Chapter 9
Quantum Inspired Swarm Optimization for Multi-Level Image Segmentation Using BDSONN Architecture

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ABSTRACT

This chapter is intended to propose a quantum inspired self-supervised image segmentation method by quantum-inspired particle swarm optimization algorithm and quantum-inspired ant colony optimization algorithm, based on optimized MUSIG (OptiMUSIG) activation function with a bidirectional self-organizing neural network architecture to segment multi-level grayscale images. The proposed quantum-inspired swarm optimization-based methods are applied on three standard grayscale images. The performances of the proposed methods are demonstrated in comparison with their conventional counterparts. Experimental results are reported in terms of fitness value, computational time, and class boundaries for both methods. It has been noticed that the quantum-inspired meta-heuristic method is superior in terms of computational time in comparison to its conventional counterpart.

INTRODUCTION

Image segmentation is one of the most important challenges encountered in the field of image processing (Gonzalez & Woods, 2002), which is crucial for image understanding and analysis to interpret its contents. The objective of image segmentation is to extract meaningful non-overlapping homogeneous regions from an image. The process of image segmentation is executed based on the principle that each of the pixels in a region is similar to other with respect to some characteristics such as intensity, texture

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or color. Segmentation can be carried out by several classical techniques, viz. histogram based, edge based, region based split/ merge techniques (Ho & Lee, 2001). Histogram based approaches are those in which pixels are classified using the histogram of the images according to their color intensity. Pixels representing marked intensity shifts are extracted and then linked into contours that represent object boundaries are offered in edge based approaches. These approaches offer low computational cost but on the other hand pose serious difficulties in setting the appropriate thresholds and producing continuous one-pixel-wide contours (Sahoo, 1988; Helterbrand, 1996). Region based approaches aim to detect regions satisfying a certain homogeneity criterion. This class includes region growing (Adams, 1994; Chang, 1994; Hojjatoleslami, 1998) and pyramidal methods (Rezaee, Van der Zwet, Lelieveldt, van der Geest, & Reiber, 2000) which are powerfull but may lead to an over segmentation. Split/merge approaches aim to overcome the problem of over segmentation by means of a two phase process. The first phase subdivides the original image into primitive homogeneous regions. The second one tries to get a better segmentation by merging neighboring regions which are judged similar enough (Chun, 1996; Bhandarkar, 1999).

The objects in an image usually have a strong correlation with the regions of the segmented image. The resulted segmented image 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. To determine which are the features that can lead to successful classification, *a priori* knowledge or/and presumption about the image are generally needed. Most of the image segmentation algorithm yield segmentation of different objects with respect to the image background.

Here both methods are capable to perform multilevel image segmentation of gray scale images. The soft computing approaches applied in this direction either resorts to a deterministic analysis of homogeneous intensity values of images or to an application of heuristic search and optimization techniques, though these techniques suffer from several degrees of random time complexity.

Swarm intelligence (Englebrecht, 2002), which takes inspiration from the social behavior of insects and other animals, is a relatively new computational approach to solve problems. In a PSO system, particles fly around in a multidimensional search space. During flight, each particle adjusts its position according to its own experience, and the experience of its neighboring particles, making use of the best position encountered by itself and its neighbors.

In particular, ants have inspired a number of techniques collectively known as ant colony optimization (Dorigo & Stutzle, 2005). Ant colony based algorithms are bio-mimetic evolutionary algorithms. These algorithms have parallel positive feedback mechanisms having advantages of parallelism, robustness and easy combination with other methods. The discreteness of parallelism of the ant colony based algorithms makes them potential candidates for digital image analysis and hence can be applied to image processing.

Quantum computing is a new field in computer science, which has emerged to offer a speed-up of the classical algorithms by inducing physical phenomena like interference, superposition, entanglement etc. (McMohan, 2008). The time complexity of quantum computing has been reduced, due to the utilization of parallelism present in *qubits* (quantum bits), the building blocks of quantum computer. The various approaches towards this direction can be classified as quantum algorithms and quantum inspired algorithms. There are so many features present in quantum computing like linear superposition, coherence and decoherence operators, interference, rotation gates entanglement etc. In this chapter we propose a quantum inspired ant colony optimization based optimized multilevel sigmoidal (OptiMUSIG) activa-