Blind Source Separation of Signals from Dynamic Contrast Enhanced Breast Magnetic Resonance Images

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Introduction

Breast cancer is the most frequently diagnosed cancer and the leading cause of death among women in the United States. Although many imaging modalities have been utilized to detect and assess the breast cancer, dynamic contrast enhanced breast magnetic resonance imaging (MRI) is presently the best strategy for differentiating benign from malignant breast lesions because of its sensitivity and specificity. As compared to the others, dynamic breast MRI generates larger amount of images. Picking up the dynamic response of lesions and spatial lesion morphology is thus laborious. It is therefore necessary to find a way to work effectively on large samples automatically. Blind source separation (BSS) is a promising statistical technique to separate multiple signals from their mixture without any apriori information. In this abstract we evaluated the application of BSS on dynamic breast MRI. Our retrospective analysis of DCE breast data shows that BSS findings correlate highly with the clinical diagnosis.

Materials and Method

MR Data acquisition : Data from six patients that underwent DCE in our institution were analyzed using the BSS technique. The patients' ages range from 42 to 57. Four of the patients were diagnosed as having malignant lesions and two had benign lesions. The data were all acquired on 1.5T clinical MR scanner (Siemens). Image matrix was 448x448. Slice number varied from 160 to 175 with 2mm slice thickness (no slice gap). Contrast was injected following the first time point of the dynamic acquisition with 5-7 subsequent acquisitions obtained after the injection at 60 second intervals for a total of 6-8 dynamic scans. Four of the patients had 6 dynamic scans and two patients had 7 and 8 dynamic scans respectively.
BSS data processing: As the name implies, BSS can extract uncorrelated and independent components from a dataset. Principal component analysis (PCA) and independent component analysis (ICA) are two main approaches for BSS. [2] In this application, we first conduct the dimension reduction by PCA, remove the mean from each principal component, then extract the independent but meaningful components from the transformed data using SICA. [3]

Results

Five to seven independent components were produced depending upon the patient. Figure 1 (upper row) illustrates one of the prominent resulting independent components for the six patients. These components represent distinct temporal patterns of the dynamic data as determined during clinical diagnosis. Also shown in figure 1 (lower row) are the color-coded maps of correlation coefficient (0.5: blue, 1: red) with each independent component respectively. The regions with significant correlation are the lesions indicating the spatial characteristics of the enhancement.
The BSS findings were also compared with the radiologist's diagnosis (see figure 2). As demonstrated in the two figures, the dynamic curves are similar, and the locations of lesions are comparable.

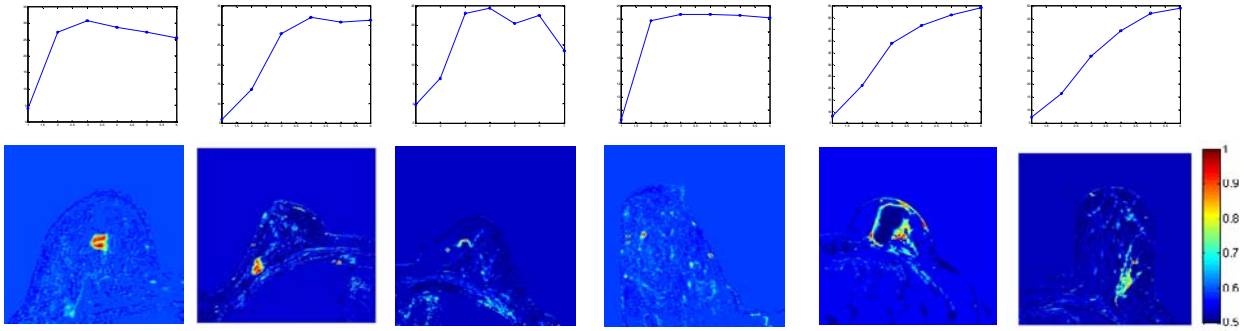

Figure 1: The location and dynamic response of lesions (six patients) extracted by BSS.

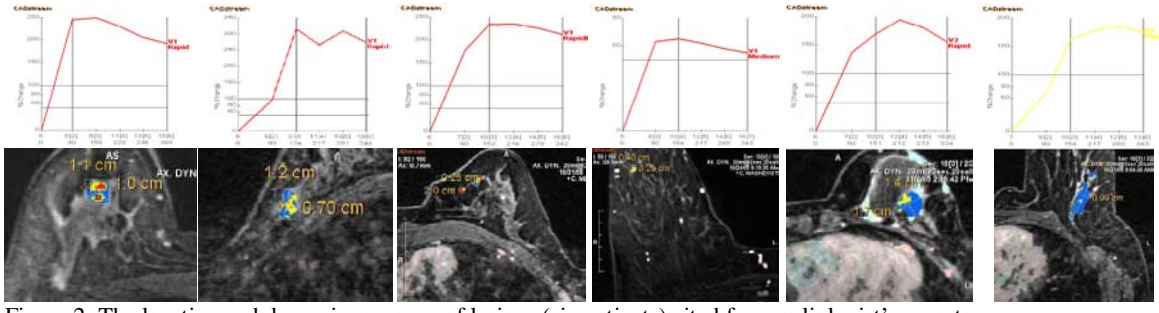

Figure 2: The location and dynamic response of lesions (six patients) cited from radiologist's reports.

Discussions and conclusion

The successful application of BSS to dynamic contrast-enhanced breast MRI demonstrates that BSS is capable of extracting lesion's dynamic response automatically. The first two independent components from any given data satisfied the clinical diagnosis. There were no lesions that were clinically diagnosed that were missed by BSS. However, the relevance of other components are not clear given the small study. Efforts are underway to perform BSS in real time which will enable us to further probe the suspicious lesions through techniques such as MR spectroscopy.

References

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