Segmentation of Hepatic Tissue in MRI Using Fuzzy Logic

Y. A. Costa*, **G. A. Flores****, **E. L. L. Rodrigues***, **F. F. Paiva****
*Department of Electrical and Computer Engineering, University of São Paulo, São Carlos, Brazil -
**Institute of Physics of São Carlos, University of São Paulo, São Carlos, Brazil
e-mail: yuri.ajala@usp.br

Introduction: Liver segmentation in magnetic resonance imaging (MRI) is a challenging task due to its several acquisition parameters, intricate organ irrigation and variable tissue signal intensity. For these reasons, it lacks in specialized algorithms and public databases. Segmentation isolates the organ, limiting an analysis to a region of interest. We propose here a manually initialized algorithm based on fuzzy logic for segmentation of the hepatic tissue in magnitude in-phase (IP) and opposed-phase (OP) MR images, avoiding major internal blood vessels and biliary structures for better fat fraction calculation in the assessment of liver steatosis.

Materials and methods: First, the user inputs seeds over the liver tissue, the brightest and darkest ones are chosen for region growing operations. The average intensity of each resulted area is stored. Then, fuzzy rules are applied to the areas, in both IP/OP images. For OP images, a given pixel is classified as boundary if its intensity is lower than the calculated average, liver if it is the same within a range and vessel if higher. Opposite rules apply for IP images. Aggregation method was `AND`. Each pixel is assigned a boolen value representing liver or not-liver. Finally, the results from both images are combined using logical `AND`, binary erosion and opening. The algorithm was tested in 32 pairs of OP/IP images of patients diagnosed with moderate or no significant steatosis. Results were compared to manual segmentation.

Results: Figure 1 shows an example of OP (A) and IP (B) images, their manual (C) and computerized (D) segmentation. Great similarities can be observed both in outer and inner boundaries, demonstrating the efficiency of the adopted scheme. Average results for 32 pairs of images were: Jaccard coefficient of 0.85, accuracy of 0.99, sensitivity of 0.93 and specificity of 0.99. Other authors who recently performed abdominal organ segmentation in the same type of IP/OP images achieved Jaccard coefficients of 0.75 [1] and 0.89 [2]. Lower coefficients were found either in regions with B1 inhomogeneities artifacts due to coil proximity or when images were misregistred.

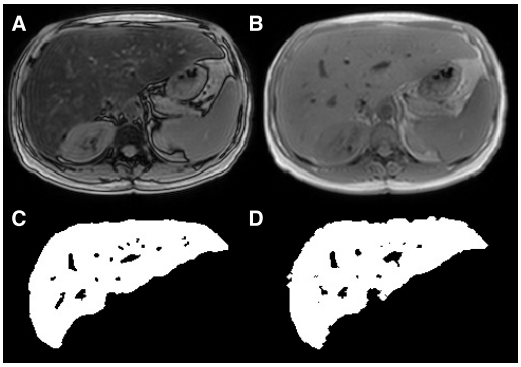

Figure 1 – (A) and (B) are OP/IP a image pair used for segmentation. (C) is the reference manual segmentation, (D) is the algorithm output with Jaccard coefficient = 0.89.

Conclusion: The proposed method achieved results slightly higher than literature and excluded internal structures of the liver, a desirable feature for fat fraction calculation as their presence may impair the results. The algorithm is open to contributions at https://github.com/livertools/fuzzyliver.

References: [1]Yan, Z. et al. "Atlas-based liver segmentation and hepatic fat-fraction assessment for clinical trials", Comput Med Imaging Graph , v. 41, 80–92, 2015. [2]Shen, J. et al. "Automatic segmentation of abdominal organs and adipose tissue compartments in water-fat MRI: Application to weight-loss in obesity", Eur J Radiol, v. 85, 1613–21, 2016.