similar characterstics for example same gray level intensity etc. The seed growing technique is very simple it works as follows.

Create a region that contains only the seed point initially. Compare its gray level intensity to its neighbours if any one of the having similar gray level intensity add that one to the region. Now region size is increased, that contain initial seed plus newly added pixels. For each pixel added newly we can consider them as seeds and repeat the procedure of adding pixels to the region. When will the process stops? The stopping criteria is all the added pixels are processed and its not possible to add no more pixels to the region.

Algorithm:

Step 1: Start from an initial region R that contains only seed point.

Step 2: let p(x,y) be the seed point then check its 4 neighbors p(x+1,y), p(x-1,y), p(x,y+1), p(x,y-1) for the gray level. If all are at same gray level add them to the region.

Step 3: Repeat step 2 for newly added points considering them as new seeds in that region until no more new seeds can be determined and all of the pixels in region are processed.

Region Merging Module: During the region merge based on the color similarity and spatial adjacency segmented regions are merged and the result is a complete segmentation of input image. Here the spatial adjacency measure used is Euclidian distance.

Region merge is in order to solve over-segmented regions. An agglomerative method is used here.

Algorithm:

Step 1: Distances between two regions are calculated and stored in a distance Table.

Step 2: The pair of regions with minimum distance are merged together.

Step 3: The color feature vector of newly formed region calculated and distance table is updated.

Step 4: Steps 1 through 3 continues until a maximum threshold for distance reached.

Hypotheses: For studying the superiority of FRACTAL JSEG over JSEG we test the following hypothesis

H1: Color quantization algorithm used should not reduce the visual quality.

H2: Fractal dimension calculation at various grid sizes should increase boundary detection.

CONCLUSION

The Results of the study will show a comparison of various bottom up segmentations using FRACTAL JSEG and I-FRAC. In future the performance and efficiency can be improved [12-14].

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