Quantitative analysis of multi-modal ultrasound images for breast tumor diagnosis

Yongshuai Li[1], Yuan Liu[2], Guanglei Zhang[3, 4], Zhili Wang[2] and Jianwen Luo[1] [1] Department of Biomedical Engineering, School of Medicine, Tsinghua University, Beijing, China. [2] Department of Ultrasound, Chinese People's Liberation Army General Hospital, Beijing, China. [3] Institute of Medical Photonics, Beijing Advanced Innovation Center for Biomedical Engineering, School of Biological Science and Medical Engineering, Beihang University, Beijing, China. [4] School of Biological Science and Medical Engineering, Beihang University, Beijing, China.

Background, Motivation and Objective

Ultrasound imaging techniques, including B-mode ultrasound (BMUS), shear wave elastography (SWE) and contrast-enhanced ultrasound (CEUS), are routinely used for breast tumor diagnosis in clinical practice. We aimed to develop a quantitative analysis method that leverages these multi-modal ultrasound images to improve the diagnostic performance of breast tumor.

Statement of Contribution/Methods

A retrospective study was conducted. 145 patients with 148 breast tumors (52 malignant and 96 benign) were included. BMUS, SWE and CEUS images were acquired using a Resona 7 ultrasound system (Mindray, Shenzhen, China) with a 5-14 MHz linear array. For CEUS imaging, 5 mL SonoVue (Bracco, Milan, Italy) were injected from median cubital vein. Data acquisition lasted for 30-90 seconds with a frame rate of 10 Hz. A quantitative analysis method, i.e., radiomics with attribute bagging (RAB), was proposed. First, a total of 1,226 radiomic features were extracted, including 16 intensity features, 84 gray-level co-occurrence matrix-based texture features and 300 contourlet transform-based texture features from each modal and 16 shape features from BMUS and 10 perfusion features from CEUS. Then, attribute bagging was used for analysis. 30 small subsets of features were selected with replacement by genetic algorithm and each was used to train a support vector machine (SVM). The SVMs were ensembled to predict whether a breast tumor was malignant or benign. The histological examination results acted as the gold standard. The results of an experienced clinician according to breast imaging-reporting and data system (BI-RADS) and several feature selection algorithms, including principle component analysis, hierarchical clustering and genetic algorithm, were used for comparison. Five-fold cross-validation was used to evaluate their performances.

Results/Discussion

The proposed RAB achieves the best performance with accuracy, sensitivity, specificity and area under the receiver operating characteristic curve (AUC) of 92.67%, 98.08%, 89.80% and 0.975, respectively, exceeding that of the experienced clinician with accuracy, sensitivity and specificity of 88.67%, 98.08% and 83.67% (Fig. 1). The RAB exceeds other feature selection algorithms by large margin because it makes more efficient use of features. The proposed quantitative analysis method combined with multi-modal ultrasound images is promising for accurate diagnosis of breast tumor.

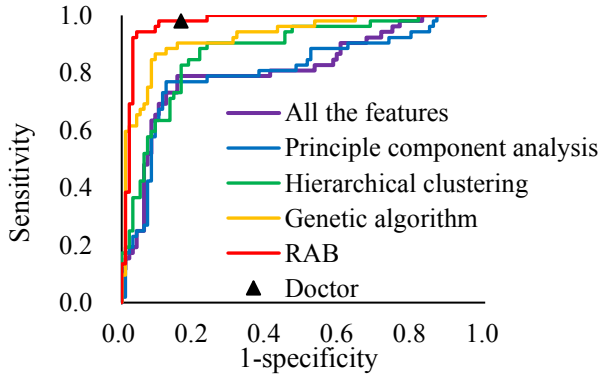

Fig. 1. ROC curves of different methods with multi-modal ultrasound images.