様式 7

論　文　内　容　要　旨

報告番号	甲　先　第　177　号	氏　名	Ahmed Shawky Mohamed Maklad
学位論文題目	Segmentation of the liver based on blood vessel information from the portal phase of an abdominal CT dataset 血管の情報を用いた門脈相腹部ＣＴ画像からの肝臓セグメンテーションに関する研究		

内容要旨

Purpose

Liver segmentation is the basis for computer-based planning of surgical interventions. Accurate preoperative estimates of graft weight is imperative to avoid small-for-size syndrome in the recipient and ensure donor safety after adult living donor liver transplantations.

Blood vessel (BV) information can be used to guide body organ segmentation on computed tomography (CT) imaging. The proposed method uses abdominal BVs (ABVs) to segment the liver through the portal phase of an abdominal CT dataset. This method aims to address the wide variability in liver shape and size, separate liver from other organs of similar intensity, and segment hepatic low-intensity tumors (LITs).

Methods

Thin ABVs are enhanced using two three-dimensional (3D) morphological operations (erosion and dilation). ABVs are extracted and classified into hepatic BVs (HBVs) and non-hepatic BVs (non-HBVs) with a small number of interactions. The ribs boundary surface is constructed and added to the non-HBVs cluster. HBVs and non-HBVs are used for constraining automatic liver segmentation. HBVs has unique information for each liver. Using end points of the extracted HBVs' thinning result, core region of the liver is individually segmented by applying Delaunay triangulation. To separate the liver from other organs, this core region and non-HBVs are used to construct an initial 3D boundary surface orthogonally and equidistantly between them based on their Euclidean distances. To segment LITs, the core region is classified into non-LIT- and LIT-parts by fitting the histogram of the core region using a variational Bayesian Gaussian mixture model. Based on number of peaks of the fitted histogram, a core region classified into NLIT- (one peak) or LIT-case (two peaks). Each part of the core region is extended based on its corresponding component of the mixture, and extension is completed when it reaches a variation in intensity or the constructed boundary surface, which is reconfirmed to fit robustly between the liver and neighboring organs of similar intensity. A solid-angle technique is used to refine

main BVs at the entrances to the inferior vena cava and the portal vein.

Results

The proposed method was applied to eighty datasets: 30 Medical Image Computing and Computer Assisted Intervention (MICCAI) and 50 non-MICCAI; 30 datasets of non-MICCAI data include tumors. Abnormal datasets contain 45 tumors of different sizes (average maximum length, 38.2 mm; standard deviation (SD), 21.1 mm), with 13 tumors adjoined to the liver boundary and 32 located inside the liver. Our results for MICCAI-test data were evaluated by sliver07* organizers with an overall score of 85.7, which ranks best on the site as of July 2013. These results (average ± standard deviation) include the five error measures of the 2007 MICCAI workshop for liver segmentation as follows. Results for volume overlap error, relative volume difference, average symmetric surface distance, root mean square symmetric surface distance, and maximum symmetric surface distance were 4.33 ± 0.73, 0.28 ± 0.87, 0.63 ± 0.16, 1.19 ± 0.28, and 14.01 ± 2.88, respectively; and when applying our method to non-MICCAI data, results were 3.21 ± 0.75, 0.06 ± 1.29, 0.45 ± 0.17, 0.98 ± 0.26, and 12.69 ± 3.89, respectively. These results demonstrate high precision of the method when applied to different CT datasets.

Conclusions

BVs can be used to address the wide variability in liver shape and size, as BVs provide unique details for the structure of each studied liver. Constructing a boundary surface using HBVs and non-HBVs can separate liver from its neighboring organs of similar intensity. By fitting the histogram of the core region using a variational Bayesian Gaussian mixture model, LITs are segmented and measuring the volumetry of non-LIT- and LIT-parts becomes possible. Further examination of the proposed method on a large number of datasets is required for clinical applications, and development of the method for full automation may be possible and useful in the clinic. Extracted ABVs can help surgeons to decide the reconnection technique of ABVs in liver transplantation. Segmentation of NLIT- and LIT-parts of a liver separately makes accurate estimation of tumor volumetry compared to whole liver possible.

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論文審査の結果の要旨

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学位論文題目

Segmentation of the liver based on blood vessel information from the portal phase of an abdominal CT dataset

血管の情報を用いた門脈相腹部ＣＴ画像からの肝臓セグメンテーションに関する研究

審査結果の要旨

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ABVs are extracted and classified into hepatic BVs (HBVs) and non-hepatic BVs (non-HBVs). Ribs boundary surface is constructed. HBVs and non-HBVs are used for constraining automatic liver segmentation. Using the extracted HBVs, core region of the liver is individually segmented. To separate the liver from other organs, this core region and non-HBVs are used to construct an initial 3D boundary surface between them. To segment LITs, the core region is classified into non-LIT- and LIT-parts by fitting the histogram of the core region using a variational Bayesian Gaussian mixture model. Each part is extended based on its corresponding component of the mixture. A solid-angle technique is used to refine main BVs.

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