Chapter 4
Multilevel Image Segmentation Using Modified Particle Swarm Optimization

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ABSTRACT

Particle Swarm Optimization (PSO) is a well-known swarm optimization technique. PSO is very efficient to optimize the image segmentation problem. PSO algorithm have some drawbacks as the possible solutions may follow the global best solution at one stage. As a result, the probable solutions may bound within that locally optimized solutions. The proposed chapter tries to get over the drawback of the PSO algorithm and proposes a Modified Particle Swarm Optimization (MfPSO) algorithm to segment the multilevel images. The proposed method is compared with the original PSO algorithm and the renowned k-means algorithm. Comparison of the above mentioned existing methods with the proposed method are applied on three real life multilevel gray scale images. For this purpose, three standard objective functions are applied to evaluate the quality of the segmented images. The comparison shows that the proposed MfPSO algorithm is done better than the PSO algorithm and the k-means algorithm to segment the real life multilevel gray scale images.

INTRODUCTION

The process of segregating a digital image into more than one meaningful regions or segments is known as image segmentation. The characteristics of the pixels in a single segment of an image have the same attributes though the attributes of the pixels in different segments are characteristically different to each other. The basic attributes of an image are color, shape, texture, position and similarity/dissimilarity between the regions. The objective of the image segmentation is to represent a digital image into meaningful and easy to understand components, so that any user can able to analyze that image. Image segmentation

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is considered as a preliminary step in different types of image processing, moving and non-moving video related applications. The application areas of image segmentation are very much wider, like satellite image processing, machine vision, remote sensing, medical imaging, biometric measurement, feature extraction, object recognition, etc. to detect, recognize or track an object. The multiplicity of objects in a digital image and huge variation between them are the major challenges in the segmentation process. Different types of classical and non-classical image processing application are employed to handle the image segmentation problem.

Edge detection and region growing, thresholding, normalized cut, etc. are different types of classical image segmentation techniques to segment the multilevel gray scale images. The segmentation of the images by the detection of the object boundaries in that image is the main characteristics of the edge detection image segmentation algorithms. But an incorrect segmentation may be caused by this edge detection algorithms as these processes are not helpful for segmenting the blur images or any complicated images. Region growing techniques are not efficiently employed for multilevel image segmentation as the different regions of an image is not well segregated. The histogram of an image plays a vital role in image segmentation by thresholding techniques. The segmentation of an image that have the distinctive objects and the background is very much helpful using the thresholding techniques. This process may fail when the distribution of the pixels in the image are very much complex.

It has been observed that most of the real world problems can be devised as an optimization problem. Traditional heuristic algorithms are designed to solve differentiable functions. As most real world optimization problems are non-differentiable, it is too difficult to find a heuristic algorithm which will properly work on non-differentiable optimization functions. Many meta-heuristic approaches have been developed to solve non-differentiable optimization functions. Recently, meta-heuristic algorithms are becoming more attractive and useful tools to the researchers. Evolutionary algorithms (EAs) are the metaheuristic type of algorithms and they are effective enough to solve the problem of clustering. Genetic algorithms, differential evolution, particle swarm optimization, etc. are the example of evolutionary algorithms. The functional characteristics of these type of algorithms are inspired by the principle of natural genetics.

Particle Swarm Optimization (PSO), developed by Eberhart and Kennedy in 1995, is one of the population based meta-heuristic optimization technique imitating social behavior of bird flocking or fish schooling (Kennedy, 1995). The PSO algorithm is very much popular as this algorithm converges very quickly and easy to implement. The PSO algorithm is also known as an important evolutionary algorithm. Like any other evolutionary algorithms, PSO algorithm stores the fitter solutions with respect to a particular problem and the performance of a problem improves by upgrading the entire populations instead of the individual solution.

Basically, the PSO algorithm is applied to find out the best possible solution of a problem and the best solution is noted as the g_{best} solution. This best solution in each iteration of the PSO algorithm guides to get the ultimate solution of the problem. It is usually happened that the probable solutions in different iterations may follow the global solution. It may be possible that a solution in other region may give better result. Ultimately, the diversity of the probable solutions are lost as the solution may follow the global best solution. This problem can be solved if the diversity of the probable solutions are maintained. This chapter proposes a modified version of particle swarm optimization (MfPSO) algorithm to segment multilevel gray scale images into different segments. The proposed MfPSO algorithm tries to overcome the said problem of the PSO algorithm. For that reason, the proposed algorithm tries to modify the velocity updation formula of the particles in the original PSO algorithm. The proposed method is compared with the basic PSO method as well as with the well-known *k*-means algorithm to establish its efficiency.