Chapter 52
Brain MR Image Multilevel Thresholding by Using Particle Swarm Optimization, Otsu Method and Anisotropic Diffusion

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ABSTRACT

Multilevel thresholding is widely used in brain magnetic resonance (MR) image segmentation. In this article, a multilevel thresholding-based brain MR image segmentation technique is proposed. The image is first filtered using anisotropic diffusion. Then multilevel thresholding based on particle swarm optimization (PSO) is performed on the filtered image to get the final segmented image. Otsu function is used to select the thresholds. The proposed technique is compared with standard PSO and bacterial foraging optimization (BFO) based multilevel thresholding techniques. The objective image quality metrics such as Peak Signal to Noise Ratio (PSNR) and Mean Structural SIMilarity (MSSIM) index are used to evaluate the quality of the segmented images. The experimental results suggest that the proposed technique gives significantly better-quality image segmentation compared to the other techniques when applied to T2-weitghted brain MR images.

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INTRODUCTION

Medical imaging modalities such as X-ray, computed tomography, MRI, etc., provide critical information about pathological condition of human organs. Experts predominantly take decisions by examining the images manually. However, manual examination of diagnostic images is time consuming. Automated diagnostic systems can provide interesting solutions to this problem. But medical images are inherently complex and hence automatic diagnosis has become a challenge in itself. Brain MRI can detect various pathological conditions such as edema, Alzheimer's disease, multiple sclerosis, hemorrhage, etc., and help physicians plan out appropriate treatment. Normal brain MR image contains different tissues—white matter, gray matter, and cerebrospinal fluid. It is necessary to classify pathological tissue from the normal tissues.

Segmentation is an important preprocessing step of automated image analysis system. There are many brain MR image segmentation techniques available in the literature. Multilevel thresholding is widely used in segmentation of brain MR image. Maitra and Chatterjee (Maitra and Chatterjee 2008) proposed a brain MR image segmentation technique based on Bacterial Foraging Optimization (BFO). This technique uses Kapur entropy function to perform multilevel thresholding on the images. Sathya and Kayalvizhi (Sathya and Kayalvizhi, 2011a, 2011b) proposed modified versions of BFO algorithm to improve multilevel thresholding-based MR image segmentation. Khalek et al. (Abdel-khalek et al., 2017) proposed a two-dimensional representation of Tsallis and Renyi entropy and subsequently used genetic algorithm to carry out multilevel thresholding-based image segmentation. Moth-flame optimization algorithm based multilevel thresholding technique is proposed by Khairuzzaman and Chaudhury (Khairuzzaman and Chaudhury, 2017a) to segment natural images. Sarkar et al. (Sarkar, Das, and Sinha, 2017) proposed a multi objective optimization technique using both cross entropy and Renyi entropy as objective function to perform multilevel thresholding-based segmentation of natural and medical images. Manikandan et al. (Manikandan et al., 2014) proposed a real coded genetic algorithm with Kapur entropy function to perform multilevel thresholding of medical images. Rajinikanth et al. (Rajinikanth et al., 2017) proposed a hybrid algorithm based on teaching learning-based optimization, entropy and active contour model to segment glioblastoma in brain MR images. Benerjee et al. (Banerjee, Mitra, and Shankar, 2016) proposed a brain tumor segmentation technique using Otsu function followed by a post processing technique based on connected component analysis to get the region of interest. Panda et al. (Panda et al., 2017) computed a 2-D histogram based grey gradient function and then used an evolutionary algorithm to carry out multilevel thresholding-based brain MR image segmentation. Oliva et al. (Oliva et al., 2017) proposed a brain MR image multilevel thresholding technique using crow search and minimum cross entropy function. Feng et al. (Feng et al., 2017) proposed a 3-D Otsu thresholding for medical image segmentation. Quantum behaved PSO (Particle Swarm Optimization) algorithms are developed to perform multilevel thresholding based medical image segmentation (Li et al., 2015, 2017). An automated contrast enhancement based preprocessing technique is proposed to facilitate better quality computer aided diagnosis of brain MR images (Chen et al. 2015). Another preprocessing technique which uses PSO based dynamic stochastic resonance to reduce MR image intensity inhomogeneity (Singh, 2017). Fredo et al. (Fredo and Ramakrishnan, 2015) proposed a fuzzy C-means based level set method to segment corpus callosum in brain MR image. Maity et al. (Maity et al., 2016) proposed a hybrid method based on thresholding and region growing to detect exudates and optic disc in fundus images.