Computer Aided Detection and Diagnosis System for Breast Cancer Detection Based on High Resolution 3D micro-CT Breast Microcalcifications*

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Abstract. In this study we propose a Computer Aided Detection and Diagnosis System to detect breast cancer based on characteristics of individual microcalcifications (main indicators of an early breast cancer) by scanning breast tissue with micro-CT, a high resolution 3D imaging modality. By integrating supervised machine learning techniques with feature extraction and feature selection methods, we are able to classify MCs as benign or malignant with 75.88% accuracy, 62.13% sensitivity and 86.39% specificity, outperforming the state of the art.

Keywords: Machine Learning · Computer Aided Detection and Diagnosis System · Radiomics · Breast Cancer · Microcalcifications.

1 Background

Breast cancer is one of the most widely spread cancers in women worldwide. The presence of microcalcifications (MCs) in breast tissue is a key indicator for the detection of suspicious breast lesions as their characteristics may correlate with probability of malignancy. However, they are not always restricted with malignancies as they are correlated with benign lesions as well. Discriminating between benign and malignant MCs based on their appearance on mammograms,

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is a challenging task for radiologists. Considering that mammography is a projection image, superposition of tissue can hide MCs and make their appearance to vary a lot. To help radiologists, a number of CAD systems that use MCs characteristics such us shape, size, distribution have been introduced but they are typically assessing MCs properties using 2D mammography views or 3D low resolution images. In this study, we propose a CAD system for characterization of individual MCs that are visualized in 3D by scanning breast tissue with micro-CT, a high resolution 3D imaging modality.

2 Materials, Methods and Results

The biopsy samples used are provided from University Hospital of Brussels (UZ Brussel) and scanned using a high resolution SkyScan 1076 scanner. In total, we extract 2020 3D high resolution MCs images from 46 benign samples and 1542 from 50 malignant ones. Considering that there is a ground truth for the tissue sample but not for individual MCs, the images are labeled benign or malignant depending on the sample label they appertained to. Individual MCs are segmented and extracted based on an automated thresholding method and 8 level connected component analysis. We extract a high amount of radiomic features consisting of first order statistics, shape, texture features (108 features) and high order features (1548 features) by applying Laplacian of Gaussian and two-level Wavelet decomposition. Considering the high dimensional feature space, an increased risk of over-fitting and our attempt to identify a small signature, we perform recursive feature elemination (RFE) as a feature selection method. The performance of support vector machine (SVM) and multilayer perceptron (MLP) machine learning algorithms is evaluated. We train with all but one subject which is used to test. We evaluate performance in terms of accuracy, sensitivity, specificity and area-under-curve (AUC). Results obtained on our four different setups (with/without feature selection and image filtering), show that the best results are reached with SVM when applying image transformation and feature selection methods leading to an accuracy of 75.88%, sensitivity of 62.13%, specificity of 86.39% and Area Under Curve (AUC) of 77.03%. Not surprisingly, the used algorithms have marked as the most discriminatory features, the same features as radiologists use as well such as shape elongation, flatness, compactness etc. As our results show, there is definitely an important link between characteristics of individual MCs and malignant lesions. Considering that in vivo imaging is not feasible yet, this methodology can be potentially used in intra operative imaging facilitating and accelerating anatomopathological procedures, enabling in such a way diagnosis in real-time. This work can be further improved by studying more carefully the feature extraction, feature selection and classification parameters, by evaluating the performance of deep learning algorithms etc.

References

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