Applied Computing and Informatics (2016) 12, 128–133

Saudi Computer Society, King Saud University

Applied Computing and Informatics

(http://computer.org.sa)
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www.sciencedirect.com

ORIGINAL ARTICLE

An empirical technique to improve MRA imaging

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Received 31 August 2014; revised 8 June 2015; accepted 8 June 2015
Available online 16 June 2015

KEYWORDS

Image processing;
Segmentation;
Region growing;
Medical imaging;
Vessels;
MRA

Abstract In the Region Growing Algorithm (RGA) results of segmentation are totally dependent on the selection of seed point, as an inappropriate seed point may lead to poor segmentation. However, the majority of MRA (Magnetic Resonance Angiography) datasets do not contain required region (vessels) in starting slices. An Enhanced Region Growing Algorithm (ERGA) is proposed for blood vessel segmentation. The ERGA automatically calculates the threshold value on the basis of maximum intensity values of all the slices and selects an appropriate starting slice of the image which has a appropriate seed point. We applied our proposed technique on different patients of MRA datasets of different resolutions and have got improved segmented images with reduction of noise as compared to tradition RGA.

1. Introduction

In the field of medical imaging blood vessels segmentation is an important task for diagnosis of different diseases. Segmented blood vessels provide meaningful information about the structure and position of the vessels which plays a critical role in many medical applications such as diagnosis, surgery planning and radiation treatment planning.

Medical image segmentation is considered as a difficult task due to variable shapes of objects and different qualities of images causing noise. Although a bundle of segmentation techniques have been developed [1–5] still there is no single segmentation technique that is applicable for all imaging applications. The most common region segmentation method is based on threshold value, which is most often used as an initial step in the majority of image processing applications.

A lot of research has been done in this area but region growing technique has got more attention due to its simplicity, noise suppression, automation and whole tree detection of vessels. In region growing algorithm results of segmentation are totally dependent on the selection of seed point. An inappropriate seed point leads toward poor segmentation. The majority of MRA datasets do not contain required region (vessels) in start of slices. We have been studying and published papers in MRI enhancement [6,7].

The paper is organized as follows: In Section 2, we give a brief literature survey, the details of proposed ERGA is presented in Section 3, while Section 4 demonstrates the measured results and conclusion is given in Section 5.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.aci.2015.06.002
2210-8327

2. Related work

In MRA, the blood vessels show a wide range of intensity values due to the amount of blood flow. This is similar to the region growing technique where the rate of growth is also based upon the range of intensity values. Therefore, the conventional region growing technique fails to extract whole vessels tree. In order to solve the intensity range problem for the segmentation of blood vessels, a range of strategies based upon region growing have been proposed by various authors. Paulina et al. [1] implemented the idea of both global thresholding and local thresholding. Global thresholding is applied to the selection of seed points and local thresholding serves as a criterion to put a stop to region growing. Average intensity values of images are calculated and applied to the formula of quadratic polynomial, which gives a global threshold value. Seed points are obtained after applying global thresholding. Abdel-Dayem and El-Sakka [8] recommended the fuzzy region growing technique for the segmentation of carotid artery ultrasound images. Ultrasound images usually have problems of noise and low contrast. To overcome these problems, two preprocessing steps are performed. Histogram equalization is applied in order to increase the dynamic range of the image gray levels. For noise removal, a median filter was applied on the histogram equalized image. Dokladal et al. [9] proposed a branch-based region growing technique for the segmentation of blood vessels of MRA. According to this technique, segmentation is performed individually branch by branch. Initially a single seed point is selected manually and then it begins the search for a branch.

Another region growing based technique for the extraction of liver blood vessels from X-ray images is applied by Passat et al. [10]. Their proposed algorithm maintains hierarchical priority lists based upon "first in first out" where the priority to each list was assigned according to the value of luminosity. For the insertion of new points, lists are accessed randomly. Kim et al. [11] proposed an atlas based automatic approach for region-growing segmentation of brain vessels. They have implemented the concept of two threshold values: a higher and lower value respectively to cover all the vessels in tree. Multiple seed points are chosen with the help of a higher threshold value.

Kim and Park [12] have proposed a local adaptive thresholding based technique for the segmentation of carotid artery using MRA slices. This technique automatically computes the threshold value by considering a midpoint of maximum and minimum gray levels of only first slice. In addition, the application of the threshold value filters the first slice. Taking into account the anatomical structure of the left and right carotid arteries, the filtered slice is divided into two subregions. Seed points of each subregion are calculated and their eight connecting neighbors are labeled in order to get the region of interest.

Almi'ani and Barkana [13] proposed a modified region growing algorithm to extract cerebral vessels of MRA images. The image segmentation, pre-processing step, gamma correction and spatial operations were the components of proposed techniques. The proposed technique shows performance improvement in terms of noise attenuation, vessel enhancement and segmentation.

Priyadharshini and Anitha [14] applied region growing algorithm to diagnose glaucoma in eye. The pre-processing imaging technique and morphological operations such as dilation and erosion were incorporated and median filter was applied in the proposed technique. The technique shows performance improvement in terms of image quality and image edges compared to the thresholding techniques.

Wen et al. proposed [15] cerebrovascular segmentation algorithm to obtain accurate vessel. The finite mixture model, Gaussian distribution function and Rayleigh distribution function were used. The proposed have two limitations that are, (i) proposed algorithm iteration runs sequentially to achieve a stable state and (ii) proposed algorithm does not consider the neighborhood relationships between the voxels.

In this paper, we proposed few enhancements in region growing algorithm. Our main contribution is to determine appropriate threshold value of slice, seed point and starting slice number. We also developed a two pass algorithm for grayscale 8-connected neighbors. We applied all these components in RGA and evaluate the performance in terms of image enhancement. The region growing algorithm that applies in our proposed system is driven from [16].

3. Enhanced Region Growing Algorithm (ERGA)

In the traditional region growing algorithm, results of segmentation are totally dependent on the selection of seed point. An appropriate seed point results in quality segmentation. However, in the majority of MRA datasets, the start of the slices does not contain any required information. As a result of this, we have not applied region growing algorithm directly on the first slice. In order to begin from the required region, we have developed an automatic threshold value. To calculate the threshold, the maximum intensity value of each slice is obtained and stored in an array denoted as max_list. From this max_list, we then find the maximum and minimum intensity values, i.e. m_1 and m_2 respectively. Finally the difference between m_1 and m_2 is gained.

$$T = m_1 - m_2 \tag{1}$$

The maximum intensity of each slice is compared with threshold T given in Eq. (1). Slices are checked in a sequence in ascending order. Any slice with an intensity value greater or equal to the threshold value is selected as a first slice F_1. Region growing algorithm is then applied to F_1 and onward slices only. In this way, the starting slice F_1 is different for each dataset and is selected automatically according to maximum intensity values. The steps for ERGA are given as follows:

3.1. Steps for slice selection algorithm

1. *Initialize n with total number of slices in a dataset*
2. *Read all MRA slices of sequence images*
3. *Find maximum intensity value of each slice and store in an array, i.e. max_list, in ascending order.*
4. *Find maximum intensity value from max_list, i.e.* m_1
5. *Find minimum intensity value from max_list, i.e.* m_2
6. *Find threshold T by taking the difference of* m_1 *and* m_2 *values*
7. *Start loop from* $j = 1$ *to* n