Chapter 11
Image Segmentation Based on Bacterial Foraging and FCM Algorithm

Hongwei Mo
Harbin Engineering University, China

Yujing Yin
Harbin Engineering University, China

ABSTRACT

This paper addresses the issue of image segmentation by clustering in the domain of image processing. The clustering algorithm taken account here is the Fuzzy C-Means which is widely adopted in this field. Bacterial Foraging Optimization Algorithm is an optimal algorithm inspired by the foraging behavior of E.coli. For the purpose to reinforce the global search capability of FCM, the Bacterial Foraging Algorithm was employed to optimize the objective criterion function which is interrelated to centroids in FCM. To evaluate the validation of the composite algorithm, cluster validation indexes were used to obtain numerical results and guide the possible best solution found by BF-FCM. Several experiments were conducted on three UCI data sets. For image segmentation, BF-FCM successfully segmented 8 typical grey scale images, and most of them obtained the desired effects. All the experiment results show that BF-FCM has better performance than that of standard FCM.

INTRODUCTION

Image segmentation is one of the central problems in computer vision and pattern recognition. It refers to the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments (sets of pixels) that collectively cover the entire image. Pixels in the same region are similar with respect to some characteristics or computed properties, such as color, intensity, and texture. Adjacent regions are significantly different with respect to the same characteristics. The goal of segmentation

DOI: 10.4018/978-1-4666-2479-5.ch011

is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze (Shapiro & Stockman, 2001).

There are many general-purpose approaches available for image segmentation such as threshold methods (Mardia & Hainsworth, 1988), edge-based methods (Perona & Malik, 1990), region-based methods (Hijjatoleslami & Kitter, 1998), and graph-based methods (Felzenszwalb & Huttenlocher, 2004). In contrast to the heuristic nature of these methods, one would formalize an objective criterion for evaluating a given segmentation. This would allow us to formulate the segmentation problem as an optimization problem. The objective function that one would seek to optimize is the interclass variance that is used in cluster analysis. An optimizer can lead to efficient solutions for optimal segmentation. But the objective function is usually not a monotone chain; therefore the problem is general NP-hard. Following this way, some clustering methods have been applied to solve image segmentation problems.

Clustering techniques represent the non-supervised pattern classification in groups (Jain et al., 1999). Considering the image context, the clusters correspond to some semantic meaning in the image, which is, objects. Among the many methods for data analysis through clustering and unsupervised image segmentation is: Nearest Neighbor Clustering, Fuzzy C-Means (FCM) clustering and Artificial Neural Networks for Clustering (Jain et al., 1999). Such bio and social-inspired methods try to solve the related problems using knowledge found in the way nature solves problems. Social inspired approaches intend to solve problems considering that an initial and previously defined weak solution can lead the whole population to find a better or a best so far solution.

Among them, the most successful image segmentation algorithm into homogeneous regions is fuzzy c-means algorithm (Bezdek, 1981). There are a lot of visual applications reporting the use of fuzzy c-means, e.g., in medical image analysis, soil structure analysis, satellite imagery (Felzenszwalb & Huttenlocher, 2004; Hijjatoleslami & Kitter, 1998; Mardia & Hainsworth, 1988; Perona & Malik, 1990). Many variations of approaches have been introduced over last 20 years, and image segmentation remains an open-solution problem. As global optimization techniques, evolutionary algorithms (EAs) are likely to be good tools for image segmentation task. In the past two decades, EAs have been applied to image segmentation with promising results (Andrey, 1999; Bhandarkar & Zhang, 1999; Bhanu et al., 1995; Gong et al., 2008; Koppen et al., 2003; Maulik, 2009; Melkemi et al., 2006; Veenman et al., 2003). These algorithms exploited the metaphor of natural evolution in the context of image segmentation.

The original FCM algorithm, due to its drawbacks such as poor ability of global searching and easy sticking at local optimal solution, is often improved by combining with other optimal algorithm and then used in image segmentation. Recently there has been an increase in the presence of optimization-based techniques of image segmentation. Most of them focus on searching the right center of cluster for FCM. Yang et al. (2007) proposed a FCM based on ant colony algorithm. Tian et al. (2008) applied the FCM optimized by particle swarm optimization to segment SAR images and its experimental results on the MSTAR dataset had demonstrated that the proposed method was capable of effectively segmenting SAR images and achieving better results than the improved FCM (IFCM) algorithm. Yang et al. (2008) had proposed a three-level tree model which was inspired from the ants' self-assembling behavior to make the clustering structure more adaptive for image segmentation. In order to increase the segmentation precision of brain tissues in MR images to solve some problems existing in the present genetic fuzzy clustering algorithm, Nie,