Full paper of the method is preparing for a congress submission. Therefore, we only provide short description of our algorithm. Full paper will be uploaded later

LIVER CT SEGMENTATION: SEMI-AUTOMATIC 3D REGION GROWING BASED ON STATISTICAL FILTER AND 3D MORPHOLOGY

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ABSTRACT

The purpose of this work is the automatic segmentation of the liver tissue in computed tomography (CT) images. Several expert radiologist restrictions such as automation, an easy user-interaction, and a low time-cost were taken into account for selecting the final algorithm. The method is based on a 3D region growing algorithm. CT images are noisy and with a poor gradient between adjacent organs. These conditions are inappropriate for a region growing method, and, therefore, a pre-processing step based on statistical image parameters and a post-processing step focused on 3D morphology are carried out to reduce these intrinsic problems.

1. METHOD

The block diagram of our algorithm is presented in Fig. 1.

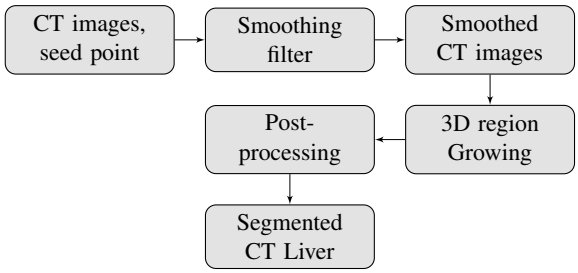

Fig. 1. Algorithm segmentation flowchart.

The first purpose of the algorithm is to obtain a CT volume with a liver tissue as uniform as possible but preserving the gradient between adjacent organs. Several smoothing filters were evaluated: a curvature flow filter [1], a morphological center filter [2], and an adaptive filter proposed in this paper that is based on fist-order statistics of the image, such as the mean (m) and the variance (σ). Several experiments demonstrate that the adaptive filter obtains a more uniform grey-level in the liver, preserving better its boundaries.

In the next step, a 3D region growing method is applied to the smoothed CT volume. Finally, post-processing filters are applied to obtain the final result. First, the holes are closed in all 2D images with a morphological reconstruction by dilatation [3]. After that, a 3D erosion is applied with a cylindrical structuring element. The erosion step is carried out to

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eliminate connexions between the liver and organs as heart, stomach or kidneys with similar greylevels that the 3D region growing segmented as liver. Every object is labelled, the largest is selected, and a dilatation with the same structuring element than the erosion is carried out to recover the original size of the liver.

2. RESULTS

Table 1 summarizes the mean (m) and the standard deviation (σ) of five goodness coefficients of the twenty training datasets [4].

Table 1. m and σ of 5 Coefficients of 20 training datasets

	VOE (%)	RVD (%)	ASSD (mm.)	RMSSSD (mm.)	MSSD (mm.)
m	**11.91**	**-5.02**	**3.03**	**6.9**	**53.5**
σ	*4.24*	*6.78*	*0.96*	*2.71*	*24.9*

3. REFERENCES

[1] L. Ibanez, W. Schroeder, L. Ng, and J. Cates, *The ITK Software Guide*, Kitware, Inc. ISBN 1-930934-15-7.

[2] F. López-Mir, V. Naranjo, J. Angulo, E. Villanueva, M. Alcañiz, and S. López-Celada, "Aorta segmentation using the watershed algorithm for an augmented reality system in laparoscopic surgery," in *2011 IEEE International Conference on Image Processing (IEEE ICIP2011)*, Brussels, Belgium, sep 2011.

[3] Pierre Soille, *Morphological Image Analysis*, vol. Second edition, Springer, 2002.

[4] T. Heimann, B. van Ginneken, et al., "Comparison and evaluation of methods for liver segmentation from ct datasets," *IEEE Transactions on Medical Imaging*, vol. 28, no. 8, pp. 1251 –1265, aug. 2009.