

MRI segmentation using histogram based active contour method: application to prostate MR image analysis

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Purpose

Image segmentation of MRI data is a challenging problem due to the specificity of the acquisition process and more precisely to the particularity of the associated corrupting noise that can be modeled by a Rician distribution. This particular distribution leads to multimodal area within MR image where foreground and target organs are characterized by different probability density functions (pdf) (mainly Rayleigh distribution and Gaussian distribution). Due to this particularity, classical automatic segmentation technique like Chan-Vese often failed in obtaining satisfying results of delineations in MR images where pdf of organs could overlap with background. This is the case for example in MR prostate image analysis, where bladder, prostate, and rectum can be hardly segmented thanks to classical approaches.

Method

In the framework of active contour segmentation [2], we propose to evaluate for MRI segmentation performances of histogram based method [1,3]. Main idea of this approach is to define, in a variational framework of region based active contours segmentation, evolution criteria accounting for the distances between probability density functions (pdf) of the inner and outer regions of the active contour and given pdfs of reference of objects and background. To achieve the performances evaluation, first a statistical study of the accuracy of the technique is proposed on synthetic MR data for different levels of corrupting noise and for different distance criteria between two given pdf and, second, a prospective study made on prostate MRI is shown for bladder, prostate and rectum segmentation, which respective delineation is of primary interest in the radiotherapy treatment of prostatic adenocarcinoma.

Results

A statistical study performed on synthetic MR images shows that histogram based active contour method outperform classical approach like the Chan-Vese one in terms of accuracy and that depending on the distance criterion selected, an adaptation to the level of corrupting noise is possible to reach the best accuracy possible. The prospective study made on prostate MRI (Fig. 1) shows that the proposed approach suits well to the particular MR distribution function: mainly, bladder, prostate and rectum segmentation are better performed by the proposed approach than with more classical active contour approaches.

Conclusion

Challenging questions for the proposed segmentation technique concern now the distance measure related to the evolution function related to active contours. Experiments show that the Rician noise level can influence the performance of a given distance and that, depending on the practical application some distances can fail to achieve a satisfying segmentation. Future investigations could be a study of different distance measure that could be less influenced by application and noise level. More precisely, the Wasserstein distance, recently introduced by [4] could be of real interest: this particular distance, defined on cumulative pdf, could lead to less sensitive results of segmentation.

Clinically speaking, future work would concern the quantitative validation of the proposed segmentation technique on prostate MRI. This would also permit to compare the histogram based approach to previous studies of the literature made in the active contour framework . If so, obtained results would permit to build a biomechanical model of the pelvis area, which is of primary importance for radiotherapy planning and treatment.

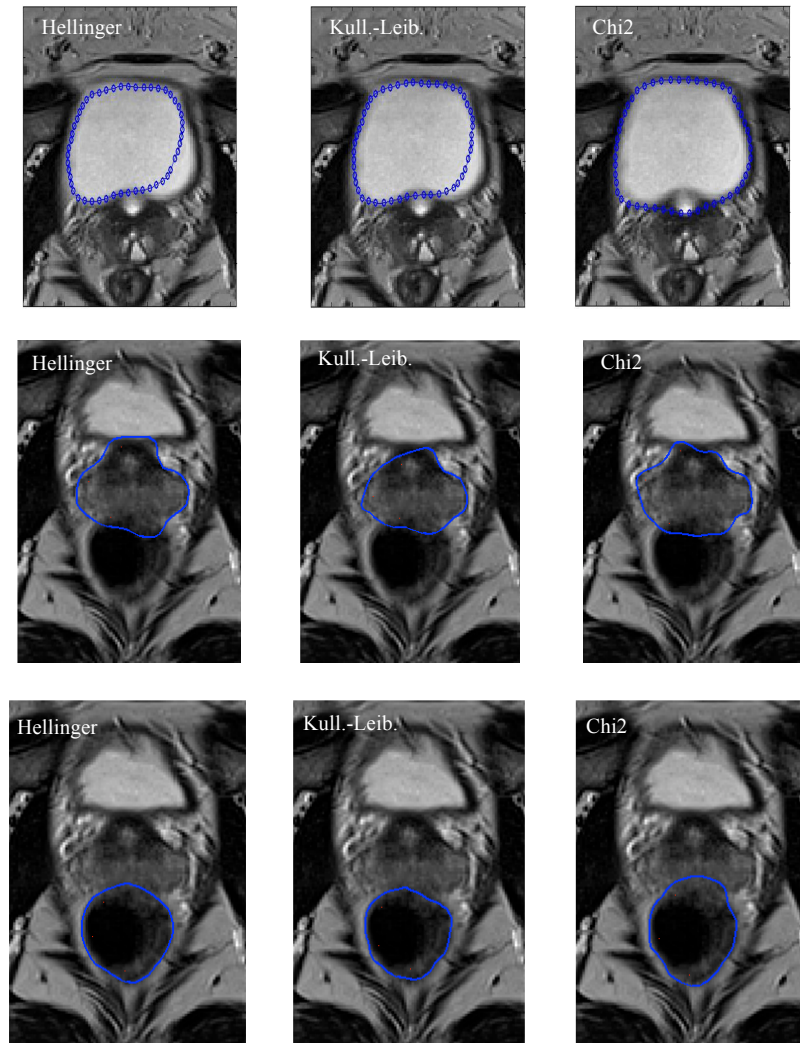


Fig. 1 Segmentation results using histogram based active contour for different targeted organs (from up to bottom: bladder, prostate and rectum) using different distance measures

References

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