

Image segmentation is, along with multimodal and monomodal registration, the operation with the greatest applicability in medical image processing. There are many operations and filters, as much as applications and cases, where the segmentation of an organic tissue is the first step. The case of liver segmentation in radiological images is, after the brain, that on which the highest number of scientific publications can be found. This is due, on the one hand, to the need to continue innovating in existing algorithms and, on the other hand, to the applicability in many situations related to diagnosis, treatment and monitoring of liver diseases but also for clinical planning.

In the case of magnetic resonance imaging (MRI), only in recent years some solutions have achieved good results in terms of accuracy and robustness in the segmentation of the liver. However these algorithms are generally not user-friendly. In the case of computed tomography (CT) scans more methodologies and solutions have been developed but it is difficult to find a good trade-off between accuracy and practical clinical use.

To improve the state-of-the-art in both cases (MRI and CT), a common methodology to design and develop two liver segmentation algorithms in those imaging modalities has been proposed in this thesis. First, after studying the state-of-the-art, a suitable algorithm with the accuracy and robustness needed for the desired applicability in each case (MRI and CT) has been designed. These algorithms have been designed using different techniques and methods previously published although in many cases they have been improved and new ones have been designed. The initiation and interaction of these algorithms and their computation cost have also taken into account.

The second step has been the validation of both algorithms. In the case of CT images, there exist public databases with images segmented manually by experts that the scientific community uses as a common link for the validation and comparison of their algorithms. The validation is done by obtaining certain coefficients of similarity between the manual and the automatic segmentation. This way of validating the accuracy of the algorithm has been followed in this thesis, except in the case of magnetic resonance imaging because, at present, there are no databases publicly available. In this case, there aren't public or accessible images. Accordingly, a private database has been created where several expert radiologists have manually segmented different studies of patients that have been used as a reference. This database is composed by 17 studies (with more than 1,500 images), so the validation of this method in MRI is one of the more extensive currently published. By contrast, the comparison of the proposed methods with other state-of-the-art algorithms is not direct as in the case of the algorithm for liver segmentation in CT.

In the validation stage, an accuracy above 90% in the Jaccard and Dice coefficients has been achieved. The vast majority of the compared authors achieves similar values. However, in general, the algorithms proposed in this thesis are more user-friendly for clinical environments because the computational cost is lower, the clinical interaction is non-existent and it is not necessary an initiation in the case of the magnetic resonance algorithm and a small initiation (it is only necessary to introduce a manual seed) for the computed tomography algorithm. For this reason, the design and validation of both algorithms are an improvement in the state-of-the-art of liver segmentation in high resolution anatomical images.

In this thesis, a third hypothesis that makes use of the results of liver segmentation in MRI combined to augmented reality algorithms has also been developed. Specifically, a real and innocuous study, non-invasive for clinician and patient has been designed and validated through it has been shown that the use of this technology creates benefits in terms of greater accuracy and less variability versus the non-use in a particular case of laparoscopic surgery. In particular, a support system for trocar placement in this type of surgery was implemented. A 3D model of the patient's abdomen is obtained from the previous segmentation of the liver, and other abdominal organs of interest. In the operating room, thanks to a camera, a real image of the patient's abdomen is obtained and its position is detected with a mark centered in their navel. Then, the 3D model of the organs is registered and fused with this real image, to provide the clinician with an aid tool for the location of the incision points through the trocars will be introduced.