Region Based Image Segmentation using Cuckoo Search Algorithm

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ABSTRACT

In image processing, image segmentation is a fundamental task used for image description and classification. In this paper we have proposed a region based color image segmentation. First, initial seeds are selected using histogram analysis. Regions are grown from these initial seeds based on similarity condition. In the next phase, the threshold for region growing is optimized using cuckoo search optimization algorithm. Using this optimized threshold regions are grown and segmentation of images is carried out. Finally, the performance of both segmented output are evaluated using NPR, GCE and VOI.

KEY WORDS: Region based Segmentation, initial seed, Optimization, Cuckoo Search.

1. INTRODUCTION

Image segmentation is a process which groups pixels into different salient image regions, that exhibits similar features like color, texture or intensity. Image segmentation techniques are generally classified as a) segmentation based on threshold, b) Region based segmentation, c) Boundary based segmentation, d) Hybrid method. Threshold – based segmentation is the simplest method and is used to segment any gray scale image. Generally, thresholds are selected from the histogram of the given input image. The selected threshold is used to separate the foreground from the background. The thresholded output image will be a binary (black and white) image. Region-based segmentation is used to segment color images. In any given image, different regions will differ in color, intensity or texture. Hence, in region based segmentation, images are segmented by assuming that the adjacent pixels in the same region have related features like color, intensity or texture. Boundary – based segmentation is done based on the assumption that there will be a boundary between two regions and this boundary will show a abrupt change in intensity level. Hybrid technique is a combination of any of the above said method.

Luis Garcia (2009) proposes an algorithm namely GSEG, which uses the gradient values for detecting the edges. Here the color similarity is used for region growing. Texture characterization is carried out to improve the performance of textured images. Deng and Manjunath (2001) proposes an automatic method to identify the textured regions. Regions are grown based on its spatial information. In case of varying illumination this method provides an over segmented image. Saber (1997) proposes a method in which segmentation is done by combining the edge and color information. It incorporates the split and merge procedure to obtain improved segmentation. Fan (2001) proposes a clustering based color image segmentation algorithm. The centroids between neighboring regions are taken as initial seed. In this the difficulty is to find the correct threshold to distinguish true and false edge pixels. D'Elia (2003) proposes a method which combines Bayesian Classifier and Split and Merge technique. They uses split and merge gain to guide the splitting and merging of regions. The main disadvantage of this method is, it yields too many segments in patterned or textured regions. (Vinay Thakur, 2013) proposes a color image segmentation algorithm using classification in 3-D color space. They used a classifier that depends on mathematical morphology. Chen (2005) proposes an algorithm for segmenting nature related images, instead of predetermined texture sets. The textures are classified into number of classes as smooth, complex etc., Textures classified as smooth are further segmented. Foe effective texture characterization, local color composition and spatial characteristics of gray scale component of texture is used. Chen (2004) proposes a method which uses a single threshold scheme to suppress perceptually faint boundaries. The segmentation is done based on the similarity of neighboring pixels and discontinuity of local information. The remainder of the section is as follows: Section 2 describes region based segmentation. After selecting initial seeds, regions are grown based on intensity. Region growing is based on a threshold; Section 3 describes a cuckoo search optimization algorithm, in which the threshold for region growing is optimized. Finally the results obtained in both method is compared.

2. REGION BASED SEGMENTATION

Initial Seed selection: In region growing adjacent pixels are compared with the initial seed pixels. Pixels with similar characteristics like color, intensity or texture are assembled together with the seed pixel to form a region. The performance of the final segmented image depends on the initial seed pixel. Hence care should be taken while selecting the initial seed pixel. In our proposed segmentation algorithm, the given RGB image is converted into CIE L*a*b color space. CIE L*a*b space is a better model for human visual perception, which is justified by the fact that the difference in the magnitude between any two colors is proportional to the supposed differences as seen by the human eye (Green and MacDonald, 2002). The RGB space does not support this property.

The converted L*a*b image is divided into several grids of equal size. Then from the histogram analysis of each grid, the most probable pixel is chosen as the initial seed pixel. The region growing procedure searches for region with high similarity and to discard regions where there is no similarity. Comparison of similarity between the neighboring pixel and the seed pixel is done by means of a threshold value. For every generated seed pixel, the difference in intensity between the seed pixel and the neighboring pixels are calculated. If the difference is less than the threshold, they both are considered as similar pixel and are grouped together to form a region. If the difference is more than the threshold, they both are considered as dissimilar pixels and hence it is discarded. This region growing process is repeated until all the ungrouped pixels in the image have been allocated to its corresponding region.

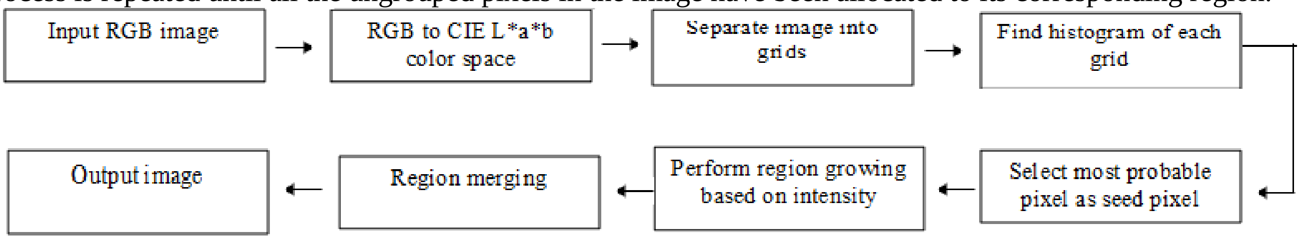


Fig.1. Block diagram of the proposed method

This can be summarized as follows:

- Separate the image into grids G_i of equal size
- For each grid, find the histogram. Determine the most frequent pixel and assign that as seed pixel with intensity I_p.
- Set a threshold for intensity. Let it be T_{in}.
- Compare the neighboring pixels I_n, with the seed pixel (ie) find the difference in intensity between two pixels.

$$D_{in} = \|I_p - I_n\|$$

- If the difference in intensity $D_{in} < T_{in}$, then the corresponding neighboring pixel is grouped together with the seed pixel to form a region.
- Finally, check whether all neighboring pixels are added to any one of the region.
- If not again repeat the whole steps.

Region Merging: Generation of several seeds during initial seed selection, results in over segmented image. Merging of regions is done to overcome this over segmentation problem. In this proposed work regions are merged based on the size. The distance between two regions is computed and if this distance is less than a particular threshold, they two are merged to form a single region. A similar check is done between this newly generated region and its adjacent region. This process is repeated until no region has a distance less than the threshold. By experimentation, regions less than 0.65% of the image are merged to form a large homogeneous region.

Cuckoo-search based threshold Optimization: By optimizing the threshold for region growing, the performance of the final segmented image can be improved. Optimization is done by choosing the objective function. In image segmentation, the objective is to improve the performance of the final segmented image. This performance can be evaluated by means of many segmentation evaluation parameters. He we have chosen the NPR index as the parameter to improve its performance. Hence the objective function is

$$f = \max(NPR) \qquad (1)$$

PR is the Probabilistic Rand Index. This PR allows comparison of a test segmentation result with a ground truth segmentation image (Luis Garcia Ugarriza, 2009).

The Probabilistic Rand Index is defined as

$$PR(S_{test}, S) = \frac{1}{\binom{N}{2}} \sum_{\substack{i,j \\ i<j}} [p_{ij}{}^{c_{ij}} (1 - p_{ij})^{1-c_{ij}}] \qquad (2)$$

Where C_{ij} is the information about each pair of pixel (x_i,x_j), S_{test} is the test segmentation image and S is the ground truth image. This index takes values between 0 and 1, where 0 means 0% similarity and 1 means 100% similarity.

For threshold optimization we have used a bio-inspired cuckoo-search algorithm. Cuckoo search algorithm is first introduced by Xin-She Yang and Suash Deb in 2009. Cuckoos are brood parasites. They used to lay their eggs in other host birds nest. If the host bird finds its egg, it will either throw away or abandon its own nest and build a new one. Hence in case of the cuckoo bird, only the eggs with more fitness will move on to the next generation. Cuckoo search can be described by three generalized rule (Yang, 2009) (a) Each cuckoo lays one egg at a time, and dump its egg in randomly chosen nest; (b) The best nests with high quality of eggs will carry over to the next generations; (c) The number of available host nests is fixed, and the egg laid by a cuckoo is discovered by the host bird with a probability P_a = [0, 1]. In this case, the host bird can either throw the egg away or abandon the nest, and build a completely new nest. Fig 2 shows the general block diagram for the proposed cuckoo search optimization algorithm.

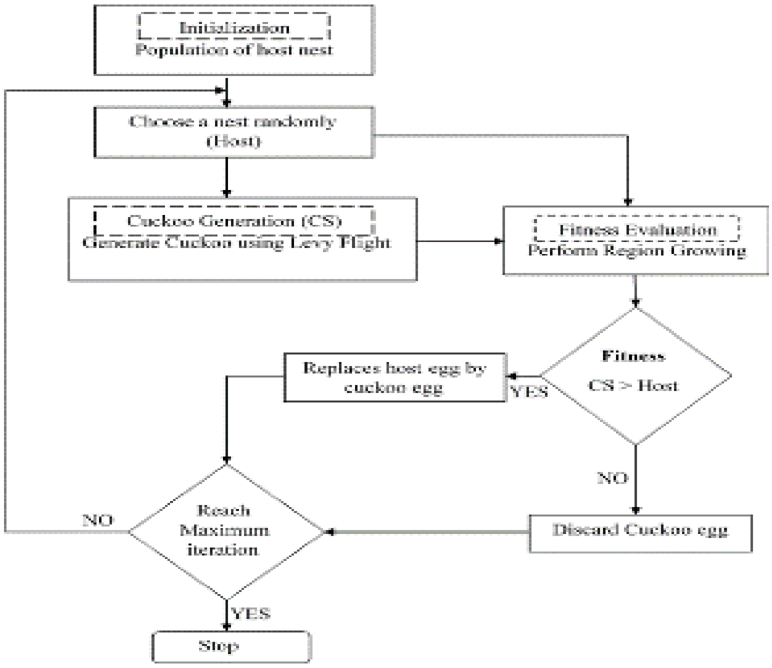


Fig.2. Block diagram of the proposed Cuckoo-Search optimization

The pseudo code for the proposed cuckoo search algorithm is as follows:

Input : Original Image = I,
Begin: Generate 10 initial solutions where each solution (nest) contains 2 number of eggs
while (t < Max generation/iteration), Generate a cuckoo (i)randomly via Levy flights;
Segment the original input image using the generated cuckoo and evaluate its fitness F_i;
Choose a nest among the host randomly (j);
Segment the original input image and evaluate its fitness F_j;
Rank the segmented output based on the fitness and find the current best;
if $(F_i > F_j)$
Replace host by the new cuckoo solution; end
Abandon a fraction (P_a) of worse nests [new build new nest at new location via Levy flights];
Keep the nest with high quality solution;
Rank the results and find the current best;
end while
end
Segment input image I by the current best.

In cuckoo search optimization algorithm, the population of the host nest is randomly initiated. The host nest contains the candidates for optimal parameters. From the population of the host nest, select any nest randomly. In the selected host nest, a new cuckoo egg is laid which is very much similar to the host egg. These new cuckoos are generated using Levy flights. The fitness function of the cuckoo egg is compared with the fitness of the host egg. This comparison is done by performing region growing algorithm on both the host egg and the newly generated cuckoo egg. Fitness comparison is done using eq (1). If the fitness of the cuckoo egg is better than the host egg, then it is replaced by the cuckoo egg. A probability of worst nest is discarded and new nest is build using Levy flight. Thus the worst eggs are discarded from evaluation. The population derived by this iteration now is evaluated and the best solution is found. The iteration then goes on until the stop criterion is reached. Best threshold is obtained after performing maximum iteration. This threshold is the optimized threshold for segmentation.

3. RESULTS AND DISCUSSION

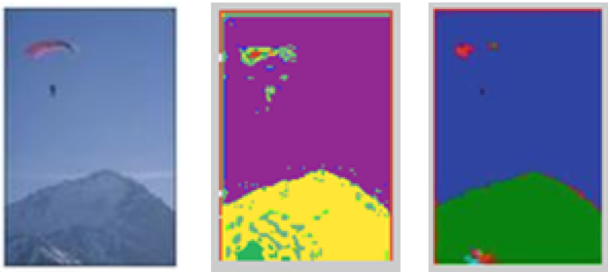
To evaluate the performance of the proposed algorithm, we have chosen the color images from the publicly available Berkeley Dataset. This dataset provides 1633 manual segmentations for 300 images created by 30 human subjects (Martin, 2001). The results of the proposed segmentation algorithm is shown in Fig 3. Fig 3.a shows the input color image and Fig 3.b and Fig 3.c shows the segmented output image before and after optimization respectively. Fig (4) and (5) presents some added results of our proposed algorithm.

(a) (b) (c)

Fig.3.(a) Input Image (b) Segmented Output before Optimization (c) Segemented output after Optimization

(a) (b) (c)

Fig.4.(a) Input Image (b) Segmented Output before Optimization (c) Segemented output after Optimization



(a) (b) (c)

Fig.5.(a) Input Image (b) Segmented Output before Optimization (c) Segemented output after Optimization

Performance Evaluation: The performance of this proposed segmentation algorithm is evaluated by means of various segmentation parameters like Normalized Probabilistic Rand Index (NPR), Global Consistency Error (GCE) and Variation of Information (VOI).

Normalized Probabilistic Rand (NPR) Index: It Compares test results and ground truth images. It takes values between 0 and 1. (0 means no similarity, 1 means both are same).

Global Consistency Error: This is computed to quantify the consistency error between the test results and ground truth images. It takes values between 0 and 1. (1 means no similarity, 0 means both are same).

Variation of Information: It measures the sum of information loss and information gain between two segments. It takes values between 0 and 1. (1 means no similarity, 0 means both are same).

Table: 1 Performance Evaluation

Performance measure	Segmentation before Optimization	Segmentation after Optimization
NPR	0.76	0.85
GCE	0.51	0.23
VOI	0.58	0.27

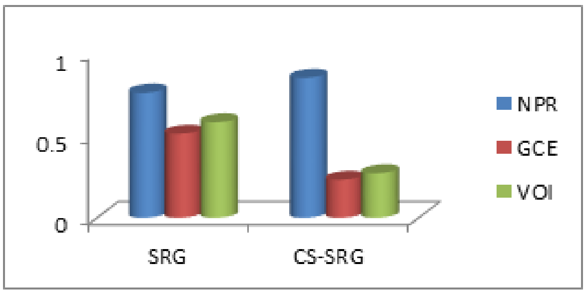


Fig.6. Graphical Representation for Performance Evaluation

Corresponding graph for the Table.1 is plotted in Fig.6. From this comparison it can be shown that image segmentation using the optimized threshold will provide better performance.

4. CONCLUSION

In this paper, we have proposed an color image segmentation algorithm based on region growing. Initial seeds are selected using a threshold value. This threshold is again optimized using cuckoo search optimization algorithm. Finally, both results are compared using the performance evaluation parameters NPR, GCE and VOI and the results show that the optimized threshold provides better segmentation results.

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