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IMAGE SEGMENTATION TECHNIQUES AND GENETIC ALGORITHM

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***Abstract*— Image Segmentation is a decomposition of scene into its components. It is a key step in analysis. Edge, point, line, boundary texture and region detection are the various forms of image segmentation. Various technologies for image segmentation are there like thresholding, cluster based, edge based, region based and watershed segmentation. Two of the main image segmentation techniques thresholding and region growing are highly in use for image segmentation. Image segmentation by region growing method is robust fast and very easy to implement, but it suffers from: the thresholding problem, initialization, and sensitivity to noise. OTSU method of thresholding is also used for image segmentation but it also suffers from thresholding problems. Genetic algorithms are particular methods for optimizing functions; they have a great ability to find the global optimum of a problem. Here I proposed a genetic algorithm which provides the better solution than region growing and OTSU methods for the image segmentation. In proposed algorithm we will see that we get better peak signal to noise ratio and maximum absolute error comparatively than region growing and OTSU.**

***Index Terms*— genetic algorithm, Image Segmentation, OTSU, region growing**

I. INTRODUCTION

Image Segmentation is one of the most crucial parts of image processing. Its applications include image visualization, image coding, image synthesis, pattern recognition, rendering displacement estimation, etc. [1]. It is important for image segmentation to select an adequate threshold of gray level for extracting object from there background. Image thresholding is a necessary step in many image analysis applications [2]-[5]. In its simplest form, thresholding means to classify the pixels of a given image into two groups (e.g. objects and background).One including those pixels with their gray values above a certain threshold and the other including those with gray values equal to and below the threshold. In this paper we are going to discuss image segmentation through region growing and OTSU method. Image segmentation by region growing method is robust fast and very easy to implement, but it suffers from: the thresholding problem, initialization, and sensitivity to noise [6]. OTSU method of thresholding is also used for image segmentation but it also suffers from thresholding problems. Genetic algorithm used for solving the optimization problems in medical image segmentation [7] Genetic algorithm is an adaptive segmentation process to change in image characteristics caused by variable environmental condition such as time of day, time of year, clouds, etc. [8].

II. REGION GROWING METHOD

The region growing algorithm is a method of segmentation based on the approach region, the principle of this algorithm is as follows [6]:

☐We fix the points (seed) starting in the image. These points are called germs of regions searched.

☐We fix a criterion of homogeneity (threshold) of the region searched for example, the grey level or texture criteria.

☐For a recursive procedure (step by step), are included in the region all the points that satisfy the criterion related.

It is growing and the region as the criterion is met. The choice of starting points is the critical part of the algorithm. The growing stage will use a similarity measure to select the pixels to be agglomerated. The growing stop when you cannot add more pixels without breaking homogeneity.

2.1 Seed Points

The choice of starting points or initialization is the critical part of the algorithm. Indeed, the growth stage will use a similarity measure based on a given threshold, to select the pixels to be agglomerated. If the starting point is located in a non-homogeneous, the similarity measure will produce large variations and growth will stop very soon.

2.2 Region Growing (growing)

This step aims to grow a region by agglomerating neighboring pixels. The pixels are selected to maintain the homogeneity of the region. For this, we need to define an indicator of homogeneity. Neighboring pixels are added to the region of homogeneity if the indicator is true. Growth stops when you cannot add pixels without breaking the homogeneity. The choice of germs and the threshold can be either manually or automatically. In this work we will give germs a priori and we determine the optimal threshold automatically by genetic algorithm.

The main steps for region growing method are shown below.

$$\bigcup_{i=1}^{n} R_i = I \quad (1)$$

Ri is a connected region, i = 1, 2… n (2)

$Ri \cap Rj = \emptyset$ for all i and j, i ~= j. (3)

$P(Ri) = TRUE$ for i = 1, 2… n. (4)

$P(Ri \cup Rj) = FALSE$ for any adjacent regions Ri and Rj. (5)

Image segmentation result of region growing is shown in figure (6).

III. THE OTSU'S METHOD

Let the pixels of a given picture be represented in L gray levels $[1; 2\ldots L]$ .The number of pixels at level i is denoted by ni and the total number of pixels by $N = n1 + n2 + \ldots; +nL$. In order to simplify the discussion, probability distribution: [9]

$$p_i = \frac{n_i}{N},\ p_i \geq 0, \sum_{i=1}^{L} p_i = 1 \tag{6}$$

Now suppose that we dichotomize the pixels into two classes $C0$ and $C1$ (background and objects, or vice versa) by a threshold at level k ,$C0$ denotes pixels with levels$[1; 2;\ldots; k]$,and $C1$ denotes pixels with levels$[k + 1;\ldots ; L]$.Then the probabilities of class occurrence and the class mean levels, respectively, are given by: [9]

$$\omega 0 = p_{r(C_0)} \sum_{i=1}^{L} p_i = \omega(\mathrm{k}) \tag{7}$$

$$\omega 1 = p_{r(C_1)} \sum_{i=k+1}^{L} p_i = 1-\omega(\mathrm{k}) \tag{8}$$

And

$$\mu_0 = \sum_{i=1}^{k} i p_{r(\mathrm{i}|C_0)} = \sum_{i=1}^{k} i \frac{p_i}{\omega 0} = \frac{\mu(\mathrm{k})}{\omega(\mathrm{k})} \tag{9}$$

$$\mu_1 = \sum_{i=k+1}^{L} i p_{r(\mathrm{i}|C_1)} = \sum_{i=k+1}^{L} i \frac{p_i}{\omega 1} = \frac{\mu_T - \mu(\mathrm{k})}{1-\omega(\mathrm{k})} \tag{10}$$

Where

$$\omega(\mathrm{k}) = \sum_{i=1}^{k} p_i, \qquad \mu(\mathrm{k}) = \sum_{i=1}^{k} i p_i, \qquad \mu_T = \mu(\mathrm{L}) \sum_{i=1}^{L} i p_i$$

It is the total mean level of the original picture. We can easily verify the following relation for any choice of k:

$$\mu 0 \omega 0 + \mu 1 \omega 1 = \mu_T,\ \omega 0 + \omega 1 = 1 \tag{11}$$

The class variances are given by: [9]

$$\sigma_0^2 = \sum_{i=1}^{k} (\mathrm{i}-\mu 0)^2 p_{r(\mathrm{i}|C_0)} = \sum_{i=1}^{k} (\mathrm{i}-\mu 0)^2 \frac{p_i}{\omega 0} \tag{12}$$

$$\sigma_1^2 = \sum_{i=k+1}^{L} (\mathrm{i}-\mu 1)^2 p_{r(\mathrm{i}|C_1)} = \sum_{i=k+1}^{L} (\mathrm{i}-\mu 1)^2 \frac{p_i}{\omega 1} \tag{13}$$

These require second-order cumulative moments (statistics). In order to evaluate the" goodness" of the threshold (at level k), we shall introduce the following discriminant criterion measures (or measures of class separate ability) used in the discriminant analysis: [9]

$$n = \frac{\sigma_B^2}{\sigma_T^2} \tag{14}$$

Where

$$\sigma_W^2 = \omega 0 \sigma_0^2 + \omega 1 \sigma_1^2, \qquad \sigma_T^2 = \sum_{i=1}^{L} (\mathrm{i}-\mu_T)^2 p_i$$

And

$$\sigma_B^2 = \omega 0(\mu 0 - \mu_T)^2 + \omega 1(\mu 1 - \mu_T)^2 = \omega 0 \omega 1 (\mu 1 - \mu 0)^2$$

The optimal threshold k^* that maximizes η, or equivalently maximizes σ_B^2, is selected in the following sequential search by using:

$$\sigma_B^2 = \frac{[\mu_T \omega(k) - \mu(\mathrm{k})]^2}{\omega(k)[1-\omega(k)]} \tag{15}$$

And the optimal threshold k^* is

$$\sigma_B^2(\mathrm{k}^*) = \max \sigma_B^2(\mathrm{k}), 1 \leq k < L \tag{16}$$

Image segmentation result of OTSU method is shown in figure (7).

IV. GENETIC ALGORITHM

4.1 *Basic Concept*

Genetic algorithms are techniques for optimizing functions. GA is based on the evolution of a population of solutions which under the action of some precise rules optimized. A GA manipulates a population of constant size. This population is formed by chromosomes. Each chromosome represents the coding of a potential solution to the problem to be solved; it is formed by a set of genes belonging to an alphabet.

At each iteration is created a new population by applying the genetic operators: selection, crossover and mutation. The algorithm chooses in selection the most pertinent candidates. Crossover consists in building 2 new chromosomes from 2 old ones referred to as the parents, figure 2. Mutation realizes the inversion of one or several genes in a chromosome, figure 3. Figure (1) show steps of genetic algorithm GA. [6]

Random generation of the initial population
Fitness evaluation of each chromosome
Repeat
    Selection
    Crossover
    Mutation
    Fitness evaluation of each chromosome
Until Satisfying the stop criterion

Figure 1: Basic Genetic Algorithm [6]

Selection: - Fitness-proportional selection-The chromosome with minimum fitness value and another randomly chosen chromosome are selected from the parent pool to process crossover and mutation.

Crossover: - The crossover recombines two individuals to have new ones which might be better, shown in figure (2).

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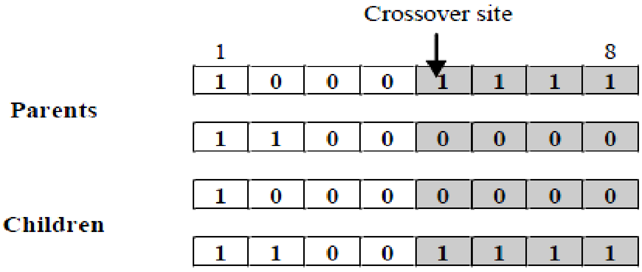


Figure 2: Crossover Operator [6]

Mutation:-The mutation procedure introduces random changes in the population in order to steer the algorithm from local minimums that could prevent the discovery of the global solutions to the problem. The GA is started with a set of abstract candidate solutions population. These solutions are represented by chromosomes (genotypes or genomes). The Solutions from one population are taken and used to form a new population. It is shown in figure (3).

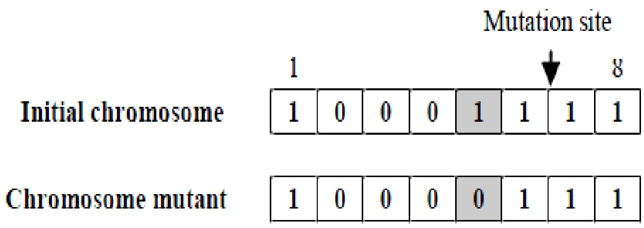


Figure 3: Mutation Operator [6]

4.2 *Evaluate Fitness Function*

For the fitness function which we are going to use is defined by below equation (17).

For that we consider some parameters shown below.

Popsize =8
lchrom =8
i=1: popsize
j=1: lchrom
(x, y) = size of the image

$$fitness(1,i) = lownum * highnum * (d1 - d2)^2 \quad (17)$$

Where

$$d1 = \frac{lowsum}{lownum}, \; d2 = \frac{highsum}{highnum},$$

$$highsum = highsum + double(C(x,y))$$
$$lowsum = lowsum + double(C(x,y))$$

Where

$$C(x,y) = b(1,i)$$

$$b(1,i) = \frac{c * 255}{(2^{lchrom-j})}$$

$$c = c + chrom(1,j) * (2^{lchrom-j})$$

4.3 *Proposed Genetic Algorithm*

Figure 4 shows the flow chart of the proposed algorithm:

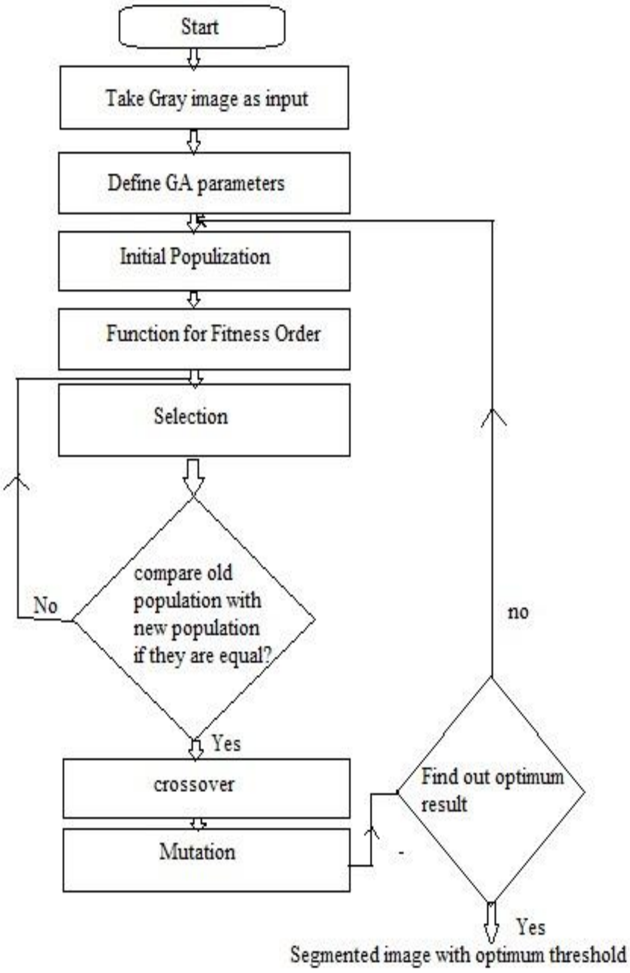


Figure 4: flow chart of proposed genetic algorithm

V. Results and Evaluations

5.1 *Original Image of Lenna*

In order to evaluate the performance of the proposed Algorithm. For that I have used lenna image of 489*489. Figure 5 shows the grey image of lenna.

Figure 5: Original Image of Lenna

5.2 *Result of Region Growing Method*

Figure 6 shows the result of image segmentation techniques using region growing method. Here we are doing image segmentation at threshold value 118. Figure 6(a) shows original lenna image. Figure 6(b) shows seed region image. Figure 6(c) shows binary image passing threshold value at 118. Figure 6(d) shows result after 8-connectivity connected to seed point.

Figure 6: Results of Region Growing Method. (a) Original Image (b) Seed Region Image (c) Binary Image Passing Threshold Test (d) Result After 8-Connectivity Connected To Seed Point.

5.2 *Result of The OTSU's Method*

Figure 7(a) shows the original image of lenna and figure 7 (b) shows the segmented image using OTSU method.

(a)

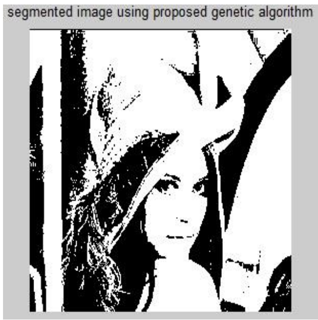
(b)

Figure 7: (a) Original Image of Lenna (b) Segmented Image of Lenna Using OTSU Method

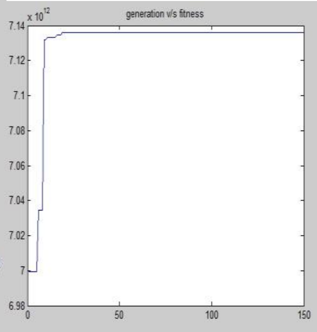
5.3 *Result of Proposed Genetic Algorithm*

Here Figure 8 (a) shows original image of lenna. Figure (8) (b) shows segmented image using proposed genetic algorithm. Figure 8 (c) shows the graph of generation v/s fitness. Figure 8 (d) shows the graph of generation v/s threshold value.

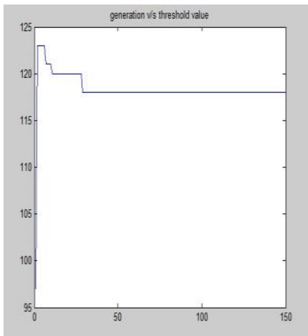
(a)



(b)



(c)



(d)

Figure 8: Results of Proposed Genetic Algorithm (a) Original Image of lenna. (b) Segmented Image Using Proposed Method. (c) Graph of Generation v/s fitness (d) Graph of Generation v/s Threshold value.

5.4 *Comparison*

Here we are going to compare all segmentation methods using image quality parameters like peak signal to noise ratio (PSNR) and maximum absolute error (MAE).

Calculate **Mean Absolute Error (MAE)** by given below equation no. (18)

$$MAE = \frac{1}{xy}\sum(F_1(x,y) - F_2(x,y)) \qquad (18)$$

Where F1 (x, y), F2 (x, y) is image pixel representation with M, N diminutions.

Calculate **Peak Signal to Noise Ratio (PSNR)** by given below equation no (19).

$$PSNR = \frac{10\log 255^2}{MSE} \qquad (19)$$

Where MSE is for mean square error

Comparison of various image segmentation methods is shown in table no. 1

TABLE I. for Lenna image

No.	Image Segmented Method	MAE	PSNR
1	Proposed method	92.5395	8.3233
2	Region growing method	158.9365	8.2585
3	OTSU method	100.9438	8.2236

Where: MAE for maximum absolute error and PSNR stand for peak signal to noise ratio.

VI. Conclusion and Future Work

Image segmentation by region growing method and OTSU is robust fast and very easy to implement, but it suffers from: the thresholding problem, initialization, and sensitivity to noise From the results and comparison we can find that proposed genetic algorithm gives better image quality than region growing and OTSU method. We can easily compare maximum absolute error and peak signal to noise ratio from the comparison table. For the future work we can use fuzzy logic algorithms for the segmentation method.

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Authors Profile

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