Chapter 5
Multilevel Image Segmentation by a Multiobjective Genetic Algorithm Based OptiMUSIG Activation Function

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ABSTRACT

The proposed chapter is intended to propose a self supervised image segmentation method by a multi-objective genetic algorithm based optimized MUSIG (OptiMUSIG) activation function with a multilayer self organizing neural network architecture to segment multilevel gray scale intensity images. The multiobjective genetic algorithm based parallel version of the OptiMUSIG (ParaOptiMUSIG) activation function with a parallel self organizing neural network architecture is also discussed to segment true color images. These methods are quite efficient enough to overcome the drawbacks of the single objective based OptiMUSIG and ParaOptiMUSIG activation functions to segment gray scale and true color images, respectively. The proposed multiobjective genetic algorithm based optimization methods are applied on three standard objective functions to measure the quality of the segmented images. These functions form the multiple objective criteria of the multiobjective genetic algorithm based image segmentation method.

INTRODUCTION

Image segmentation (Jahne, 1993; Jain, 1989) is a basic and important technique of segregating an image space into multiple non-overlapping meaningful homogeneous regions. The process of image segmentation is executed based on the principle that each of the pixels in a region is similar to the other with respect to some characteristics, such as, color, intensity or texture. The objects in the image usually have a strong correlation with the regions of the segmented image. The resultant segmented image signifies that each

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object is labeled in such a way that facilitates the description of the original image so that it can be interpreted by the system that handles the image. Some *a priori* knowledge or/and presumptions about the image are usually needed to determine which are the features that can lead to successful classification. Most of the image segmentation algorithms yield segmentation of different objects with respect to the image background. Different classical image processing application is quite handy with these types of image segmentation algorithms but it is not acceptable for applications dealing with more complex scenes, where several objects have to be detected.

In this chapter, we propose a method capable to perform multilevel image segmentation of the gray scale images as well as true color images. Ghosh *et al*. (Ghosh, 1993) proposed a single multilayer self organizing neural networks (MLSONN) that has the capability to extract the binary objects from a noisy binary image scene by applying some fuzzy measures of the outputs in the output layer of the network architecture. The standard backpropagation algorithm is applied to adjust the network weights with a view to derive a stable solution. The main drawback of this network architecture is that multilevel objects cannot be extracted with this network architecture since it is characterized by the generalized bilevel/bipolar sigmoidal activation function. This problem is handled by Bhattacharyya *et al*. (Bhattacharyya, 2008) by incorporating a functional modification of the MLSONN architecture. The introduced multilevel sigmoidal (MUSIG) activation function is applied for mapping multilevel input information into multiple scales of gray. The single MLSONN architecture is induced with the multiscaling capability by the MUSIG activation function as this activation function is a multilevel version of the standard sigmoidal function. The different transition levels of the MUSIG activation function is determined by the number of gray scale objects and the representative gray scale intensity levels. However, the approach assumes that the information contained in the images are homogeneous in nature, which on the contrary, generally exhibit a varied amount of heterogeneity. The pure color images can be extracted from a noisy color image background using the parallel version of the MLSONN (PSONN) architecture (Bhattacharyya, 2003; Bhattacharyya, 2007) which consists of three independent and parallel MLSONNs. The individual MLSONNs of the PSONN are applied to process the individual color components. The MLSONN architecture as well as the PSONN architecture uses the generalized bilevel sigmoidal activation function with fixed and uniform thresholding. Bhattacharyya *et al*. (Bhattacharyya, 2007) introduced a self supervised parallel self organizing neural network (PSONN) architecture guided by the multilevel sigmoidal (MUSIG) activation function for true color image segmentation. Since the utilized activation functions use fixed and uniform thresholding parameters, they assume homogeneous image information content. The optimized MUSIG (OptiMUSIG) activation function (De, 2010a) has been applied to segment multilevel gray level images by incorporating the heterogeneous information content in the MUSIG activation function. De *et al*. (De, 2010b) also proposed a method to apply the OptiMUSIG activation function to segment true color images. These methods may or may not generate a good quality segmented image as the segmentation criteria of these methods are based on single objective or single segmentation evaluation criterion.

In order to solve a certain problem in many real world situations, several incommensurable and competing constraints of that problem have to be optimized simultaneously. Usually, there will be a set of alternative solutions instead of a single optimal solution. These solutions are considered as optimal solutions so that no other solutions are superior to these solutions when all constraints are considered. The foremost problem considering multiobjective optimization (MOO) is that there is no accepted definition of optimum in this case

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