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A New Evolutionary Algorithm developed for Global Optimization (BBO)

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ABSTRACT: Biogeography based optimization (BBO) is a type of evolutionary algorithm. It is a population based optimization algorithm and provides clarification about the changing distribution of all species in different environment with time. Biogeography-based Optimization (BBO) is a new intelligent optimization algorithm, which was developed by the simulation of the migration of biological organisms on the basis of an overall analysis of the activities in colonial organisms. More and more researchers have focused on BBO due to its unique search mechanism and good optimization performance. BBO is an evolutionary process that achieves information sharing by species migration. 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, clustering algorithms, GA, ABC etc. This paper elaborates BBO approach for image segmentation i.e. partitioning an image into multiple segments.

KEYWORDS**:** Biogeography based optimization, Segmentation, Clustering, Region Growing, Evolutionary algorithms, Optimization

1. BASIC INTRODUCTION

Evolutionary algorithms (EAs) have been introduced to solve complex optimization problems. Some well-established and commonly used EAs are genetic algorithms (GAs), ant colony optimization, and particle swarm optimization. Each of these methods has its own characteristics, strengths, and weaknesses. Biogeography-based optimization (BBO) is a new EA developed for global optimization. This stochastic EA was introduced by Simon in 2008 and demonstrated good performance on various benchmark functions and a real-world sensor selection problem. It is expected to become a desirable method for solving complex problems once its true potential and merits has been explored and once it has successfully been applied to more practical cases. BBO is an application of biogeography to EAs. It is modeled after the immigration and emigration of species between habitats to achieve information sharing. One characteristic of BBO is that the original population is not discarded after each generation. It is rather modified by migration. Also, for each generation, BBO uses the fitness of each solution to determine its emigration and immigration rate.

2. IMAGE SEGMENTATION

"Segmentation**"** refers to the process of dividing a digital image into multiple segments such as a sets of pixels, also known as superpixels (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 are 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

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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. 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 neighboring pixels of initial "seed points" and determines whether the pixel neighbors should be added to the region (Yu and Clausi, 2007). 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 is given below in Fig. 1

Original Image Segmented Image

Fig. 1 An Example of Image segmentation

2.1 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
- Traffic control systems
- Brake light detection
- Machine vision
- Agricultural imaging – crop disease detection.
- Medical imaging
  - Locate tumors and other pathologies
  - Measure tissue volumes
  - Computer-guided surgery
  - Diagnosis
  - Treatment planning
  - Study of anatomical structure

3. Biogeography-Based Optimization

Biogeography-Based Optimization is a type of evolutionary algorithm. As its name implies, Biogeography is the study of the migration, speciation, and extinction of species. Biogeography has often been considered as a process that enforces equilibrium in the number of species in habitats(D. Simon,2011).Moreover it defines as the study of the distribution of animals and plants over time and space.HSI is a measure of the goodness of the solution which is represented by the habitat, which is also called fitness (Haiping Ma,2010),it represent that high value of HSI means large number of species and low value of HSI means less number of species in habitat.BBO has demonstrated good performance on various unconstrained and constrained benchmark functions (Du et al., 2009; Ergezer et al., 2009; Ma and Simon, 2010). The species model of a single habitat is shown below in Fig. 2

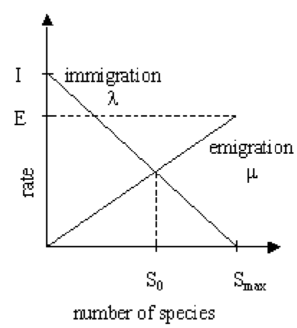

Fig.2. Species model of a single habitat containing number of species

Fig.2 illustrates a model of species abundance in a single habitat. The immigration rate λ and the emigration rate μ are functions of the number of species in the habitat. In immigration curve, maximum possible immigration rate I to the habitat occurs when there are zero species in the habitat. As the number of species increases fewer species are able enter to the habitat and the immigration rate decreases. The largest possible number of species in habitat Smax is at which point the immigration rate becomes zero. For emigration curve, if there are no species in the habitat then the emigration rate must be zero. As the number of species increases more species are able to leave the habitat and the emigration rate increases. The maximum emigration E rate occurs when the habitat contains the largest number of species. The equilibrium number of species is So at which point the immigration and emigration rates are equal. Each individual has its own λ and μ and are functions of the number of species *K* in the habitat and is expressed by equation (1) and (2).

$\lambda = I\,(1-K/n)$ …………………………… (1)
$\mu = E/n$ ……………………………… (2)

Where k is the number of species of the k-th individual;
n is the maximum number of species.
E is Maximum emigration rate and
I is Maximum immigration rate.
λ = the probability that the immigrating individual's solution feature is replaced.
μ = the probability that an emigrating individual's solution feature migrates to the immigrating individual

3.1 Immigration and Emigration

Biogeography based optimization (BBO) is type of evolutionary algorithm which involves the methodology of modifying a system in order to make some aspect of it work more efficiently. It is the process that achieves information sharing by species migration. It works on principle of immigration and emigrations of species to achieve information sharing.

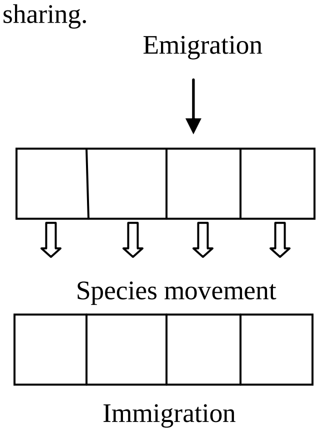

Fig.3 illustrates emigration and immigration of species. The process of species leaving the habitat is called emigration. The process of entering the species in particular habitat is called immigration.

Further 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 modeled 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 has a high species immigration rate because of their sparse populations. LSI habitats are more dynamic in their species distribution than HSI habitats.

3.2 BBO Important Key Factors

a) Migration
The BBO migration strategy in which we decide whether to migrate from one region to other or not.The migration rates of each solution are used to probabilistically share features between solutions. 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).

b) Mutation
Mutation is a probabilistic operator the randomly modifies a solution feature. The purpose of mutation is to increase habitat among the population. For low value solutions, mutation gives them a chance of enhancing the quality of solutions, and for high fitness value solutions, mutation try to improve the value as compared to the previous value.

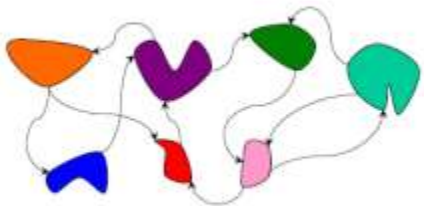

Fig.4 Migration of spice (Simon, 2008)

4. Some of the distinctive features of BBO

First, Biogeography-Based Optimization is a type of evolutionary algorithm. As its name implies, Biogeography is the study of the migration, speciation, and extinction of species. 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 neighbors 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.

5. METHODOLOGY

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., Kmeans, 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 started 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. HIS have a low species immigration rate because they are already nearly saturated with species. Therefore, HIS habitats are more static in their species distribution than LSI habitats. LSI has 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 it's migrate to other region, otherwise its make its own region.

6. IMPLEMENTATION & DESIGN

For implementing BBO approach for image segmentation firstly we take RCB image, and then convert it into Lab image as shown below Fig. 5. Then we segmented the objects in image and make different clusters. Those objects contain red objects are shown in Fig 6.

Fig. 5 Lab Image

Fig. 6 Red objects

Image Segmentation is one of the important aspects of Digital image processing. Color Image Segmentation is a process of extracting the image domain from one or more connected regions satisfying uniformity criterion which is based on features derived from spectral components. The image first considered is a color image; color image is taken because this image is further divided into different color spaces. Lab color model are widely used in this algorithm. The flow chart of this algorithm is shown in below Fig. 7. RGB image is taken as an input, which is an image of colorful fabric that consists of five different colors.

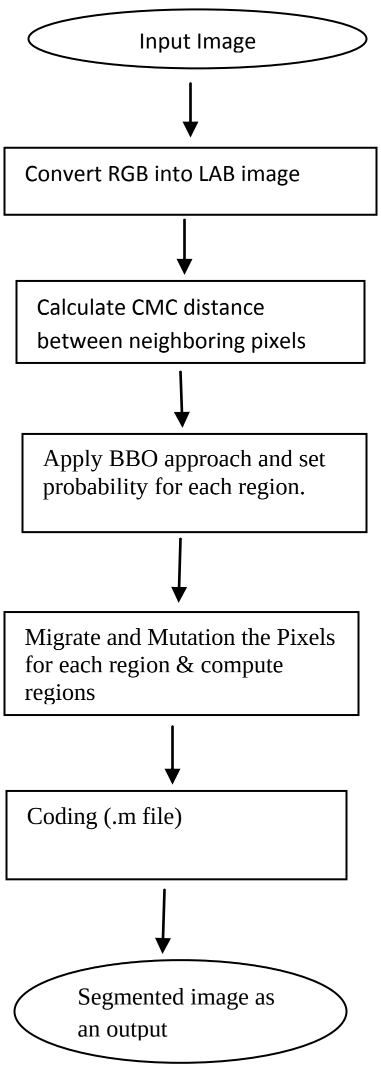

Figure 7: Flowchart of Proposed Work

The L*a*b* color space enables to visual stimulus RGB image is taken as an input, which is an image of colorful fabric that consists of five different colors. The L*a*b* color space enables to quantify these visual colors. The L*a*b* space consists of a luminosity 'L*' or brightness layer, chromaticity layer 'a*' indicating where color falls along the red-green axis, and chromaticity layer 'b* indicating where the color falls along the blue-yellow axis. Each color marker has an „a*' and a 'b*' value. To classify each pixel in the image by calculating the Euclidean distance between that pixel and each color marker. The smallest distance tells that the pixel most closely matches that color marker. **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.

7. CONCLUSION & FUTURE SCOPE

Color images allow for more reliable Image Segmentation than for gray scale images. As concluded, Biogeography Based Optimization is more reliable and fast search algorithm for Image Segmentation purposes. Biogeography Based Optimization generally results in better optimization results than the Genetic Algorithm for the problems that we investigate. Biogeography based Image Segmentation produce different cluster of different color at low migration rate with higher computational time. Biogeography Based Optimization is therefore a generalization of Genetic Algorithm. Due to its non-uniform immigration rate, Biogeography Based Optimization can be viewed as including additional **selection pressure** that is missing from Genetic Algorithm. 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."**For the future work** the Image Segmentation techniques or noise removal methods can be improved, so that the input image to be extracted could be made better which can improve the final outcome.

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