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Fast Automated Liver Delineation from Computational Tomography Angiography

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Abstract

Accurate liver segmentation is essential for surgery planning and diagnosis of liver abnormality with algorithms. We propose and validate a multi-atlas segmentation approach with local decision fusion for fast automated liver (with/without abnormality) segmentation on computational tomography angiography (CTA). Thirty-five patients were enrolled in this study. A co-registered segmented CTA atlas is constructed with 20 CTA scans, normal and abnormal subjects with wide range of body-mass index (BMI). Liver segmentation candidates are achieved by a multi-atlas registration algorithm which propagates the segmentation label on each atlas image to the test image by image registration. The final segmentation result is calculated by applying local decision fusion weights to each propagated candidate segmentation. We applied our algorithm on the rest 15 patients and compared them with manual segmentation by two expert readers. Voxel overlap by Dice coefficient between the algorithm and expert readers was 0.93 (range 0.89 - 0.94). The mean surface distance and Hausdorff distance in millimeters between manually drawn contours and the automatically obtained contours were 1.1 ± 0.9 mm and 5.9 ± 1.7 mm respectively. Using our approach, physicians can accurately segment liver from CTA without tedious manual tracing. Our automated algorithm for liver segmentation achieved accurate segmentation with/without abnormality.

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Keywords: Liver; segmentation; computational tomography angiography; atlas; registration;

1. Introduction

Liver segmentation is essential for surgery planning and computer-aided diagnosis. Liver segmentation from CT images is more challenging compared to other abdominal organ segmentation. First, intensity distributions between

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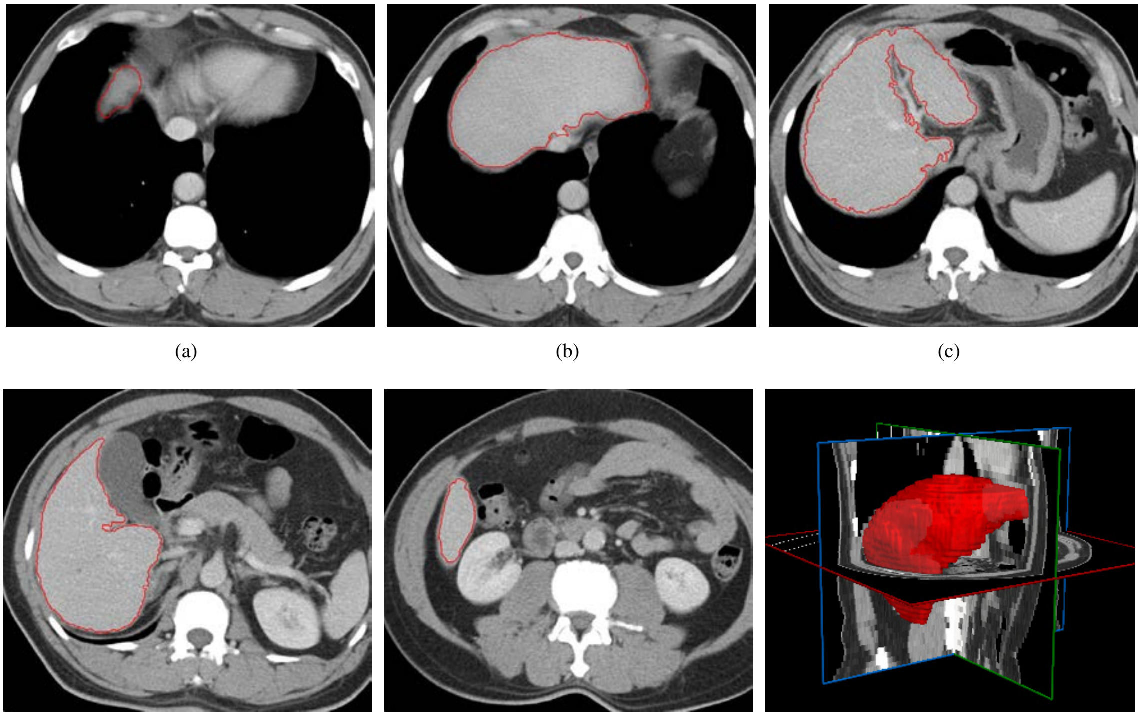

(a) (b) (c) (d) (e) (f)

Fig. 1. Example of atlas images and manual tracing of liver region. (a)-(e) 2D contours on transverse slices within upper and lower limits of liver, (f) 3D mask created from the 2D contours.

the liver and its nearby organs are similar. Moreover, diffident livers, especially abnormal ones, have varied shapes. Thus, fully-automated liver segmentation is still an open problem.

Several investigators have reported methods for liver segmentation on CT data. Gao[1] extracted information from the global histogram of abdominal CT images and combined morphological operators to define the liver area. This intensity-based method is unstable in the area of the liver boundary where fuzzy voxel intensity is present. Luo[2] extracted pixel-level features of wavelet coefficients and Haralick texture descriptors[3], classified the data into pixel-wised liver or non-liver by support vector machines and combined morphological operations to delineate the liver. Militzer[4] designed strong and compact classifiers for feature classification based on the AdaBoost algorithm and Probabilistic Boosting Trees to get high accuracy for liver tumors segmentation. These methods are relatively simple in the process of target region refinement, and only based on morphological filtering. Statistical shape models are also applied to liver segmentation to overcome the over-segmentation problem of intensity and texture based methods. Zhang[5] used a statistical shape model driven by optimal surface detection. Okada[6] fused a probabilistic atlas and multilevel statistical shape model to integrate global shape and appearance features of abdominal CT images for liver segmentation.

In this paper, we present an automated liver segmentation method that can handle livers with/without abnormality based on a fast multi-atlas based method. The experimental results demonstrate that compared to expert manual tracing, the proposed method is significantly effective and robust for the segmentation of liver from CTA images.

2. Method

In this section, we first describe the image acquisition protocol, followed by the creation of the liver CTA atlases. Next, we present the proposed liver segmentation algorithm.