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Implementing Color Image Segmentation Using Biogeography Based Optimization

Surbhi Gupta [1], Krishma Bhuchar [2], Parvinder S. Sandhu [1 +]

1 Senior Lecturer, Department of Computer Science, RIEIT , India

2 Student, Department of Computer Science, RIEIT, India

1+ Professor, Department of Computer Science, Rayat & Bahra, Mohali, India

Abstract. This paper proposes a Biogeography Based optimization approach for automatically grouping the pixels of an image into different homogeneous regions. Biogeography is the study of the geographical distribution of biological organisms. BBO is basically an optimization techniques it does not involve reproduction or the generation of “children.” From many years Image segmentation are done with many techniques like PSO, ACO etc. This paper elaborates BBO approach for image segmentation i.e. partitioning an image into multiple segments.

Keywords: Segmentation, Clustering, Region Growing, Biogeography.

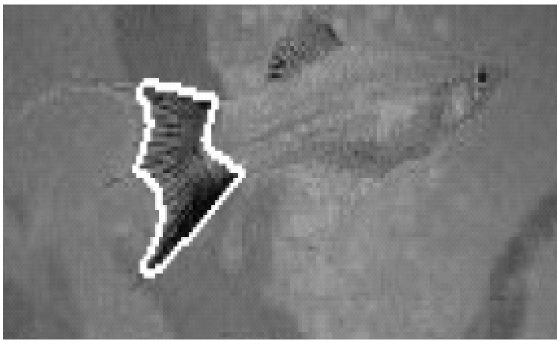
1. Introduction

The goals of this paper are threefold. First, to give a general presentation of the new optimization method called BBO. Second, make use BBO approach for image segmentation. Third, is to compare and contrast BBO with other population-based optimization methods. We do this by looking at the commonalities and differences from an algorithmic point-of-view, and also by comparing their performances on a set of benchmark functions.

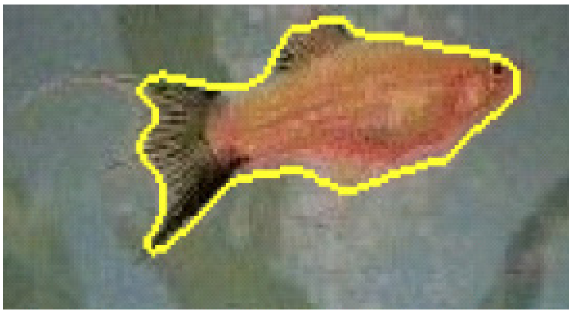
1.1. Image Segmentation

“Segmentation” refers to the process of dividing a digital image into multiple segments such as a sets of pixels, also known as super pixels (Chad and Hayit ,2002). The main objective of segmentation is to simplify and/or change the representation of an image into meaningful image that is more appropriate and easier to analyze. Segmentation is basically a collection of methods that allowing spatially partitioning close parts of the image as objects.

“Image segmentation” is an important aspect of digital image processing. Image segmentation may be defined as a process of assigning pixels to homogenous and disjoint regions which form a partition of the image that share certain visual characteristics (Fan, Zeng and Hacid,2005). Image segmentation is used to locate and find objects and boundaries (lines, curves, etc.) in images. It basically aims at dividing an image into subparts based on certain feature. Features could be based on certain boundaries, contour, color, intensity or texture pattern, geometric shape or any other pattern (Pichel, Singh and Rivera, 2006). It provides an easier way to analyze and represent an image. The image segmentation process consists in grouping parts of an image into units that are homogeneous with respect to one or more characteristics as shown in fig 1 (Thomas , and Dresden, 2008). The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (Bab Hadiashar and Gheissari,2006). An example of image segmentation are given below:-



(I) Original Image



(II)Segmented Image

Fig. 1: An Example of Image segmentation (Courtesy, images: Thomas and Dresden, 2008).

Region growing is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighbouring pixels of initial “seed points” and determines whether the pixel neighbours should be added to the region (Yu and Clausi, 2007).

Application of Image segmentation:-

Image segmentation is mainly used to locate objects or object boundary, lines etc in an image so it can be used in applications which involve a particular kind of object recognition such as:

- Face Recognition
- Fingerprint Recognition
- Locating objects in satellite images

Since it deals with object detection, so it can also be used in applications involving object tracking such as traffic surveillance etc (Lynch and Ghita, 2008). Some of the practical applications of image segmentation are (Fritz, Rinck and Unterhinninghofen, 2005):

- Medical imaging
- Locate tumors and other pathologies
- Measure tissue volumes
- Computer-guided surgery
- Diagnosis
- Treatment planning
- Study of anatomical structure
- Traffic control systems
- Brake light detection
- Machine vision
- Agricultural imaging – crop disease detection

1.2. Biogeography-Based Optimization

Biogeography-Based Optimization, a type of evolutionary algorithm. As its name implies, BBO is based on the mathematical study of biogeography. Biogeography is the study of the distribution of animals and plants over time and space. Its aim is to elucidate the reason of the changing distribution of all species in different environments over time (Haiping Suhong and Man, 2009).

BBO is an evolutionary process that achieves information sharing by species migration. It is modelled after the immigration and emigration of species between habitats to achieve information sharing. BBO operates by migrating information between individuals, thus resulting in a modification of existing individuals. Individuals do not die at the end of a generation One characteristic of BBO is that the original population is not discarded after each generation. It is rather modified by migration (Simon, 2008).

BBO is a population-based optimization algorithm it does not involve reproduction or the generation of "children." Mathematical equations that govern the distribution of organisms were first discovered and developed during the 1960s. Mathematical models of biogeography describe how species migrate from one island (habitat where they live) to another, how new species arise, and how species become extinct. Biogeography basically based on two criteria-HIS and LSI. Geographical areas that are well suited and more compatible as residences for biological species are said to have a highly suitability index (HSI). Features that correlate with HSI include such factors as rainfall, diversity of vegetation, diversity of topographic features, land, area, and temperature (Simon, 2008). The variables that characterize habitability are called suitability index variables (SIVs). Habitats with a HSI tend to have a large number of species, while those with a low HSI have a small number of species. Habitats with a HSI have a low species immigration rate because they are already nearly saturated with species. HIS are more static than LSI. LSI have a high species immigration rate because of their sparse populations. LSI habitats are more dynamic in their species distribution than HSI habitats.

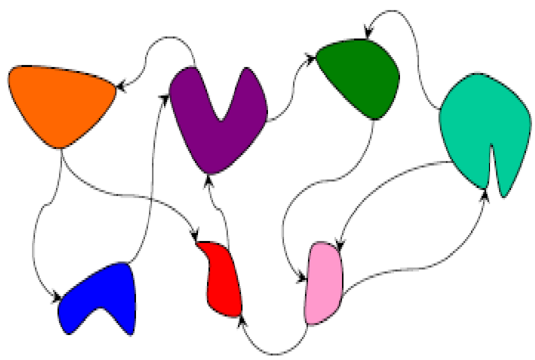


Fig. 2: Migration of spice (Simon, 2008)

BBO basically depends upon following theory:

- Migration

The BBO migration strategy in which many parents can contribute to a single offspring, but it differs in at least one important aspect. BBO migration is used to change existing habitat. Migration in BBO is an adaptive process; it is used to modify existing islands. Migration stage arises when LSI occurs. When spices are less compatible with their habitat then they migrate (Simon, 2008).

- Mutation

The implemented mutation mechanism is problem dependent. In which a new region are created by hybrid others region.

- Certain Features of Biogeography Based optimization Approach:-
  - BBO has a way of sharing information between solutions.
  - BBO solutions survive forever (although their characteristics change as the optimization process progresses)
  - BBO solutions do not necessarily have any built-in tendency to cluster.
  - It does not require a priori knowledge of the number of partitions in the image.

- It yields regions, more homogeneous than the existing methods even in presence of noise.

Some of the distinctive features of BBO:

First, we note that although BBO is a population-based optimization algorithm it does not involve reproduction or the generation of "children." This clearly distinguishes it from reproductive strategies such as GAs and evolutionary strategies. BBO also clearly differs from ACO, because ACO generates a new set of solutions with each iteration (Pakhira and Bandyopadhyay, 2005) . BBO, on the other hand, maintains its set of solutions from one iteration to the next, relying on migration to probabilistically adapt those solutions. BBO has the most in common with strategies such as PSO and DE. In those approaches, solutions are maintained from one iteration to the next, but each solution is able to learn from its neighbours and adapt itself as the algorithm progresses (Hansen, 2006). PSO represents each solution as a point in space, and represents the change over time of each solution as a velocity vector (Nikolaus and Raymond, 2008). However, PSO solutions do not change directly; it is rather their velocities that change, and this indirectly results in position (solution) changes (Wang, Gong and Zhang, 2009). DE changes its solutions directly, but changes in a particular DE solution are based on differences between other DE solutions. Also, DE is not biologically motivated. BBO can be contrasted with PSO and DE in that BBO solutions are changed directly via migration from other solutions (islands). That is, BBO solutions directly share their attributes (SIVs) with other solutions (Qiyao and David, 2008). It is these differences between BBO and other population-based optimization methods that may prove to be its strength.

2. Proposed Algorithm

Image Segmentation is one of the important aspects of Digital image processing. Many techniques are used for image segmentation like clustering techniques where the features describing each pixel correspond to a pattern, and each image region (i.e. a segment) corresponds to a cluster (Lynch and Ghita, 2008). Therefore many clustering algorithms have widely been used to solve the segmentation problem (e.g., K-means, FCM, ISODATA and Snob).Here we use new biogeographic technique for image segmentation (Taiwi, 2004). BBO is a population-based optimization algorithm it does not involve reproduction or the generation of "children." As we started we select a seed using some set of predefined criteria. After selecting examine neighbour pixels of seed points and calculate MSE color distance between pixels (Auger and Hansen, 2005). If we use RGB image, then we calculate MSE color distance. If we use LAB color space then we calculate CMC color distance between neighbouring pixels (Haisong and Hirohisa, 2005). According to the BBO approach make three islands HIS, MSI and LSI.HSI (highly suitability index) that contain pixels which have more similar properties. Medium suitability index (MSI) basically contains pixels which have medially suitable. Low suitability index (LSI) that contain pixels which contain pixels that not so familiar. HSI tend to have a large number of species, while those LSI have a small number of species. HSI have many species that emigrate to nearby habitats, simply by virtue of the large number of species that they host. HSI have a low species immigration rate because they are already nearly saturated with species. Therefore, HSI habitats are more static in their species distribution than LSI habitats. LSI have a high species immigration rate because of their sparse populations. Then we select threshold value (Fritz, Rinck and Dillmann, 2006). If our calculated distance less than threshold then its migrate to other region, otherwise its make its own region.

The Image Segmentation using BBO algorithm can be informally described with the following algorithm.

- **Step1)** Take an image and convert it into Lab image.
- **Step2)** Calculate CMC distance between neighboring pixels.
- **Step3)** Initialize the BBO parameters. Allocate the maximum species count Smax and the maximum migration rates E and I, the maximum mutation rate mmax. The maximum species count and the maximum migration rates are relative quantities.
- **Step4)** Initialize a random set of habitats corresponding to a potential solution to the given problem. For each habitat, map the HSI to the number of species S, the immigration rate, λ and mutation μ. Compute S, λ,μ, for each solution.
- **Step5)** Modify habitats (migration) based on λ, μ based on probability.

- **Step6)** Go to step (3) for the next iteration. This loop can be terminated after a predefined number of generations or after an acceptable problem solution has been found.

3. Implementation

For implementing BBO approach for image segmentation firstly we take RCB image, then convert it into Lab image as shown below:

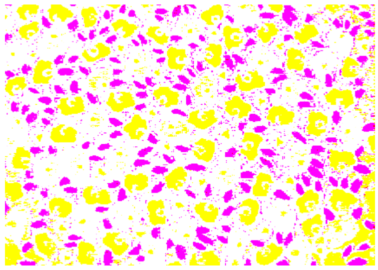


Fig. 3: Lab Image

Then we segmented the objects in image and make different clusters. Those objects contain red objects make red cluster are shown below with histogram:

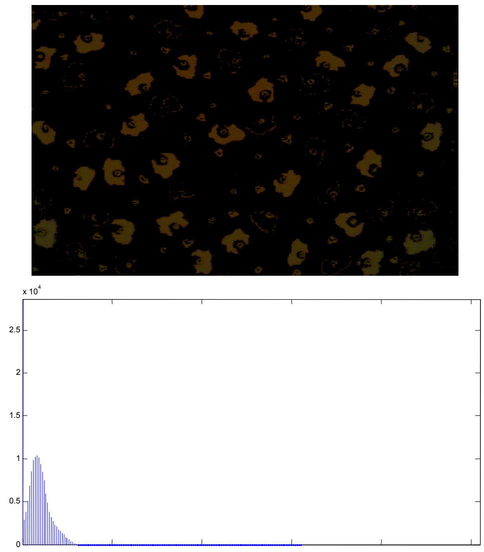


Fig. 4: Histogram for red Image

Those objects contain green color are segmented and shown in fig5 with histogram:

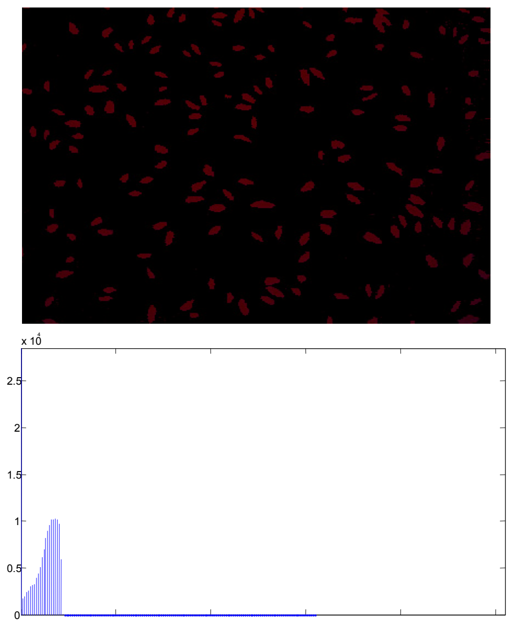


Fig. 5: Histogram for green Object

Those objects contain purple color are segmented and shown in fig 6with histogram:

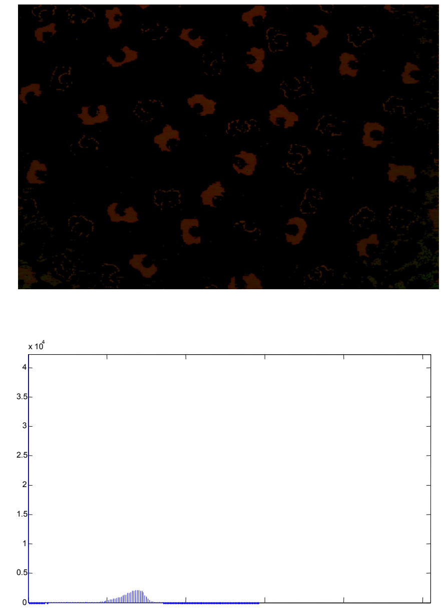


Fig. 6: Histogram For purple Objects

Those objects contain magenta color are segmented and shown in fig 7with histogram:

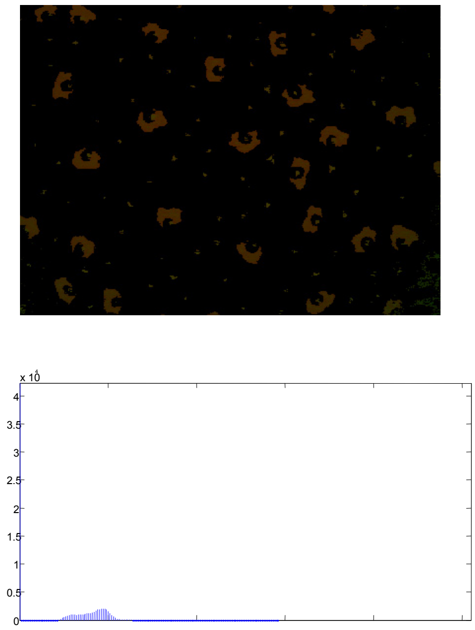
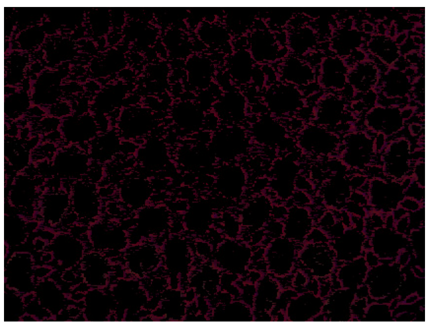


Fig. 7: Histogram for Magenta Object

Those objects contain yellow color are segmented and shown in fig 8with histogram:



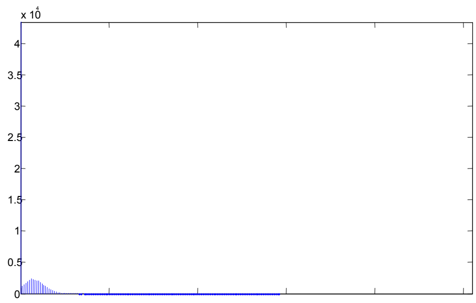


Fig. 8: Histogram For yellow Objects

4. Conclusion

Segmentation is a collection of methods allowing interpreting spatially close parts of the image as objects. From many decades, image segmentation is implemented using many techniques like PSO, GA, clustering techniques etc. BBO is uniquely a biogeography technique used for implemented image segmentation which provide more accurate segmented image as compared to other evolutionary algorithm. BBO is a population-based optimization algorithm and it does not involve reproduction or the generation of "children."

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