Improving the Specificity of Breast MRI with Fuzzy Cluster Analysis

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Introduction: MRI has shown promise in aiding the characterization and diagnosis of mammographically-detected breast tumours. After reviewing recent studies showing the high sensitivity of Gd-enhanced breast MRI, the American Cancer Society has recently recommended breast MRI for screening of high-risk women [1]. However, while sensitivity is excellent, specificity is challenged by the enhancement of many benign features such as fibroadenomas and fibrocystic lesions, and has been reported to be as low as 30%. Part of the problem in characterizing enhancing lesions is the manner in which contrast kinetics are analyzed. To evaluate kinetics, a radiologist will typically calculate the time course of a selected region inside the tumour. However, if the enclosed region exhibits both malignant and benign kinetics, the distinction may be masked by the averaging process, resulting in an indeterminate time course that may be of little diagnostic value. We propose a means of allowing the radiologist to view and evaluate significant time courses without manual selection or undesired averaging through the use of fuzzy cluster analysis (FCA) [2]. Fuzzy clustering allows the user to separate the image time courses into a defined number of significantly different time course clusters, allowing the radiologist to use FCA to rapidly cluster and evaluate enhancing areas of the image. The advantages of this method are twofold: superior characterization of the primary tumor site, and screening for potential ipsilateral and contralateral secondary tumors with similar kinetic characteristics.

Methods: Anonymized, *in vivo,* Gd-enhanced, dynamic image sets were collected on a 1.5T scanner from clinical patients by collaborating radiologists. Dynamic contrast enhanced breast imaging parameters: TR/TE – 9/4ms, 45˚ flip, IR fat suppression, 512x256x32 matrix resulted in a temporal resolution of 90 s. 6 time points were obtained. Fuzzy clustering was performed using the EvIdent® [3] fuzzy clustering software package.

Results: In figure 1, panel A illustrates FCA processing of a 51 year old patient. Centroids of the resulting clusters reflect both benign (yellow) and malignant (red) features. The tumour was biopsied and shown to be a malignant carcinoma. A previously-unnoticed contralateral enhancing area with kinetics similar to the primary tumour site was also revealed. Another case (41 yo) with proven carcinoma is shown in panel B. Regions with malignant kinetic characteristics (in green) are present at the periphery of the tumour. This is consistent with the presence of a hypoxic core. The same patient with a ROI covering the bulk of the tumour demonstrates how averaging a region can result in an indeterminate time course (panel C).

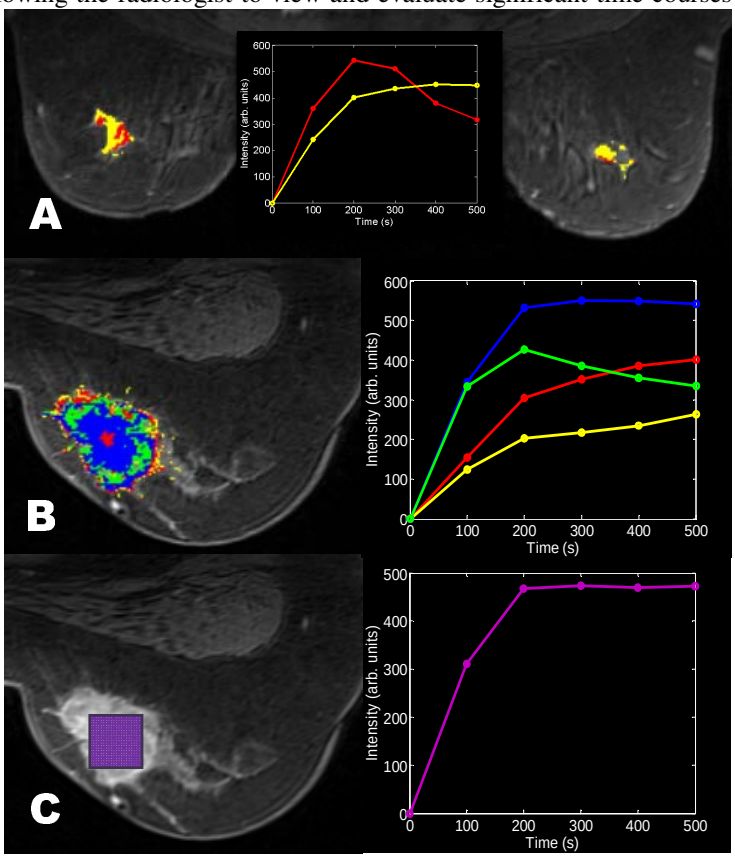

Figure 1. (A) Patient with confirmed carcinoma in right breast. FCA reveals a suspicious contralateral region with similar kinetic characteristics. (B) Malignant tumor site with detailed metabolic characteristics revealed by FCA, featuring a malignant outer layer (green). (C) Sample ROI covering the bulk of the tumour reveals a persistent enhancement with little diagnostic value.

Discussion: Preliminary results with FCA analysis show a clear improvement in kinetic evaluation over traditional ROI averaging techniques. The analysis was made with neither prior knowledge of the expected response nor operator region-of-interest (ROI) contouring. Complex-uptake kinetics and morphological features can be quickly and reliably analyzed, summarized, and presented to the radiologist in a manner which allows for rapid evaluation.

References:

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