

Chapter 15

Automatic MRI Brain Image Segmentation Using Gravitational Search–Based Clustering Technique

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ABSTRACT

Image segmentation plays an important role in medical imaging applications. In this chapter, an automatic MRI brain image segmentation framework using gravitational search based clustering technique has been proposed. This framework consists of two stage segmentation procedure. First, non-brain tissues are removed from the brain tissues using modified skull-stripping algorithm. Thereafter, the automatic gravitational search based clustering technique is used to extract the brain tissues from the skull stripped image. The proposed algorithm has been applied on four simulated T1-weighted MRI brain images. Experimental results reveal that proposed algorithm outperforms the existing techniques in terms of the structure similarity measure.

INTRODUCTION

The rapid advancement in the technology has lead to the design and development of medical tools that are in use for analyzing the human body and detecting diseases with good accuracy. Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are most widely used techniques so far

as analysis of the human brain is concerned. MRI is preferred over CT because it provides better contrast between different soft tissues of the brain (Gao & Xie, 2009). MRI Brain image provides a way of observing brain anatomy and helps in the diagnosis of brain irregularities.

With the increasing number of MRI brain images, the use of computers has become neces-

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sary. Computer algorithms have been developed for analyzing the anatomical structures in brain image, called image segmentation algorithms (Pham et al., 1998). The segmentation of MRI brain plays a crucial role in neuro image analysis. Automatic brain image segmentation is of great importance in neurological research. The accurate segmentation of MRI brain image into different brain tissues like white matter, gray matter, and cerebrospinal fluid, is an important task (Riad et al, 2010). The accurate estimation of these brain tissues provides valuable information for disease diagnosis. However, the automatic brain image segmentation remains a persistent problem. The overlapping of magnetic resonance intensities of different brain tissues further complicates the segmentation process.

It is difficult to design an automatic segmentation algorithm without any prior knowledge of an organ being imaged. To alleviate this problem, a framework for automatic brain image segmentation using gravitational search based clustering has been proposed in this chapter. It consists of two main stages. The first stage is the extraction of brain tissues from non-brain tissues using the skull stripping procedure. The skull stripping procedure consists of anisotropic diffusion filtering, edge detection and morphological operations. In the second stage, the proposed gravitational search based clustering is applied on the skull stripped image to form the clusters with optimized cluster centroids without any prior knowledge. In the proposed work, the algorithm would be applied on different MRI brain images to extract brain tissues like white matter, gray matter and cerebrospinal fluid.

This chapter aims to formulate the image segmentation of MRI brain images as a soft computing problem, and segment the brain tissues using gravitational search based clustering technique. It includes a general overview of brain image segmentation with emphasis on recently introduced

segmentation techniques followed by proposed Gravitational Search Algorithm based brain image segmentation technique. The performance evaluation has been done using brain images. It also suggests some future research directions.

BACKGROUND

In this section, we first define the terminology that will be used and brief description of recently developed segmentation methods.

Definitions

Image segmentation is an important process for medical image analysis. It is defined as the process of subdividing the image into constituent regions. These regions have two main properties: 1.) homogeneity within a region, 2.) heterogeneity between the regions. The mathematical formulation of segmentation is defined as follows (Raut et al., 2009):

Let I be the set of all image pixels. By applying segmentation on I , it is partitioned into n different non-overlapping regions $\{R_1, R_2, \dots, R_n\}$ such that:

$$\bigcup_{i=1}^n R_i = I, \quad \text{where } R_i \cap R_j = \phi \quad (1)$$

The main goal of segmentation is to change the representation of an image into something that is more meaningful and easier to analyze (Shapiro & Stockman, 2001). Image segmentation is often treated as pattern recognition problem since it requires classification of pixels (Li et al., 2005). The role of segmentation in medical imaging is to study anatomical structure of brain, identify the brain tissues, measure the growth of tumor and help in radiation dose calculation.

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