Pre and Post Liver Lesion Thermal ablation FDG-PET: background driven GMM segmentation

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Abstract—**Two novel and innovative segmentation algorithms are presented, for liver metastases and necrotic tissues in pre- and post-ablation, respectively. Both are based on Gaussian Mixture Model (GMM), adapted to include healthy liver knowledge and proximity information. Preliminary validation results on 20 patients and 42 lesions are discussed showing high accuracy versus manual segmentation gold standard outperforming simpler GMM and thresholding methods.**

I. Introduction

Thermal ablation [1] is a minimally invasive technique for liver metastases treatment. Accurate image guidance is mandatory in pre-treatment, to evaluate the lesion characteristics, and in post-treatment, to define the interventional outcomes. 18F-FDG-PET imaging, often combined in PET/CT scans, is a major diagnostic tool, which provide tissues metabolic information. It is able to enhance tumors, which appear as hot spots, and treated necrotic tissues, cold spots, with respect to the surrounding healthy liver background. A reliable hot and cold spots segmentation allows both a better tumor characterization in pre-treatment and, after the intervention, a numerical comparison of pre- and post-treatment volumes as to understand if the entire tumor has been correctly treated. Gaussian Mixture Model (GMM) [2] clustering is a powerful method able to well fit the PET intensity distribution. The aim of this work is to better finalize the GMM potentiality to the specific hot and cold spots segmentation by the addition of a preliminary analysis of the healthy background and by the inclusion of proximity information.

II. Methods

A total of 42 lesions were treated and analyzed in 20 patients, who gave informed consent. All patients underwent a pre- and post-treatment PET/CT scan. Noteworthy, segmentations were based only on FDG-PET, while CT, because of its major spatial resolution, was used for pre- to post- image registration. PET-CT fusion was used for whole liver segmentation. The pre-treatment algorithm consisted of two steps: lesion free background processing and tumor region processing. The background was characterized through 4 GMM classes. Next a modified GMM algorithm was run over tumor regions including the 4 background classes plus further 4 classes to fit the hot lesion features. The GMM Expectation-Maximization iterations included the previous classification of neighbors as a prior, thus privileging connected sets. Two versions of neighborhood prior were tested: hard, with immediate influence of neighbor classification and soft, which considered persisting classifications of neighbors only. The post-treatment processing shared the same background analysis. A further GMM necrosis classification was shown to provide poor results; conversely, a simple thresholding driven by the previous background analysis was proven to be accurate. In pre-treatment the proposed hard and soft methods were compared to usual fixed thresholding at 42% maximum (TH42), standard GMM and K-means. In post-treatment the GMM tuned threshold (THGMM) was compared to the fixed TH42. Outcomes were compared by their similarity with manual contouring by an expert taken as gold-standard (GS). Indexes were: volume ratio (VR): estimate / GS, Dice index of overlap with GS and Hausdorff distance (HD) from GS.

III. Results

Both hard and soft pre-treatment algorithms encompassed all the other ones: VR) 1.1012±0.095 hard, 1.035±0.078 soft, 1.923±1.212 TH42, 0.432±1.212 GMM, 2.765±2.323 K-means; Dice) 0.989±0.012 hard, 0.991±0.003 soft, 0.965±0.030 TH42, 0.766±0.032 GMM, 0.902±0.065 K-means; HD) 0.765±0.157 hard, 0.644±0.222 soft, 1.088±0.412 TH42, 1.054±0.199 GMM, 1.432±0.543 K-means. In post-ablation the proposed THGMM was also more similar to GS than TH42: VR) 1.012±0.077 THGMM, 2.523±1.176 TH42; Dice) 0.977±0.011 THGMM, 0.845±0.057 TH42; HD) 1.257±0.268 THGMM, 1.897±0.312.

IV. Conclusion

In this paper, two innovative and accurate segmentation techniques of liver metastases and post ablation necrotic areas are presented, thus offering potential improvements in treatment planning and post-treatment outcomes evaluation.

References

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