

Automated segmentation of liver parenchyma and blood vessel with in-vivo radial Gradient and Spin-Echo (GRASE) datasets for characterization of diffuse liver disease

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Introduction: The analysis of imaging parameters in the liver has become of increased importance for the evaluation of diffuse conditions such as fibrosis, inflammation and iron deposition. Although a series of parametric imaging techniques have been developed, the analysis of parameters maps is mainly restricted to an ROI within the liver. Whole liver analysis, as opposed to the analysis of an ROI, should yield a better representation of the disease and if the analysis is automated it can be used routinely in the clinic. In this work, we present a combined liver and vessel segmentation technique that is used with a radial gradient and spin-echo GRASE (radGRASE) acquisition strategy [1]. radGRASE yields two important parameters for the characterization of diffuse liver disease [2]: a T2w map of the water component (T2w) and a fat fraction (FF) map. These two maps are registered by the nature of the acquisition, thus providing unique properties for automatic segmentation. We have initially tested the segmentation method using a simulated liver phantom [3]. We are now evaluating the method in vivo using a set of 18 liver images (from 4 subjects) and compared to the results of manual segmentation.

Methods: The radGRASE acquisition scheme used in this work was based on the collection of 4 gradient echoes per spin-echo period. All four gradient echoes are used to obtain initial fat-water estimates, corrected for the effects of field in homogeneities. For T2 estimation, the gradient echoes that are closest to the SE point were used to generate images at various TE_{eff} from which the T2w and the final fat and water images and FF maps are calculated

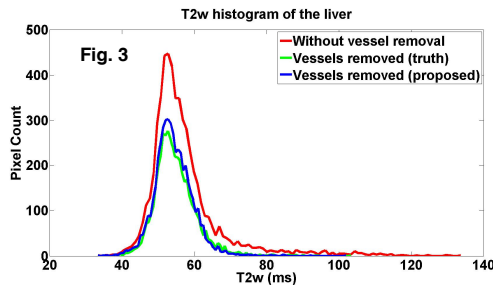
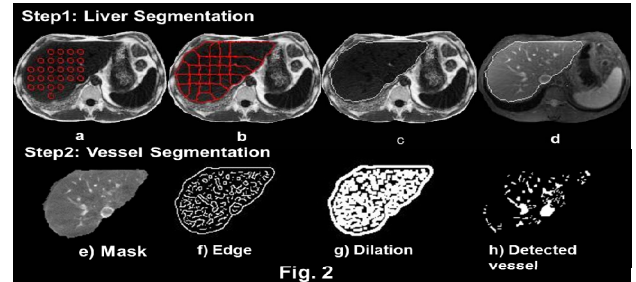
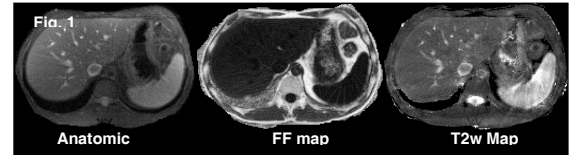


Table 1	Mean T2w (ms)	St. Dev. T2w
Without vessel Removal	54.39	13.59
Proposed Method	51.30	7.46
Truth	51.72	7.03

the anatomical image. The mask generated from step 1 was transferred to the T2w map (Fig. 2e; since the maps are perfectly registered) for vessel segmentation. The vessel segmentation step consisted of: an edge map, created using the Canny operator (Fig. 2f), followed by dilation (Fig. 2g) and a filling operation. An intensity based threshold applied to the T2w map is then combined with the dilation to give the resulting vessel map (Fig. 2h).

A mask of the liver parenchyma without vessels was then created to generate T2w histograms. For comparison purposes we also generated a mask without vessel segmentation. To avoid including pixels in the histograms corresponding to T2w fitting noise we limited the T2w values such that pixels with high (>200) or very low intensity (<5) were not included in the histograms. As “truth” for the segmentation algorithms we used the same images but where the liver and vessels were segmented manually in consultation with an experienced radiologist.

Results: Fig. 3 shows histograms for one of the subjects in our study. The histograms correspond to liver masks without vessel removal (red), vessels removed (blue) and “truth” (green). Table 1 shows histogram parameters for the three cases. Clearly, the mean and SD values of the proposed method are very close to “truth”. Fig. 4 is a plot of T2w mean and SD for all 18 slices. We can see that data processed with the proposed method (blue dots) cluster with the data for “truth” (green dots). When vessel are not removed (red dots), however, the means and SD are clearly higher than truth. On average the difference between means of the proposed method and truth over the 18 slices analyzed is 0.79.

Conclusions An automated liver parenchyma and vessel segmentation method for radial GRASE data was presented. With the proposed segmentation method one can identify the liver parenchyma and its vessels. In a data set of 18 slices (from 4 subjects) we showed that the proposed approach yields T2w mean and SD that are very close to manual segmentation (truth). This methodology should facilitate the analysis of liver parameter maps in a clinical setting.

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References: [1] Li Z, Graff C et al, MRM 61:1415, 2009. [2] Barr T et al, ISMRM 19, 4088, 2012. [3] Bilgin A, et al ISMRM 18, 2045, 2011. [4] Caselles V et al, Int. Journal of Comp. Vision, 1997:22, 6. [5] Ray N et al, IEEE MI, 22:2: 2003.

