Toward Efficient Segmentation of Brain Tumors Based on Support Vector Machine Classifier Through Optimized RBF Kernel Parameters and Optimal Texture Features

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ABSTRACT

This paper presents a brain tumor automatic segmentation approach applied to magnetic resonance (MR) images. The authors’ approach addresses all types of brain tumors. The proposed method involves therefore: image pre-processing, feature extraction via wavelet transform-spatial gray level dependence matrix (WT-SGLDM), dimensionality reduction using genetic algorithm (GA), parameters optimization by GA-SVM model and classification of the reduced features using support vector machine (SVM). These optimal features and optimized parameters are employed for the segmentation of brain tumor. The resulting method is aimed at early tumor diagnostics support by distinguishing between the brain tissue, benign tumor and malignant tumor tissue. The authors’ contribution consists in involving the parameters optimization phase to improve the classification and segmentation results by using GA-SVM model. The segmentation results in different types of brain tissue are evaluated by comparison with the manual segmentation as well as with other existing techniques. The qualitative evaluation shows that their approach outperforms manual segmentation with a Match Percent measure (MP) equal to 97.08% and 98.89% for the malignant and the benign tumors respectively. The quantitative evaluation displays that the authors’ attitude overtakes FCM algorithm with an accuracy rate of 99.69% for benign tumor and 99.36% for malignant tumor.

Keywords: Genetic Algorithm, Image Pre-Processing, Image Segmentation, Parameters Optimization, Support Vector Machine

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1. INTRODUCTION

Brain tumor segmentation is a medical image processing which consists of extracting tumor regions from images. This diagnostic device proves helpful in medical diagnosis as it provides doctors with data associated to anatomical structures as well as potential abnormal tissues and necessary to treatment planning and patient follow-up. The process of tumors segmenting in MR images poses many challenges due to the high diversity in tumors appearance. In fact brain tumors may appear in different image intensities and may deform nearby structures in the brain giving an abnormal geometry for tissue. Therefore the manual segmentation can be tedious, time-consuming, and even impossible which makes an automated brain tumor segmentation method preferable.

A large variety of image processing techniques has been developed for brain MR image segmentation. These methods are classified according to five criteria: contour-based, region-based, structure-based, shape-based and finally graph-based approaches (Lecoeur & Barillot, 2008). In this context, Clark et al. (1998) presented a knowledge-based and fuzzy classification approach to initially segment MR brain tumor images. Ho et al. (2002) introduced a level set-based technique that uses T1-weighted images both with and without contrast agent for tumor detection. Another fully automatic segmentation method based on a combination of a deformable model and spatial relations was introduced by H. Khotanlou et al. (2009). Hybrid systems combining fuzzy logic and artificial neural networks (Fuzzy-Neural Networks) have been proposed. Among these approaches, Benamrane et al. (2005) used region growing and mathematical morphology for segmentation. There are brain tumor segmentation methods using outlier detections (tumor voxels being outlier from normal) from Guido Gerig’s group (Marcel, John, Weili, & Guido, 2005; Marcel, Elizabeth, Sean, & Guido, 2004) and Eric Grimson’s group, texture-based tissue classifications from a number of research groups, and multi-parametric MR images (Pohl, Fisher III, Kikinis, Grimson, & Wells III, 2005; Gering, Grimson, & Kikinis, 2002). Several computer-aided diagnosis (CAD) systems are needed to find a compromise between manual and automated intervention in the segmentation procedure (Giger, Chan, & Boone, 2008). This can be achieved through a supervised method for brain image segmentation based on a classification method, e.g.: Support Vector Machines (SVM). The choice of margin cost $C$ and kernel parameters have an important effect on the performance of SVM classifier (Chapelle, Vapnik, Bousquet, & Mukherjee, 2002). The optimal parameters that lead to the minimal generalization error are data-dependent. Two-dimensional grid is usually used to tune a pair of parameters such as $C$ and $\gamma$ (Gaussian function width in RBF kernel) due to its complexity. The main contribution of this paper is to optimize SVM parameters and to find an optimal texture feature set that extracts benign tumor, and malignant tumor by using block classification rather than classical segmentation methods and having as input optimized SVM parameters and optimal selected features. The aim of our contribution is to guarantee tumor detection, decrease the number of wrong detection and to help their diagnosis at an early stage.

2. MATERIALS AND METHODS

2.1. Method Overview

We developed an automated brain tumor segmentation method made up of six phases: pre-processing, features extraction, dimensionality reduction, GA-SVM for parameters optimization, SVM training and testing, and finally segmentation. Figure 1 depicts the block diagram of the whole process. Our approach aims to extract tumor regions from brain images. To this end, images need to be pre-processed. The pre-processing stage ensured by contrast enhancement to improve image quality. The pre-processing stage output presented the same images, but with enhanced quality. The second phase deals with texture information extraction from images. In this
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