Image Segmentation Using Biogeography Based Optimization (BBO)

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Abstract- Image segmentation is an important problem in computer vision to completely understand the image for better results, i.e., identification of homogeneous regions in the image and has been the subject of considerable research for over the last three decades. Many algorithms have been elaborated for this purpose. This paper elaborates two algorithms one is global optimization method Biogeography Based optimization for automatically grouping the pixels of an color image into disjoint homogeneous regions and the other is clustering method Fuzzy K-means algorithm for reducing the computational complexity of image. And then comparison between both the techniques is calculated. In this purposed work these two algorithms are applied to image and performance is evaluated on the basis of computational time. Fuzzy K-means produces results which require more computational time than Biogeography based optimization. Therefore, comparison shows that Biogeography Based Optimization is more reliable and faster approach for image segmentation than Fuzzy K-means clustering algorithm.

Keywords- *Image Segmentation, BBO, Fuzzy K-means.*

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I. INTRODUCTION

"Segmentation" is the process of dividing a digital image into multiple segments such as a set of pixels, also known as super pixels. The main objective of segmentation is to simplify and 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 allows spatially partitioning close parts of image as objects [1]. "Image segmentation" is a very important aspect of digital image processing. Image segmentation may be defined as a process of assigning pixels to homogeneous and disjoint regions which form a partition of the image that share certain visual characteristics. It basically aims at dividing an image into subparts based on certain features. Features could be based on certain boundaries, contour, color, intensity, or texture pattern, geometric shape or any other pattern. Image segmentation is used to locate and find objects and boundaries in image. 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 pixel of initial "seed point" and determines whether the pixel neighbors should be added to the region [1].

Biogeography Based Optimization:

Biogeography Based Optimization is a type of evolutionary algorithm. As its name implies, BBO is based on mathematical study of biogeography. Biogeography is the study of the distribution of animals and plants over time and space. BBO is an evolutionary process that achieves information sharing by species migration. It is modeled after the emigration and immigration of species between habitats to achieve information sharing. BBO operates by migrating information between individuals, thus resulting in a modification of existing individual. Individual do not die at the end of generation. One such characteristic of BBO is that original population is not discarded after each generation rather it is modified by migration [3].

BBO is a population based optimization algorithm it does not involve reproduction or the generation of "offspring". In 1960, the first mathematical equations were discovered and developed that govern the distribution of organisms. Therefore, mathematical model of biogeography describe how species migrate from one island to another, how species arise and how species become extinct. Biogeography technique is based basically on two criteria-HSI and LSI. Geographical area that are well suited and more compatible residence for biological species are said to have highly suitability index (HSI). Features that correlate with HSI include factors such as rainfall, diversity of vegetation and topographic features, land area and temperature. The variables that are characterized habitability are called suitability index variables (SIV). Habitat with HSI tends to have large number of species, while those with LSI have a small no of species. HSI are more static than LSI. LSI has a high species immigration rate because of their scattered population [2].

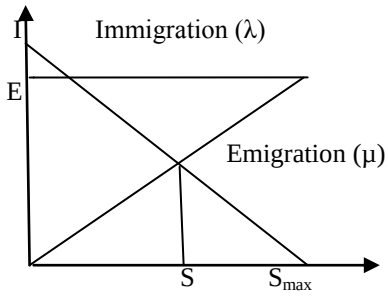

Fig. 1:-Species model of a single habitat containing number of species

Fig. 1 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, the maximum possible rate to the habitat is I, which occurs when there are zero species in the habitat. By increasing the number of species the habitat will become more congested and accordingly fewer species will be able to adapt immigration to the habitat and therefore immigration rate decreases. The largest possible number of species in habitat S_{max} is at which point the immigration rate becomes zero. Now if there are no species in the habitat then the emigration rate of that habitat will be zero. As the number of species increases more species are able to leave the habitat and the emigration rate increases. The equilibrium stage occurs when S_o occurs when immigration rate and emigration rate are equal.

BBO depends on following two theories:-

Migration:-The BBO migration property states that whether to migrate from one region to other or not. The migration rates of each solution are used to probabilistically share features between solutions. Migration in BBO is an adaptive process; it is used to modify existing islands. Migration stage arises when LSI occurs. When species are less compatible with their habitat then they migrate (Simon 2008).

Mutation:-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.

Fuzzy K-means clustering:

Fuzzy K-means clustering is basically a partitioning method applied to analyze data and treats observations of the data as objects based on locations and distance between various input data points. Partitioning the objects into mutually exclusive clusters (K) is done by it in such a fashion that objects in other clusters remain as close as possible to each other but as far as possible from objects in other clusters. Each cluster is characterized by its centre point i.e. centroid. The distances used in clustering in most of the times do not actually represent the spatial distance. In a dataset, a desired number of clusters K and set of K initial starting points, the K- means clustering algorithm find the desired number of distinct clusters are their centroids. A centroid is a point whose co-ordinates are obtained by means of computing the average of each of the co-ordinates of the points of samples assigned to the clusters [8].

The fuzzy K-means clustering algorithm is a special case of the generalized fuzzy K-means clustering algorithm scheme, where point representatives are adopted and the Euclidean distance is used to measure the dissimilarity between a vector X and its cluster representative. The fuzzy K-means clustering (FKM) algorithm performs iteratively the partition step and new cluster representative generation step until convergence. This algorithm is one of the most common methods of clustering which starts with a set of K reference points and data points belong to K cluster based on distance criteria [9].

II. PURPOSED METHODOLOGY

Firstly, image segmentation is done through BBO and then it is applied to Fuzzy K-means clustering algorithm. So, the purposed algorithm for both techniques is as discussed below:-

Purposed Algorithm for BBO:-

Step1:- Take a medical image and convert it into Lab image.

Step 2:- Apply optimization technique BBO and clustering technique on the medical image.

Step 3:- Select the optimum value of population size, fitness element and immigration rate in BBO. Initialize the BBO parameters.

Step 4:-Select lambda using BBO in segmentation. Calculate contour point and fitness value in segmentation.

Step 5:-Calculate elapsed time using BBO technique. Go to step (3) for next iteration. This loop can be terminated after a predefined number of generations or after an acceptable problem solution has been found.

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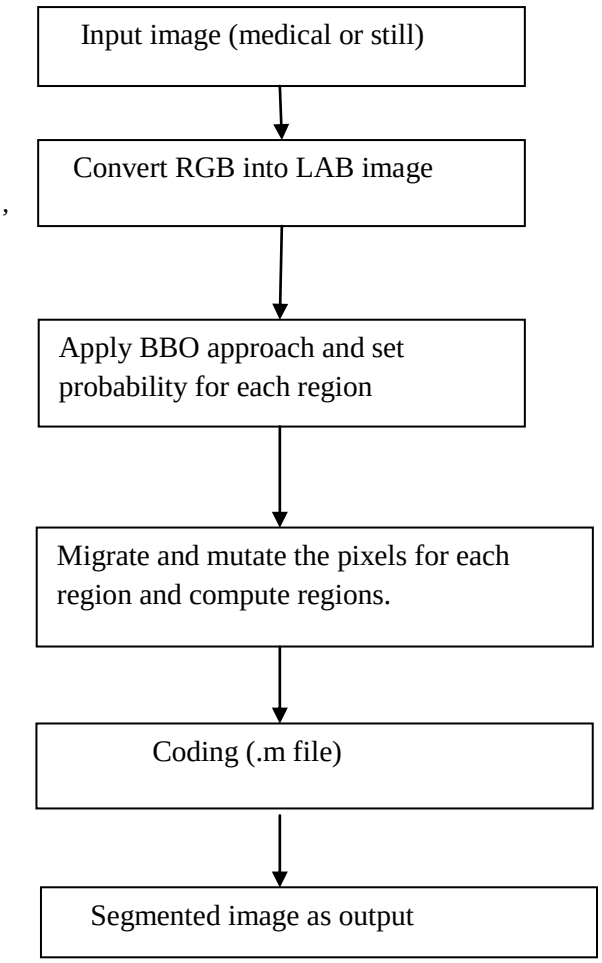

Fig. 2:-Flowchart of purposed work

Purposed algorithm for Fuzzy K-means:-

Fuzzy K-means algorithm is one of the most important clustering algorithm. In this algorithm, the samples are first divided into two or more clusters and the number of clusters has already been specified. In Fuzzy K-means clustering algorithm the main function is:-

$$j = \sum_{i=1}^{c}\sum_{k=1}^{n} U_{ik}^{m} d_{ik}^{2} = \sum_{i=1}^{c}\sum_{k=1}^{n} U_{ik}^{m} \ \|x_k - v_i\|^2 \quad (1)$$

In formula 1: m is a real number which is bigger than 1 where X_k is the k^{th} sample, V_i is the centre of cluster and n is the number of samples. U_{ik} shows the dependency of i^{th} sample in k^{th} cluster. $\|x\|$ is determined the similarity of samples (distance) from the centre of the cluster[11].

Step 1:-Set K-To choose a number of desired clusters, K.

Step 2:-Initialization-To choose k starting points which are used as initial estimates of the cluster centroids. They are taken as the initial starting values.

Step 3:-Classification-To examine each point in the dataset and assigning it to the cluster whose centroid is nearest to it.

Step 4:-Centroid calculation-When each point in the dataset is assigned to a cluster, it is needed to recalculate the new k centroids.

Step 5:-Convergence criteria-The steps (3) and (4) are repeated until no point changes its cluster assignment.

III. RESULTS AND DISCUSSIONS

In this purposed method two algorithms are presented to reduce the computing time taken to segment the image. Firstly, medical image is segmented using BBO optimization technique and then Fuzzy K-means is applied to the same image. After that two techniques are compared on the basis of time and then time elapsed to segment the image is calculated. The purposed work clearly shows that BBO gives results faster as compared to Fuzzy K-means on the basis of time taken to segment the image. Following results are shown with original image and segmented images.

Fig. 3:-Original image of head.

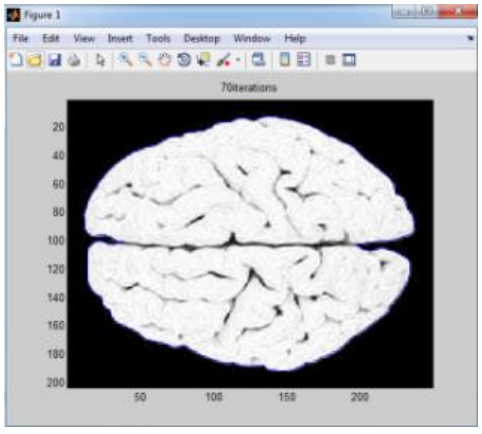

Fig. 4:-Segmented image at 70^{th} iterations after applying BBO algorithm.

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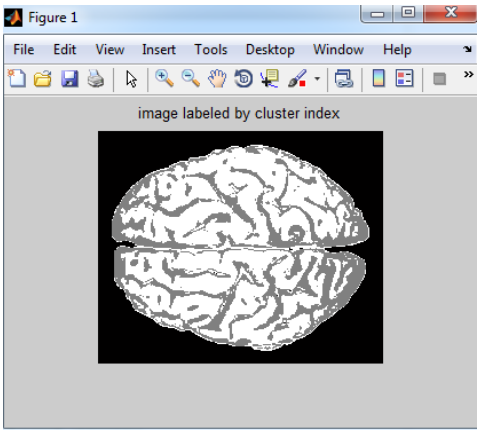

Fig. 5:-Image labeled by cluster index after applying FKM algorithm.

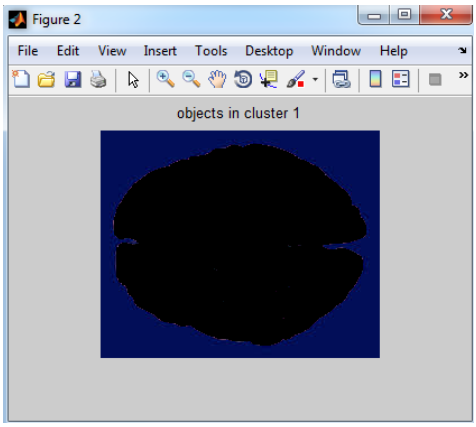

Fig. 6:-Image showing objects in cluster 1

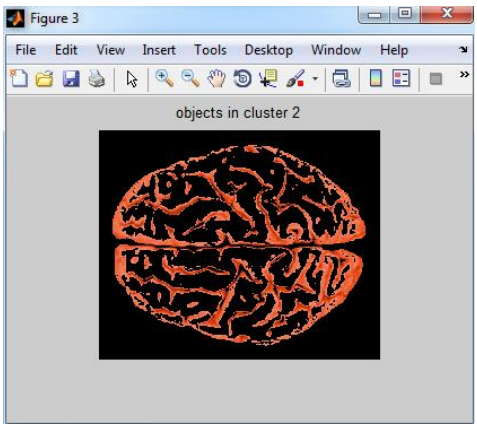

Fig. 7:-Image showing objects in cluster 2

Figure.3 shows the original image of head and figure.4 shows segmented images of head after applying BBO technique at 70th iteration. Figure.5 shows the cluster index of image after applying FKM algorithm. Figure.6 and 7 shows the segmented image in cluster 1 and 2 respectively. To further evaluate the versatility of purposed method, different medical images are taken as example and are subjected to above discussed methods. The following comparative table clearly shows that BBO provides faster results than Fuzzy K-means.

Table I:-Compared time elapsed results using both techniques

Input Images	Time taken to segment image in seconds	
	BBO	Fuzzy K-means
Head.jpg	4.25	5
Brain.bmp	3.3	4.12
Twocells.bmp	9.83	11.49

IV. CONCLUSION

As concluded from the results BBO is more reliable and fast search algorithm for image segmentation purpose. BBO plays an important role in enhancing the quality and contrast of natural images. BBO is a better technique to detect abnormal growth of tissues as compared to other techniques. BBO is a population based algorithm and it does not involve reproduction or the generations. Segmentation is a collection of methods allowing interpreting close parts of the image as objects. BBO takes less time and provides more accurate segmented image when compared with Fuzzy K-means algorithm. So in future, BBO can be used in medical image segmentation to detect objects. Further image segmentation techniques or noise removal methods can be improved so that the input image to be extracted could be made more efficient which can improve the final outcome.

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