Excitation Independent Fat Suppression for DCE MRI of Breast Cancer, using a Multivariate Statistical Approach

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Introduction

Effective fat suppression in images is of major importance for dynamic contrast enhanced MRI of breast cancer. Current approaches rely on subtraction, fat suppression or water excitation. Selective saturation or excitation require high field homogeneity, which can often present a challenge, and may result in longer measurement times and increase power deposition. Subtraction imaging will not completely remove fat, since fatty tissue enhances to some extent. It should be noted that images are affected by stochastic noise and subtraction operation will increase noise of the resulted image, so even if the tissue is not enhancing, it would posses residual noise artefacts on the subtracted image. As a result the tumour-outline is not always well defined. In this abstract we propose a post-processing method of fat suppression using Principal Components Analysis (PCA) [1], a common tool from multivariate statistical analysis. The algorithm and the results of our initial valuation are presented.

Methods

The authors found that the second principal component of an uptake vector can discriminate between the groups of vectors representing fat and non-fatty tissue. (Here an uptake vector is a set of values representing temporal evolution of a signal from a single voxel through the series of the datasets acquired during dynamic measurement.) The magnitude of signal enhancement in fat due to the contrast material is much smaller than in other breast tissues. It follows that statistical measure of enhancement may discriminate between fat and non-fatty tissue, and it was found that the second principal component is a statistical measure of enhancement. (Latter was proven by the fact that the second principal component is statistically associated with the introduced measure of enhancement defined as an angle between an uptake vector and the idempotent vector (vector of equal values.) The presented method consists of two steps. First, the uptake vectors are reconstructed from their principal components ignoring the first principal component. Since the first principal component accounts for the most common information in the study, its subtraction reveals the differences between the datasets that are due to the contrast uptake. Second, the uptake vectors having a value of the second principal component extending the estimated optimal cut-off value are replaced with zero vectors. The cut-off value is estimated decomposing the distribution of the values of the second principal component into Gaussian and residual (non-Gaussian) fractions, where the Gaussian fraction was proven to represent the cluster of fat.

Results

The authors selected 16 symptomatic breast dynamic studies acquired on a Siemens 1.5T scanner using 3D T1-weighted fast spoiled gradient echo sequence with a temporal resolution 90 sec and a spatial resolution 1.33 x 1.33 x 2.5 mm (matrix size 256 x 128 X 64) [2]. Each study had two pre-contrast and four to five post-contrast datasets acquired after bolus injection of Gd DTPA. The data were previously checked to ensure that there was not significant motion. The results were compared to the corresponding subtracted post-contrast images. In all the studies the anatomically correct fat suppression was shown along with improved contrast for lesions. An example of a processed image is shown in fig.1.

Conclusions

This study provides a way of producing dynamic images combining high temporal and spatial resolution with fat suppression. The method provides a capability of fast visual and reliable analysis of the data. Visualization of differences in the dynamic contrast characteristics of the tissue can be used for discrimination between tumour and blood vessels, and identification of structure. In addition, the method can be combined with the existing PCA based methods of noise reduction. The project is currently in progress and the next step will be validation of the method using significantly larger amount of data applying motion correction algorithms, and employing several independent observers to validate the results. The method will be subject to clinical evaluation. Future research will address using the method as input for further tissue classification and building parametric images.

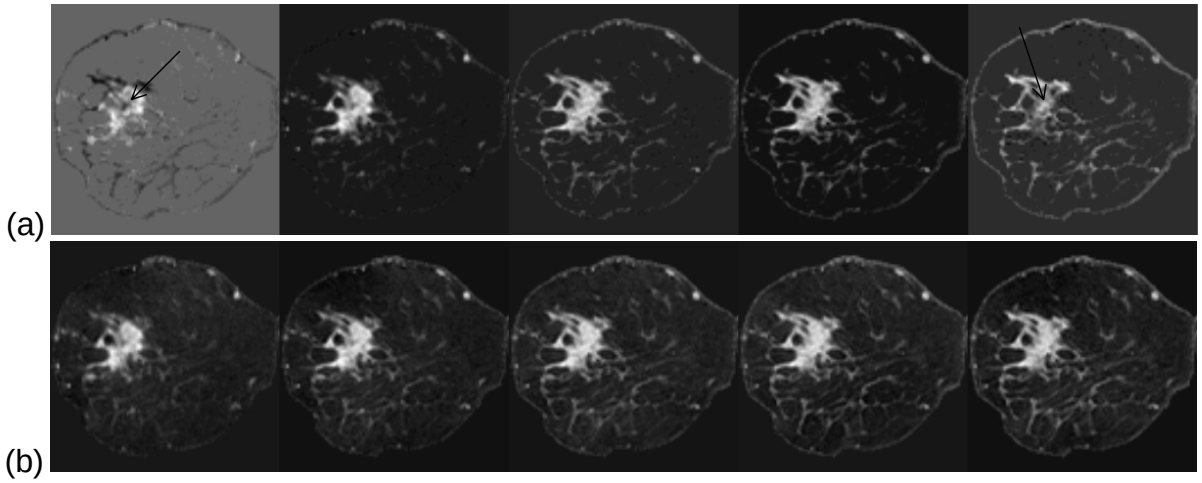

Fig.1. Sequence of post-contrast images processed by the presented approach (a) and corresponded sequence of subtracted images (b). Time increments from left to right. Comparing the sequences one can see anatomically correct fat suppression. Note that backgrounds of the images vary since the images contain signed values, and the background grey colour corresponds to the value of zero that outlines the suppressed fat. One can see differences in uptake dynamics between central and peripheral regions of the tumour. First image (on the left) shows enhancement of periphery and now enhancement in the centre (pointed by the arrow); middle images show continuous enhancement of the centre; last image show that the centre is still enhanced when the contrast material has partly washed out of the peripheral region. All these details are not clearly seen on the corresponded subtracted images.

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References

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