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Multi-Level Colour Image Segmentation Using Differential Evolution

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Abstract - *Image segmentation is an indispensable component in many image analysis and computer vision tasks. It partitions the whole image into many regions in order to identify a particular object in a given image. In this paper, Differential Evolution (DE) algorithm is applied for multilevel colour image segmentation. Inter cluster variance is used as fitness function in order to find the better chromosome for the next generation. The results show that the Differential evolution algorithm is able to produce better segmentation result with dataset of images consisting of distinct colours.*

Key Words: Differential Evolution, Colour Image Segmentation, Distinct Colours, Thresholding, Inter Cluster Variance

1.INTRODUCTION

Segmentation is an important step in the process of image analysis. Different research prospects have paved their way towards the field of Digital Image Processing. Processing digital image with the help of digital computers is called Digital Image Processing [1, 2]. Image acquisition, enhancement of the acquired images, restoring the images, feature extraction and feature selection from the images are some of the basic steps in digital image processing.

Image Segmentation is one of the most important procedures that is required for processing an image[3,4]. This particular technique paves the way as a stepping stone for analyzing the particularities of an image. High-level image processing requires segmentation as one of the key step. Normally for analyzing an image for any application, Image segmentation is the basic procedure that has to be carried out in order to move with the further steps like feature selection and feature extraction.

Image Segmentation can be done for both Gray-scale images and Colour images. In this paper, segmentation has been done for color images that have distinct colour features. The final result is a segmented image where we can see the partition between the different colors present in the image.

Color Image segmentation is very important in image processing because if we want to analyze what is inside the image or take a deeper look at the image for examining it, then this process plays an indispensable role for making everything possible. This paper aims in providing optimal solution in terms of accuracy and time complexity for segmenting an image which is the initial move of every application.

In literature, Differential Evolution gives better result among other meta-heuristics algorithms [5,6,7,8] for different applications. Many researchers have combined metaheuristic algorithms with machine learning algorithms and some researchers have used multi objective optimization algorithm to segment a particular region in an image [9-17]. Devi et al [18] has done a survey related to image segmentation using Metaheuristic algorithms. Literature reveals that Metaheuristic algorithms such as Genetic algorithm [8], Differential Evolution [19], Memetic Algorithms [20,21,22,23] has been done for many applications such as Image compression [24] Image segmentation and the like.

From the papers that have been studied, it has been inferred that most of the Colour-Image Segmentation problems carried out in the past decade had been using the Fuzzy Clustering approach, Histon based Multi-thresholding, Support Vector Machine and some of the other traditional approaches like K-Means Clustering and Watershed Algorithm. By using these techniques it has been studied that most of the authors have put maximum effort to give an Optimized solution to best of their knowledge. The main drawbacks of the above discussed algorithms are (i) The algorithms are data dependent (ii) The algorithm relies on the inceptive conditions which may cause the algorithm to meet to subprime solutions. These drawbacks can be overcome by using Differential Evolution for multilevel thresholding.

The main objective of this paper is to provide an efficient, robust image segmentation technique using Differential Evolution algorithm. The prime motive of this paper is to create a robust algorithm that is used for segmentation of natural images. One of the advantages of using Differential Evolution Algorithm over other traditional algorithm is that it avoids Noise, Low time complexity and is more accurate. And also to gather the various types of natural images, process them and cluster them based on the colors using differential evolution.

2. Multilevel Colour Segmentation using DE

Differential Evolution (DE) is a promising population based algorithm for solving global optimization problems. It directs the search process by taking

information from the current population. The following paragraphs show the step by step procedure of multi-level segmentation using differential evolution algorithm.

2.1 Population Initialization

Here cluster size (k) and number of chromosomes (n) are given as input to the algorithm. The algorithm uses Random function to create Random pixels around the desired image. Finally, it returns the output in matrix format representation (p x k matrix). An example is shown here for the input cluster size k is 3 and the number of chromosomes n =3. The random values are generated between 0 to 256.

$$Population = \begin{pmatrix} 45 & 165 & 211 \\ 32 & 147 & 250 \\ 87 & 172 & 236 \end{pmatrix}$$

2.2 Fitness Value Calculation

DE uses Inter cluster Variance as a fitness function for this application. The algorithm calculates Euclidean distance between two clusters in the generated population. Variance is calculated for all the randomly generated population. And the variance whose value is less among all is taken as optimized variance. Algorithm 1 gives the pseudo code for calculating the fitness value.

Algorithm 1: Fitness value Calculation

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for each chromosome *do*
Traverse through the entire image and compare every pixel with the values in a chromosome
Calculate the Euclidean distance between each pixel and the values in a chromosome
if the Euclidean distance is minimum
Assign the pixel to that centroid
end if
Calculate the Inter-cluster Variance
end for

2.3 Applying Differential Evolution for Multilevel Colour Segmentation

In third module, the calculated fitness value is given to Differential Evolution, it performs mutation, cross-over and finally the image is segmented in the most efficient way and also with low time complexity. The accuracy and performance will be optimized because of the usage of DE. Algorithm 2 shows the pseudo code for DE algorithm and it is adapted from [8,22]. Figure 1 shows the flow diagram for multilevel thresholding using differential evolution algorithm.

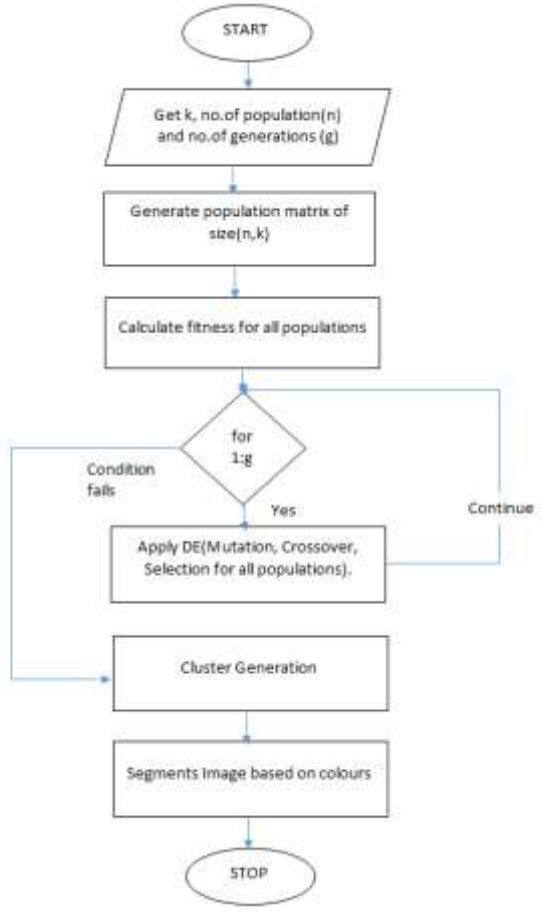

Fig-1 Multi-level segmentation using DE - Flow diagram

Algorithm 2: Differential Evolution Algorithm (taken from [18, 22])

Initialize the population randomly;
Evaluate the chromosomes;
While maximum generation not reached *do*
For each chromosome *do*
Select the target chromosome;
Choose three chromosomes in the population randomly;
Compute the mutant chromosome;
Perform crossover between the target and mutant chromosomes to form trial chromosome;
Evaluate the trial chromosome;
Replace target chromosome by trial chromosome if unfitness value of trial chromosome is smaller than target chromosome;
End for
End while
Return best chromosome;

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3. Experimental Results

The algorithm is realized using MATLAB with test images taken from Berkeley segmentation database **BSDS300** shown in figures 2 to 4. The Parameter setting for the DE simulation is given in Table 1.

Table 1: DE Simulation parameters

Parameter	Values
Population Size	20
Crossover Probability	0.8
Scaling Factor	0.4
Generations	50

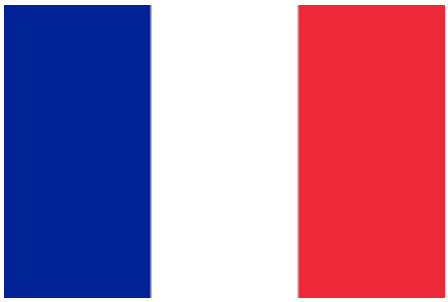

Fig -2: Sample image (i)

Fig 3: Sample image (ii)

Fig 4: Sample image (iii)

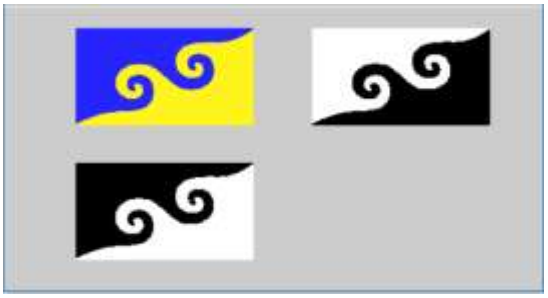

Fig 5: Output of image (i) in BSDS300

In figure 5, it is seen that the given image has two colours yellow and blue. The next shows the image that has been clustered according to one colour which is yellow and that region is shaded as black. In the same way the next colour blue is clustered and shaded as black. These are results for a single image that has been segmented based on two colours.

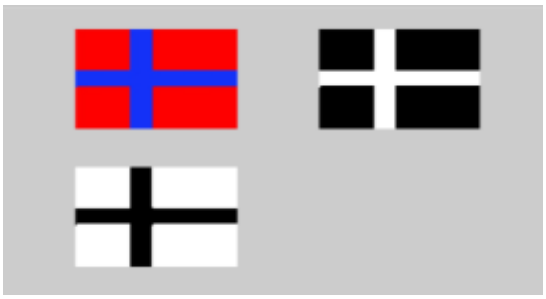

Fig 6: Output of image (ii) in BSDS300

Fig 7: Output of image (iii) in BSDS300

In figure 6, it is seen that the given image has two colors red and blue. The next shows the image that has been clustered according to one colour which is red and that region is shaded as black. In the same way the next colour blue is clustered and shaded as black. These are results for a single image that has been segmented based on two colors.

In figure 7, it is seen that the given image has four colours red, black, white and green. The next shows the image that has been clustered according to one colour which is red and that region is shaded as black. In the same way the next colour green is clustered and shaded as black and the same follows. These are results for a single image that has been segmented based on three colours.

4. CONCLUSION

In this paper, a differential evolution is applied for multilevel colour image segmentation. The experimental results show that the Differential evolution algorithm is able to produce better segmentation result with dataset of images consisting of distinct colours. However, the accuracy and performance in segmenting is depending upon various parameters like randomness of population generated, fitness calculation and the mutation procedures undertaken. Also the output will vary according to the input for the number of clusters (k) and the number of generations also plays a major role for the final result to be obtained. As a future work, the knowledge about the image can be incorporated in differential evolution algorithm to improve the search process.

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