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Hounsfield-Based Automatic Evaluation of Volumetric Breast Density on Radiotherapy CT-Scans

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Abstract : Radiotherapy is an integral part of treatment for many patients with breast cancer. However, side effects can occur, e.g., fibrosis or erythema. If patients at higher risks of radiation-induced side effects could be identified before treatment, they could be given more individual information about the risks and benefits of radiotherapy. We hypothesize that breast density is correlated with the risk of side effects and present a novel method for automatic evaluation based on radiotherapy planning CT scans. Methods: 799 supine CT scans of breast radiotherapy patients were available from the REQUITE dataset. The methodology was first established in a subset of 114 patients (cohort 1) before being applied to the whole dataset (cohort 2). All patients were scanned in the supine position, with arms up, and the treated breast (ipsilateral) was identified. Manual experts contour available in 96 patients for both the ipsilateral and contralateral breast in cohort 1. Breast tissue was segmented using atlas-based automatic contouring software, ADMIRE® v3.4 (Elekta AB, Sweden). Once validated, the automatic segmentation method was applied to cohort 2. Breast density was then investigated by thresholding voxels within the contours, using Otsu threshold and pixel intensity ranges based on Hounsfield units (-200 to -100 for fatty tissue, and -99 to +100 for fibro-glandular tissue). Volumetric breast density (VBD) was defined as the volume of fibro-glandular tissue / (volume of fibro-glandular tissue + volume of fatty tissue). A sensitivity analysis was performed to verify whether calculated VBD was affected by the choice of breast contour. In addition, we investigated the correlation between volumetric breast density (VBD) and patient age and breast size. VBD values were compared between ipsilateral and contralateral breast contours. Results: Estimated VBD values were 0.40 (range 0.17-0.91) in cohort 1, and 0.43 (0.096-0.99) in cohort 2. We observed ipsilateral breasts to be denser than contralateral breasts. Breast density was negatively associated with breast volume (Spearman: R=-0.5, p-value < 2.2e-16) and age (Spearman: R=-0.24, p-value = 4.6e-10). Conclusion: VBD estimates could be obtained automatically on a large CT dataset. Patients' age or breast volume may not be the only variables that explain breast density. Future work will focus on assessing the usefulness of VBD as a predictive variable for radiation-induced side effects.

Keywords : breast cancer, automatic image segmentation, radiotherapy, big data, breast density, medical imaging
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