Chapter 11
Multilevel and Color Image Segmentation by NSGA II Based OptiMUSIG Activation Function

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ABSTRACT

A self-supervised image segmentation method by a non-dominated sorting genetic algorithm-II (NSGA-II) based optimized MUSIG (OptiMUSIG) activation function with a multilayer self-organizing neural network (MLSONN) architecture is proposed to segment multilevel gray scale images. In the same way, another NSGA-II based parallel version of the OptiMUSIG (ParaOptiMUSIG) activation function with a parallel self-organizing neural network (PSONN) architecture is purported to segment the color images in this article. These methods are intended to overcome the drawback of their single objective based counterparts. Three standard objective functions are employed as the multiple objective criteria of the NSGA-II algorithm to measure the quality of the segmented images.

INTRODUCTION

Basically, segmentation is the segregation of similar patterns out of dissimilar patterns. A basic and important technique of segregating an image space into multiple non-overlapping meaningful homogeneous regions is on the basis of some characteristics of the pixels, such as, color, intensity or texture, etc. The successful classification of the pixels in an image is done on the basis of the inherent features of that image and for that reason, some *a priori* knowledge or/and presumptions about the image are usually required (Das, Abraham, & Konar, 2008). Due to the variety of the gray scale and color intensity gamut,

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the problem of segmentation turns more severe for multilevel gray scale and color images. Different fuzzy techniques have been applied successfully for image segmentation as it is quite capable to deal with the varied amount of uncertainty, vagueness and imprecision in the real life images. Zhao *et al*. (Zhao, Fu, & Yan, 2001) proposed an entropy function in the search for fuzzy thresholding parameters by exploiting the relationship between the fuzzy *c*-partition and the probability partition. A spatially weighted fuzzy *c*-means (SWFCM) clustering algorithm is invented by Yang *et al*. (Yang, Zheng, & Lin, 2004). In this method, the global spatial neighboring information is used into the standard FCM clustering algorithm. A good literature survey of the color image segmentation using fuzzy logic is presented in the literature (Bhattacharyya, 2011). A color image segmentation algorithm named, eigen space FCM (SEFCM) algorithm, is efficient to segment the images that have the same color as the pre-selected pixels (Yang, Hao, & Chung, 2002).

Genetic algorithms (GAs) (Goldberg, 1989; Davis, 1991) are randomized search and optimization techniques guided by the principles of evolution and natural genetics. GAs are employed to solve the image segmentation problem without knowing the segmentation techniques applied and only require a segmentation quality measurement criterion due to generality of the GAs. Population generation, natural selection, crossover and mutation are applied over a number of generations for generating potentially better solutions. Alander (Alander, 2000) presented a complete survey of GA based image segmentation. A combined approach of genetic algorithm with the *K*-means clustering algorithm has been employed for image segmentation in (Li & Chiao, 2003). GA is applied in the unsupervised color image segmentation method as it executes multi-pass thresholding (Zingaretti, Tascini, & Regini, 2002) and the different thresholds are employed in different iterations of the genetic algorithm to segment a wide variety of non-textured images successfully. A three-level thresholding method for image segmentation on the basis of probability partition, fuzzy partition and entropy theory is presented by Tao *et al*. (Tao, Tian & Liu, 2003).

Neural networks are very much efficient for the processing of the images as neural networks have different important properties like high degree of parallelism, nonlinear mapping, ability of approximation, error tolerance etc. The segmentation of gray scale images as well as color images are quite efficiently handled by the neural network. Kohonen's self-organizing feature map (SOFM) (Kohonen, 1989) is a renowned and efficient competitive neural network due to its properties such as the input space approximation, topological ordering, and density matching (Chi, 2011). The utility of SOFM in the field of image segmentation, such as segmentation of printed fabric images, or in sonar images is fully accounted in (Xu & Lin, 2002; Yao *et. al*., 2000). Kohonen's SOFM in accordance with the hybrid genetic algorithm (HGA) is employed efficiently to segment the satellite images (Awad, Chehdi & Nasri, 2007). A fast convergent network named Local Adaptive Receptive Field Self-organizing Map (LARFSOM) is applied to segment color images efficiently (Arajo & Costa, 2009).

A single multilayer self-organizing neural networks (MLSONN) (Ghosh, Pal & Pal, 1993) is capable to extract the binary objects from a noisy binary image scene. In this network, the network weights are adjusted with a view to derive a stable solution using the standard backpropagation algorithm (Ghosh, Pal & Pal, 1993). The multilevel objects cannot be extracted with this network architecture since it is characterized by the generalized bilevel/bipolar sigmoidal activation function. A functional modification has been incorporated in the MLSONN architecture by Bhattacharyya *et al*. (Bhattacharyya, 2008, 2011). They introduced the multilevel sigmoidal (MUSIG) (Bhattacharyya, 2008, 2011) activation function that is employed for mapping multilevel input information into multiple scales of gray. The different transition levels of the MUSIG activation function is determined by the number of gray scale