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A Simple Single Seeded Region Growing Algorithm for Color Image Segmentation using Adaptive Thresholding

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Abstract — **In this paper, we present a region growing technique for color image segmentation. Conventional image segmentation techniques using region growing requires initial seeds selection, which increases computational cost & execution time. To overcome this problem, a single seeded region growing technique for image segmentation is proposed, which starts from the center pixel of the image as the initial seed. It grows region according to the grow formula and selects the next seed from connected pixel of the region. We use intensity based similarity index for the grow formula and Otsu's Adaptive thresholding is used to calculate the stopping criteria for the grow formula. We apply the proposed method to the Berkley segmentation database images and discuss results based on Liu's F-factor that shows efficient segmentation.**

Keywords- ***Color image segmentation, Single seeded region growing, otsu adaptive threshold algorithm, Liu's F-factor.***

I. INTRODUCTION

Image segmentation is the basic requirement of any computer vision application because people are generally interested only in certain parts of the image. Image segmentation results in non overlapping objects labeled with different region numbers. It should be noticed that no general technique has been developed yet to segment an image precisely, so different techniques are taking floor to perform segmentation.

Threshold based image segmentation techniques discriminate regions on the basis of intensity value difference between pixels. Survey paper [1] shows analysis & comparison of various threshold based segmentation techniques. Thresholds for image segmentation have been calculated based on maximum entropy [2], interclass variation [3], histogram [4, 5]. The limitation of threshold based segmentation technique is that it performs well for images, which have only two components. For complex images, it is calculated to support further processes [6].

Texture describes the spatial distribution of gray intensity in the whole image. It provides a more accurate analysis of correlation, variance, and entropy at a lower level. Textures from an image have been calculated often with co-occurrence matrix and semi-variogram [7, 8, 9]. It is complicated to extract texture from low contrast or noisy images.

Clustering is an approach in which pixels are classified to a cluster, which is closest among all clusters. Pixels having homogeneous characteristics belong to the same cluster and different with respect to pixels of other clusters. The pixels must follow the homogeneity criteria in the same cluster. To perform clustering based segmentation, [10] present *K*-mean, [11] use LVQ efficiently. Fuzzy logic based Fuzzy *C*-Mean clustering method introduces fuzzy membership to pixels with respect to every cluster [12]. In cluster based image segmentation techniques, it is necessary to choose a certain number of clusters initially which eventually reduces the dynamicity of the technique.

Region splitting and merging techniques [13,14,15] starts with splitting an image into small regions and continued till regions with required degree of homogeneity are formed. Splitting phase impacts the overall segmentation of the image. This phase results in over segmented image which is followed by the merging phase. Thus these techniques of region splitting and merging are complex and time consuming.

The main objective of region growing is to map individual pixels called seeds in input image to a set of pixels called region. It was first introduced by Rolf Adams and Leanne Bischof in 1994 [16]. Region growing method starts with initial seeds and grows with neighboring homogenous elements. Seed may be pixel or region. Due to its efficient results for realistic images, it is used widely in different manners. Wankai Deng et al. [17] used region growing method based on the gradients and variances along and inside of the boundary curve. Chaobing Huang et al. [18] used edge and smoothness factors as criterion to determine initial seed pixels and then seeded region growing method is used to segment images based on seed regions.

In the seed based region growing method, selection of initial seed is crucial because it decides the overall segmentation by region growing technique. To select initial seed watershed algorithm by Jun Tang [19] used to first segment image to calculate no overlapped regions and then use centroid of region as initial seeds. Jianping Fan et al [20] find out initial seed by applying edge based segmentation and then use centroid as initial seeds. Weihong Cui et al [21] adopt the Harris corner detector to calculate initial seed. But seed selection affected by particular technique limitation and increases the computation overhead. In the proposed method, we start with center pixel of the image as an initial seed. Then

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region growing is done according to grow formula which follows the stopping criteria to stop the growth of region. To calculate stopping criteria we use Otsu's adaptive thresholding algorithm, which is characterized by its simplicity and high efficiency. We use Berkley segmentation database [22] which provide an empirical basis for research on image segmentation and boundary detection.

The paper is organized as follow: In section II we discuss the conventional seed based region growing technique and Otsu's adaptive threshold technique. In section III we present our proposed method for single seed based region segmentation. In section IV results of our method and the comparison with watershed segmentation technique is discussed. Section V draws the conclusion from overall results.

II. Brief Review of Region Growing

A. Seeded Region Growing

Basic function of region growing technique is partition of an image into non overlapped regions. It takes seeds as input, and then merge pixels with similar property and produce a region correspond to each seed. Result of region growing must follow following constraints:

1 $\bigcup_{i=1}^{L} R_i = I$ Here L is total no. of regions.
It means, all regions should form whole image.

2 R_i is connected region, i = 1, 2, 3…n, where n is the number of regions.

3 $R_i \cap R_j = Null$ for all $i \neq j$, mutual exclusion of region.

To perform region growing we need to address following steps:

1. Selection of initial seeds

Selection of initial seeds plays a prominent role in the process of image segmentation. Seeds should have some similar feature with respect to their neighbors. There should be a seed for every expected region in image. No seeds should be connected to each other.

2. Growing formula based on stopping criterion

Growing formula decides the homogeneity between seed and neighbors of it based on similarity index. Stopping criteria should be efficient to discriminate neighbor elements in non homogeneous domain.

B. Otsu's method for adaptive threshold

In 1979, N. Otsu proposed the maximum classes' variance method (known as the Otsu method) [23]. For its simple calculation, stability and effectiveness it has been widely used. It is a well-behaved automatic threshold selection method, and its consumed time is significantly less than other thresholding algorithms. This method regards the largest inter-class variance between target and background as a principle to choose the best segmentation threshold. Otsu method chooses the optimal threshold t by maximizing the between-class variance, which is equivalent to minimizing the within-class variance, since the total variance (the sum of the within-class variance and the between-class variance) is constant for different partitions.

C. Segmentation evaluation index: Liu's F-factor

In order to evaluate segmentation results of real images as well as synthesized ones, and to evaluate results both locally and globally, we use the global segmentation evaluation index, Liu's F-factor [24] given by:

$$F(I) = \sqrt{R} \times \sum e_i^2 \Big/ \sqrt{A_i} \qquad (1)$$

where, I is the image to be segmented, R total number of regions in the segmented image, A_i the area or the number of pixels of the I^{th} region and e_i the color error of regions. e_i is defined as the sum of the Euclidean distance of the color vectors between the original image and the segmented image of each pixel in the region. The term $\sqrt{R}$ is a local measure which penalizes small regions or regions with a large color error. e_i indicates whether or not a region is assigned an appropriate feature (color). A large value of e_i means that the feature of the region is not well captured during the SSF process In this paper, F is normalized by the size of the image and is scaled down by the factor *1/1000*. The smaller the value of F, the better is the segmentation result.

III. Proposed Single Seeded Region Growing Algorithm

Seed selection is the first step of the region growing technique. Instead of selecting seeds initially we select center pixel of the image as initial seed.

For the grow formula we use the intensity based similarity index between the seed and the 8-neighbour pixels of the seed. The similarity index between two neighborhood pixels of RGB intensities (x, y) and ($x+i$, $y+j$) respectively is calculated by Euclidean distance as follows:

$$DIST = \sqrt{D_r + D_g + D_b} \qquad (2)$$

Where $D_r = (f(x+i, y+j, 1) - f(x, y, 1))^2$

$$D_g = (f(x+i, y+j, 2) - f(x, y, 2))^2$$

$$D_b = (f(x+i, y+j, 3) - f(x, y, 3))^2$$

The stopping criterion for the grow formula is determined from the Otsu's adaptive thresholding method. If the distance between labeled pixel and non labeled pixel is less than the threshold, then we label both pixels as belonging to same region.

The proposed algorithm is executed as described in pseudo code.

Pseudo code uses following variables:

SEED: position of seed (x, y).

RCOUNT: Counter to keep track of current region being grown.

PG: stack to store pixels to grow.

BP: stack to store boundary pixels of grown region.

REGION: matrix with same size of image *I*, storing the labels of grown region.

$CP_{8\text{-}nb}$ (j): 8-neighbours of CP, where j= 1, 2, 3….8.

PSEUDOCODE:

```
Region_Growing(RGB image I)
[R, C] = size (I)
SEED = (R/2, C/2)
RCOUNT = 1
i = 1
j = 1
PG (i) = SEED
Step1:
Calculate: THR (Otsu's adaptive threshold)
While PG not empty
    CP = PG (i)
    i = i-1
    For (8-nb of CP , k=1:8 )
        If (REGION (CP_8-nb(k)) not labeled)
          Calculate: DIST(SEED,CP_8-nb(k))(as (2))
          If (DIST<THR)
            REGION (CP_8-nb(k)) = RCOUNT
            i = i+1
            PG (i) = CP_8-nb(k)
          Else
            j = j+1
            BP (j) = CP_8-nb(k)
          End if
        End if
    End for
End while
Step2:
While BP not empty
    SEED = BP (j)
    j = j-1
    RCOUNT = RCOUNT+1
    i = 1
    PG (i) = SEED
    Go to Step1
End while
```

REGION matrix contains result of proposed segmentation method and RCOUNT represents the number of segmented regions.

IV. RESULTS

To examine the efficiency of our method we use four color images from the Berkley segmentation database [22] shown in Fig.1 (a). The images are of size 481x321. Our algorithm takes approx 15 second on system configured with Intel processor 2.63 GHz and 1 Gigabyte of RAM. We use matlab2009 tool to implement our method. The results after applying our proposed method on these images are shown in Fig.1 (b). These results are obtained by converting the REGION matrix containing labeled regions to an RGB image. We also compare our results with watershed technique which is used by [25] for the initial seed selection and the results are shown in Fig.1(c). However the number of regions formed by the watershed technique is so large (as observed from the results) leading to a large volume

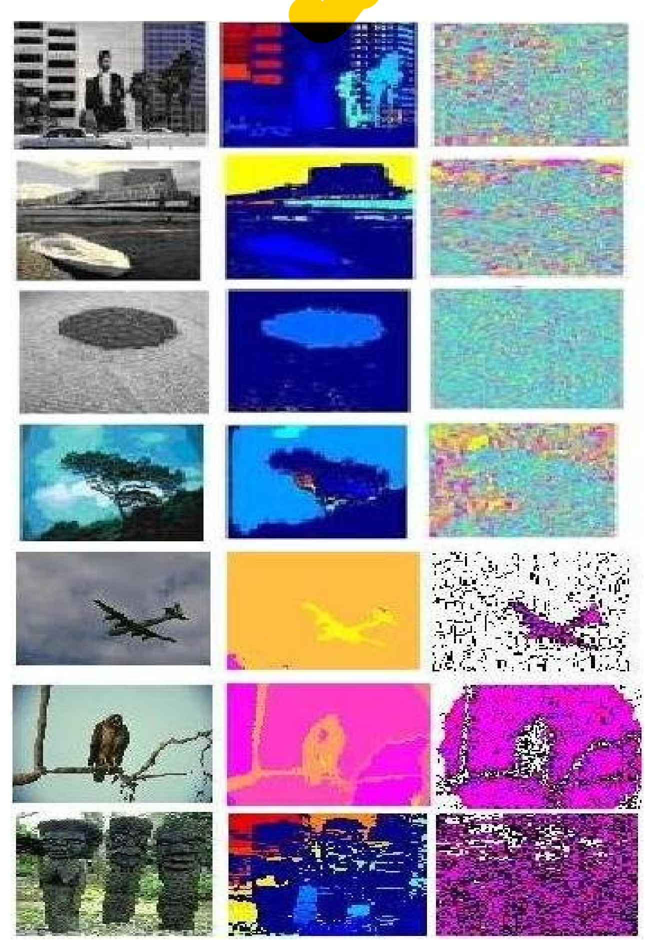

Fig.1 (a) Original images | Fig.1 (b) Segmented images using proposed method | Fig.1 (c) Segmented images using watershed technique

(Man & building, Boat, Garden, Tree, Plane, Crow, Statues) of initial seeds so that suitable region merging techniques has to be used in conjunction with the watershed algorithm. The proposed method does not require any region merging steps as a post segmentation procedure.

We evaluate the Liu's F-factor (1) for all images for both the techniques. The results of comparison of the proposed method with the watershed technique are given in table (1). It is observed from table (1) that the Liu's F-Factor is lower for our method's results as compared to watershed segmentation.

Table (1) Liu's F-Factor

S. No.	Image	Using watershed	Using proposed method
1	Man and Building	$3.784e^{-004}$	$8.625e^{-006}$
2	Boat	$1.888e^{-004}$	$5.176e^{-006}$
3	Garden	$4.233e^{-004}$	$5.332e^{-006}$
4	Tree	$2.089e^{-004}$	$5.949e^{-006}$
5	Plane	$2.139e^{-004}$	$6.453e^{-006}$
6	Crow	$1.482e^{-004}$	$5.682e^{-006}$
7	Statues	$3.358e^{-004}$	$6.163e^{-006}$

V. CONCLUSION

A new approach to segment an image using a single seed based region growing algorithm has been proposed in this paper. In this method the center pixel of the image is selected as the initial seed and the region is grown according to growing formula with the stopping criterion determined by Otsu's adaptive threshold technique. The segmented result obtained by the proposed method is compared to that of the watershed technique and is observed to have lower F values.

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