Classification of Benign and Malignant Breast Tumors by Ultrasound B-scan and Nakagami-based Images

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Abstract

The B-scan shows the intensity of reflected echoes and is clever at a clear description of tumor contour to provide knowledge of morphology. Nakagami image reflects the statistical distribution of local backscattered signals, which is associated with the arrangements and concentrations of scatterers in tumors. In this study, we explored the clinical performance of combining B-scan-based tumor contour analysis and Nakagami-image-based tumor scatter characterization in classifying benign and malignant breast tumors. To confirm this concept, raw data obtained from 60 clinical cases were acquired. The B-scan images were used to calculate the standard deviation (SD) of the shortest distance for contour feature analysis. The Nakagami images were applied to estimate the average Nakagami parameters in the region of interests (ROI) in tumors. Overall, malignant tumors were highly irregular in tumor contour, whereas they had lower average Nakagami parameters in scatter characterization. The receiver operating characteristic (ROC) curve and fuzzy c-means (FCM) clustering were used to estimate the performances of combining two parameters in classifying tumors. The clinical results showed that there would be a tradeoff between the sensitivity and specificity when using a single parameter to differentiate benign and malignant tumors. The ROC analysis demonstrated that the SD of the shortest distance had a diagnostic accuracy of 81.7%, sensitivity of 76.7%, and specificity of 86.7%. The Nakagami parameter had a diagnostic accuracy of 80%, sensitivity of 86.7%, and specificity of 73.3%. However, the combination of the SD of the shortest distance and the Nakagami parameter concurrently allows both the sensitivity and specificity to exceed 80%, making the performance to diagnose breast tumors better.

Keywords: Breast tumor classification, Nakagami image, Contour and scatterer characterization

1. Introduction

Breast cancer is the most common cancer in women worldwide. Ultrasound imaging has advantages including nonionizing radiation, noninvasiveness, real-time display, and comparatively low cost and good penetration ability compared to mammography, which make it convenient and suitable for routine and frequent breast screening. Malignant breast tumors without pseudocapsule will tend to invade the surrounding tissues, resulting in the sonofeatures of poorly defined and irregular contours, such as spiculation, microlobulations, angular margins, posterior shadowing, and tissue architectural distortion [1-4]. For these reasons, the major purpose of the conventional B-scan in breast screening is to clearly portray the tumor contour features and to take effective contour parameters for classifying between benign and malignant tumors [5-8]. Nevertheless, it is hardly to find an effective contour feature that is suited for all the tumor shapes, and the contour analysis is insufficient to describe all the tumor properties for lack of information from the interior of the tumor.

Fortunately, previous studies have confirmed that the information about the scatterer properties inside tumors may be extracted from the backscattered signals. It is worth noting that the backscattered signals are treated as random signals. Thus, modeling the probability density function (pdf) of the backscattered signals by some appropriate statistical distributions can help us understand the backscattering behaviors, which are demonstrated by the scatterer properties. Among all possibilities, the Nakagami statistical distribution has recently received considerable attention. The parameter of the Nakagami distribution estimated from the backscattered echoes can identify various backscattering distributions in medical ultrasound, having the ability to characterize biological tissues [9,10]. It has been shown that the Nakagami parameter can be used to assist conventional B-scan when classifying breast masses [11,12]. Then the ultrasonic Nakagami parametric image was developed and evaluated, and the concept of it originated from the suggestion of Shankar [13]

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