Software Tools for Breast Cancer Detection in Positron Emission Mammography Images

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Positron Emission Mammography (PEM) is a novel imaging technology utilizing a dedicated Positron Emission Breast scanner. Two detectors in a configuration that resembles a conventional mammography (MG) machine cover a 250x120x200 mm^3 volume, yielding 3D images of the breast, which is fixated between the detectors, but not compressed. The procedure depends on the administration of a radioactive contrast agent, ^{18}F FDG, as used in common whole body PET scans. Clinical studies showed the equivalent sensitivity and superior specificity of PEM regardless of hormonal status, breast density, and other factors hampering MG and MRI. Yet, due to the novelty of the imaging modality, no software support besides basic viewing and measurement capabilities exists, and common PET software is not tailored to the specific tasks in PEM image analysis.

The major contribution of dedicated software presented herein is in the area of workflow support in the clinical setting, by providing robust, fast, and reproducible methods for quantitative evaluation and efficient reporting of findings. Background uptake estimation is performed by thresholding the data set based on threshold levels derived from the histogram and its 2nd derivative. This approach is designed such that the parenchyma of the breast with minor contributions of the fatty tissue part is masked, and its average uptake is taken as the background signal. Afterwards, lesions are automatically detected, and the lesion-to-background ratio recorded. Note, that the lesion detection does not depend on the background uptake being estimated before. Detected lesions are automatically measured in terms of their maximum diameter across all three dimensions. To this end, the lesions need to be accurately segmented, which is also automatically performed with an adaptive optimal thresholding procedure that was proposed for lesions in PET images [vDa07]. This method was extended to suit PEM lesion characteristics.

All quantitative results are displayed in a prototypical software assistant that moreover allows for comparative individualized measurements of lesion diameters or the distance to the nipple. Also, the background estimation can be manually changed to a operator-defined ROI to override or compare with the automatic results. To the best of our knowledge, none of the methods described are available in existing PET software tools.

We assessed the robustness and accuracy of the automated BG estimation in a study asking three experienced radiologists to draw ROIs in the fashion they used to do it. The variation within radiologists was found to be of the same order as the variation between radiologists and the automatic procedure, being about 10% on average and up to 50% in specific cases. Further, the estimated lesion extent was compared to the measurements obtained from radiologists using the vendor software, and to pathology, showing significant size estimation differences between all three that are likely due to the respective measurement processes. Further research will clarify this, and aim at an clincally integrated tool that automates the process of PEM lesion description towards reporting and a tight integration into clinical IT systems (PACS, reporting).