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An Approach to Examine Magnetic Resonance Angiography based on Tsallis Entropy and Deformable Snake Model

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Abstract: This paper proposes a hybrid approach with the integration of a pre-processing and a post-processing technique to examine Magnetic Resonance Angiography (MRA) images. In pre-processing stage, a tri-level thresholding is implemented on the 2D MRA test image using the Chaotic Firefly Algorithm (CFA) and Tsallis entropy in order to improve the contrast enhanced regions by grouping the similar pixel levels. During post-processing stage, contrast enhanced regions of test image is extracted using the Active Contour (AC) procedure known as the deformable snake. Finally, the texture property of extracted aneurysm region is then computed using Minkowski distance function. The advantage of AC is validated using other segmentation procedures, such as watershed algorithm, level set, and Markov random field procedure existing in the literature. Further, the effectiveness of the proposed technique is validated using the TIC, Flair and T2 modality brain images existing in the BraTS MRI dataset. The experimental study established that the proposed two stage approach extracted efficiently the contrast enhanced regions from the MRA and T1C brain images. The segmentation result on theT1C confirmed that the proposed methodology achieved superior values of 89.65%, 93.05%, 98.16%, 98.36%, 98.17% and 90.88% for the Jaccard, dice, sensitivity, specificity, accuracy and precision respectively.

Keywords: Magnetic resonance angiography, Brain aneurysm, Chaotic firefly algorithm, Tsallis entropy, deformable snake, performance metrics.

1 Introduction

Intracranial aneurysm is a type of vascular disorder occurs mainly due to weak point in the partition of a cerebral blood vessel. This may cause the widening or swell in the weakest portion of the blood vessel. This disordercan be approximately classified as fatal, lateral or bifurcation aneurysms based on its association with the parent vessel (Cebral et al., 2005). Clinically, intracranial aneurysm detection is significant, where aneurismal rupture may lead tosevere complication. The rupture precarious level depends on the type-, dimension-, position-, and history-of theearlier aneurismal burst. Recent literature reported that blood vessel burst causes severe subarachnoid hemorrhage that may be the reason for unexpected death of 12.4% and fatality rates from 32% to 67% after the haemorrhage (Cebral et al., 2005; Firouzian et al., 2011).

In recent years, improved detection and localization results of the brain aneurysm are achieved for treatment planning due to the availability of superior imaging techniques. Magnetic Resonance Angiography (MRA) is one of the widely adopted imaging modalities in clinics to study the formation and progression of the vascular disorder. It is a category of the magnetic resonance imaging (MRI) that employs radio wave energy pulses and a magnetic ground to create images of the blood vessels within the human body. A general clinical practice procedure involves injecting the gadolinium contrast agent in to the vascular region, recording the contrast enhanced section using MRA, and identifying regions either manually/automatically using segmentation for further assessment (Campeau and Huston, 2012). Consequently, the segmentation process has a significant role in the MRA images processing to distinguish the vascular regions.

Computerized image segmentation methods are widely considered to extract the abnormal regions due to its simplicity and accuracy (Hernández-Hoyos et al. 2000). Passat et al. (2006) studied the anatomical information modeling for vessel segmentation based on MRA data. Passat et al. (2007) employed the watershed-based segmentation of the brain vessels. Firouzian et al. (2011) proposed a manual and level set approach to segment the abnormal regions obtained from the computed tomography angiography dataset. The level set technique accuracy has been evaluated using a three dimensional (3D) model of the segmented regions. Sen et al. (2013) initially