Chapter 1
Evaluating an Evolutionary Particle Swarm Optimization for Fast Fuzzy C-Means Clustering on Liver CT Images

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ABSTRACT
An Evolutionary Particle Swarm Optimization based on the Fractional Order Darwinian method for optimizing a Fast Fuzzy C-Means algorithm is proposed. This chapter aims at enhancing the performance of Fast Fuzzy C-Means, both in terms of the overall solution and speed. To that end, the concept of fractional calculus is used to control the convergence rate of particles, wherein each one of them represents a set of cluster centers. The proposed solution, denoted as FODPSO-FFCM, is applied on liver CT images, and compared with Fast Fuzzy C-Means and PSOFFCM, using Jaccard Index and Dice Coefficient. The computational efficiency is achieved by using the histogram of the image intensities during the clustering process instead of the raw image data. The experimental results based on the Analysis of Variance (ANOVA) technique and multiple pair-wise comparison show that the proposed algorithm is fast, accurate, and less time consuming.

DOI: 10.4018/978-1-4666-6030-4.ch001
1. INTRODUCTION

Image segmentation is the process of subdividing the image into its constituent parts, and is considered one of the most difficult tasks in image processing. It plays a vital role in any application and its success is based on the effective implementation of the segmentation technique (Annadurai & Shanmugalakshmi, 2006). For many applications, segmentation reduces to finding an object in an image. This involves partitioning the image into two classes, object or background. In the human visual system, segmentation takes place naturally. We are experts on detecting patterns, lines, edges and shapes, and making decisions based upon the visual information. At the same time, we are overwhelmed by the amount of image information that can be captured by today’s technology, as it is not feasible to manually process all such images. Instead, we design patterns which looks for certain patterns and objects of interest and put them to our attention (Gunnar, 2010).

Recent advances in a wide range of medical imaging technologies have revolutionized how we view functional and pathological events in the body and define anatomical structures in which these events take place. Medical images in their raw form are represented by arrays of numbers in the computer, with the numbers indicating the values of relevant physical quantities that show contrast between different types of body tissue. Processing and analysis of medical images are useful in transforming raw images into a quantifiable symbolic form for ease of searching and mining, in extracting meaningful quantitative information to aid diagnosis, and in integrating complementary data from multiple imaging modalities. One fundamental problem in medical image analysis is image segmentation, which identifies the boundaries of objects such as organs or tumors in images. Having the segmentation result makes it possible for shape analysis, detecting volume change, and making a precise radiation therapy treatment plan. However, despite the intensive research, segmentation remains a challenging problem due to the diverse image content, cluttered objects, occlusion, image noise, non-uniform image texture, … etc (Huang & Tschpenakis, 2009).

Computed Tomography (CT) has rapidly gained acceptance as the preferred technique for routine liver evaluation since it provides image acquisition at the peak enhancement of the liver parenchyma during a single breath hold (Bluemke, & Fishman, 1993) (Zeman et al., 1993) (Bluemke, Urban, & Fishman, 1994).

The liver is a large, meaty organ that sits on the right side of the belly. Weighting about three pounds, the liver is reddish-brown in colour and feels rubbery to the touch (Digestive Disorders Health Center, 2013). It fulfills multiple and finely tuned functions that are critical for the homeostasis of the human body. Although individual pathways for synthesis and breakdown of carbohydrates, lipids, amino acids, proteins, and nucleic acids can be identified in other mammalian cells, only the liver performs all these biochemical transformations simultaneously, and is able to combine them to accomplish its vital biological task. The liver is also the principal site of biotransformation, activation, or inactivation of drugs and synthetic chemicals. Therefore, this organ displays a unique biologic complexity. When it fails, functional replacement presents one of the most difficult challenges in substitutive medicine (Bronzino, 2000).

Due to its unreplaceable attributes, much of the research on medical imaging over the past few years has been centered on studying CT images of the liver. As such, researchers across the globe have been working towards providing a diagnostic support of liver diseases, liver volume measurements, and 3D liver volume rendering, without the need of any manual process and visual inspection, which are a mental work and a huge time consuming process. Image segmentation has been one of the many image processing methods employed on that particular task. Nevertheless, still many challenges remain before one can provide a fully autonomous image segmentation method of liver.