

Automatic Segmentation of Liver and Vessels from CT Images for Liver Surgery Planning

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Introduction

Background

- Various surgical planning methods consisting of manual, semi-automatic, and fully-automatic segmentation for the liver and its vessels have been proposed.
- The existing methods suffered from accuracy (80%-92.1%) and time efficiency (>30 min) in segmentation of the liver and vessels for surgery planning.

Objectives of the Study

- Develop an accurate and efficient surgical planning program Dr. Liver (Fig. 1), consisting of a liver extraction stage, a vessel extraction stage, and a liver segment classification stage based on abdominal computerized tomography (CT) images

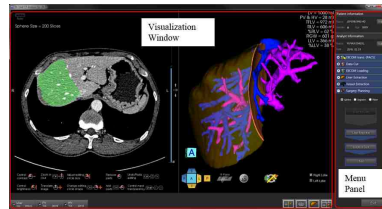


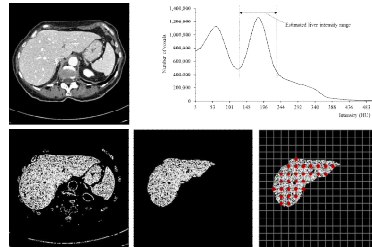
Fig. 1. Our liver surgical planning program Dr. Liver

Materials and Methods

Liver Segmentation

- Automatic liver segmentation method

S1. Automatic identification of seed points using histogram and geometric analyses



S2. Liver segmentation using a customized fast-marching level-set method for initial liver region identification and a threshold-based level-set method to evolve the initial liver region to the actual liver region

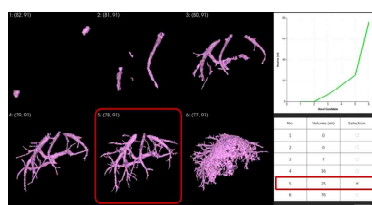


Vessel Segmentation

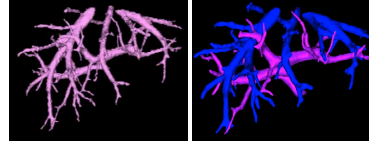
- Automatic vessel segmentation method

S1. Automatic identification of seed points using histogram and geometric analyses

S2. Vessel segmentation using a customized region growing method from multiple threshold intervals identified from intensity values of the seed points



S3. Separation of portal vein and hepatic vein using a connected component method



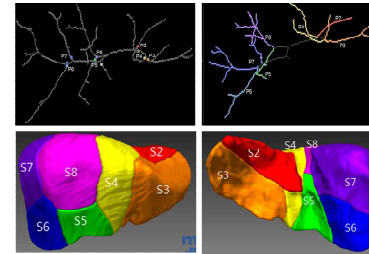
Liver Segment Classification

- Semi-automatic classification method

S1. Skeletonization of portal vein

S2. Identification of portal vein branches for each liver segment according to Couinaud classification

S3. Classification of liver segments from the identified portal vein branches using a nearest neighborhood approximation method



Results

Liver Segmentation

- Our method ranked as 6 among 108 submission at the online competition SLIVER07 website (<http://sliver07.org/results.php>)



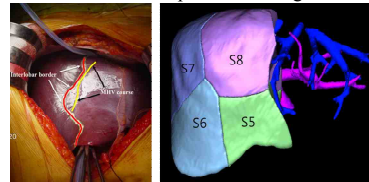
Results

For a table with more detailed results, click on the rank of the submission you are interested in.

Rank	Team	System	Submission Date	Avg Total Score
1	Niki-Lab	Semi-automatic	2013-07-29	85.7
2	Niki-Lab	Semi-automatic	2013-01-10	85.3
3	LME Erlangen	Semi-automatic	2010-01-14	84.6
4	Niki-Lab	Semi-automatic	2012-11-03	84.5
5	Niki-Lab	Semi-automatic	2013-05-25	84.0
6	EDT	Automatic	2014-02-13	83.3
7	LiverPlanner	Automatic	2015-05-24	83.4
8	LiverPlanner	Interactive	2009-02-25	82.1
9	AFM	Semi-automatic	2011-11-24	81.8

Liver Segment Classification

- Preoperatively planned cutting line highly agreed with the actual intraoperative cutting line



Discussion

- The proposed automatic liver segmentation method is accurate (average volumetric overlap ratio = 95.2%) and efficient (average liver segmentation time = 55 sec/CT dataset) to extract the liver from CT images.
- The vessel segmentation method in this study showed no false positive errors or misconnections between PV and hepatic vein (HV) in the extracted vessel trees by applying mask CT images and providing multiple segmentation candidates.
- The intraoperative actual surgical cutting line agreed with the preoperatively planned cutting line.