Using T2-weighted MRI in the Automated Analysis of Breast Cancer Lesions

N. Bhooshan[1], M. Giger[1], L. Lan[1], A. Marquez[2], H. Li[1], and G. Newstead[1]
[1]University of Chicago, Chicago, IL, United States, [2]Loyola University, Chicago, IL, United States

Purpose:

Current breast MRI computer-aided diagnosis (CADx) schemes only analyze dynamic contrast-enhanced MRI (DCE-MRI); however clinicians examine T2-weighted images alongside T1-weighted DCE-MRI images in their standard interpretation of breast MRI cases. The purpose of this study was to (1) investigate the automated analysis of T2-weighted MRI images in distinguishing malignant and benign breast lesions and (2) evaluate whether including T2-weighted computer features in the current DCE-MRI CADx can improve its diagnostic performance.

Materials and Methods:

Breast MR images were obtained on a 1.5T Philips Achieva scanner with a 16-channel breast coil between November 2008 and August 2009. The protocol included axial TSE T2-weighted images and DCE study using 1 pre- and 6 post-contrast fat-saturated axial T1-weighted images with temporal resolution of 60 seconds and in-plane resolution of 0.94x0.94mm^2. The database contained 86 benign breast lesions (no cysts) and 110 malignant breast lesions; focal lesions were excluded.

Our in-house-developed breast MRI CADx workstation automatically segmented each lesion on the T1-weighted images using the fuzzy c-means method (FCM) and then calculated each lesion's characteristic kinetic curve using FCM. Since the T1 and T2 images were registered, the same segmentation was used on the T2-weighted images. Geometric features based only on the lesion segmentation (circularity, irregularity, and size) were calculated. For the T1 images, kinetic features and morphological features including margin features (margin sharpness, variance in margin sharpness, and variance in radial gradient index (RGI)) and texture features using the gray-level co-occurrence matrix (GLCM) were automatically generated. For the T2 images, the same morphological features – GLCM-based texture features and margin features – were also calculated.

Stepwise linear discriminant analysis using a Wilks lambda cost function in a round-robin fashion was utilized for 4 classification tasks: only T2 features, only T1 features, only geometric features, and all features combined. The selected features were merged with a 2-class linear discriminant classifier using round-robin by case evaluation. The ROCKIT software was used to evaluate the classifier's performance, and the area under the ROC curve (AUC) was used as the performance metric.

Results:

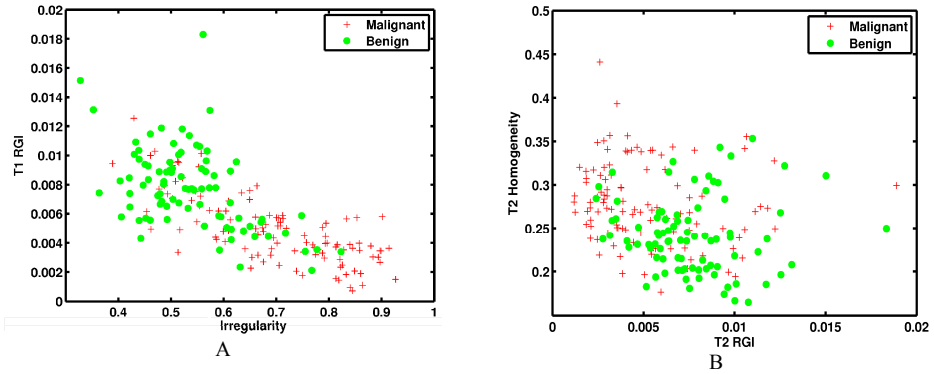

Figure 1: Relationship between (A) Irregularity and RGI from T1-weighted MRI and (B) RGI and Homogeneity from T2-weighted MRI in the task of distinguishing between malignant and benign breast lesions

Figure 1 shows the relationship of four dominant computer-extracted features. Irregularity is a geometric feature that describes the deviation of the 3D lesion surface from a spherical surface; RGI describes how well the structures in the lesion extend in a radial pattern originating from the center of the lesion. Homogeneity is a GLCM-based measure of local homogeneity within the lesion.

In comparing similar features between T1- and T2-weighted images, the Pearson correlation for the RGI and Homogeneity features were 0.67 and 0.72 (respectively) with p-value < 0.0001 for both. Since these values are less than 1, the image data for T1-weighted images vs. T2-weighted images of the same lesion contained different data.

Table 1 shows the selected features and AUC values for the classification tasks.

	T2 features	**T1 features**	**Geometric features**	**All (T1, T2, Geometric) features**
Selected features with single-feature AUC	Homogeneity (0.72) RGI (0.74) MaxCC (0.69)	RGI (0.78) Time to Peak (0.64) Signal Enhancement Ratio (0.69) Homogeneity (0.68) Variance in Time to Peak (0.55) Uptake Rate (0.58)	Irregularity(0.82) Size (0.81) Circularity (0.67)	Irregularity (0.82) T1 RGI (0.78) T1 Variance in Time to Peak (0.55) T1 Signal Enhancement Ratio (0.69) T2 Homogeneity (0.72) T2 SumAverage (0.53)
AUC ± SE	0.78± 0.03	0.83± 0.03	0.81± 0.03	0.85 ± 0.03

Table 1: Selected features and corresponding AUC values for classification tasks

Discussion:

Computer-extracted features from T2-weighted MR images yielded an AUC value of 0.78± 0.03 in differentiating between malignant and benign lesions based solely on morphological characteristics of the lesion. Thus, it shows promise in diagnostic classification. Computer-extracted features from T1-weighted MR images achieved an AUC value of 0.83± 0.03 which was expected since the DCE-MRI analysis looks at kinetic and morphological features. When using only the geometric features, which were calculated using only the segmentation outline and no image data, an AUC value of 0.81± 0.03 was reached.

When all T2, T1, and geometric features were entered into the stepwise feature selection, two T2 features (Homogeneity and Sum Average) were selected along with three T1 features and one geometric feature, indicating that the T2 features performed strongly enough among the T1 and geometric features to be selected. The resulting AUC of 0.85± 0.03 was higher than the only-T1 AUC although it failed to show statistical significance. We find this study promising in that T2-weighted MR images do contain different image information than the T1-weighted MR images which may improve the computer's performance in distinguishing malignant and benign breast lesions.