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Automatic liver segmentation in MRI images using an iterative watershed algorithm and artificial neural network

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ABSTRACT

Precise liver segmentation in abdominal MRI images is one of the most important steps for the computer-aided diagnosis of liver pathology. The first and essential step for diagnosis is automatic liver segmentation, and this process remains challenging. Extensive research has examined liver segmentation; however, it is challenging to distinguish which algorithm produces more precise segmentation results that are applicable to various medical imaging techniques. In this paper, we present a new automatic system for liver segmentation in abdominal MRI images. The system includes several successive steps. Preprocessing is applied to enhance the image (edge-preserved noise reduction) by using mathematical morphology. The proposed algorithm for liver region extraction is a combined algorithm that utilizes MLP neural networks and watershed algorithm. The traditional watershed transformation generally results in oversegmentation when directly applied to medical image segmentation. Therefore, we use trained neural networks to extract features of the liver region. The extracted features are used to monitor the quality of the segmentation using the watershed transform and adjust the required parameters automatically. The process of adjusting parameters is performed sequentially in several iterations. The proposed algorithm extracts liver region in one slice of the MRI images and the boundary tracking algorithm is suggested to extract the liver region in other slices, which is left as our future work. This system was applied to a series of test images to extract the liver region. Experimental results showed positive results for the proposed algorithm.

1. Introduction

Today, imaging techniques, such as magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET) are very important in the medical diagnosis process. A hepatic MR is a new diagnostic method that has experienced important advances. It produces high quality images and is one of the standard instruments for the diagnosis of liver pathologies, such as cirrhosis, liver cancer, and fulminant hepatic failure [1]. These advances include rapid scanning, new sequences of images with a high spatial resolution and more specific contrast for each type of lesion [2,3]. Fast and suitable algorithms for segmentation have an important role in the diagnosis, classification and quantitative description of diseases in various tissues, including liver tumors [4]. For example, in clinical surgery, accurate segmentation of the liver using MRI images is important for automated liver perfusion analysis, which provides important information about the blood supply to the liver [5]. Accurate liver segmentation in abdominal MRIs is challenging because the gray-level distribution of surrounding organs is not highly distinguishable. Therefore, the boundary regions between the liver and adjacent tissues generally have uniform intensity distributions, which often lead to the oversegmentation of the liver. Additionally, the vasculature inside the liver commonly leads to segmentation leakage [6].

To date, most research has been conducted on liver segmentation in CT images. Only a few studies have focused on MRI images. The primary reason that abdominal MRI research has been limited is that these images are more affected by artifacts. Moreover, they have a low gradient response, which makes accurate liver segmentation very difficult [7].

Zhang et al. [8] proposed an automatic liver segmentation method for CT images that was based on a statistical shape model (SSM) integrated with an optimal-surface-detection strategy. The method included three steps: first, the average liver shape model was determined by CT volume data via a 3D generalized Hough transform. Then, subspace initialization of the SSM was performed using intensity and gradient profiles. Finally, the shape model was reformed to adapt to the liver contour through an optimal-surface-detection approach based on graph theory.

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