Highly accelerated *k-t* SENSE cardiac perfusion imaging

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Introduction

In first-pass contrast-enhanced myocardial perfusion imaging, high spatial and high temporal resolutions are crucial requirements in order to acquire diagnostically meaningful perfusion information [1]. However, as it is generally the case in dynamic MRI, there is a trade-off between the achievable spatial and temporal resolutions. In order to relax this trade-off and accelerate perfusion imaging, techniques which exploit either spatial [2] or spatiotemporal correlations [3, 4] jointly with coil encoding have been proposed. Despite the reduced acquisition time achieved, further acceleration is desired in order to increase spatial resolution as well as coverage.
In this work, the potential of *k-t* SENSE [5] in perfusion imaging using high reduction factors is investigated. In order to reduce the temporal blurring induced by the high acceleration factors and the coarse spatial resolution of the training data, *k-t* SENSE was modified to allow for increased spatial resolution of the training without compromising net acceleration. This was attained by applying parallel imaging to the training data, thus achieving higher spatial resolution while keeping the same number of acquired profiles [6].

Methods

A realistic computer model was generated based on an actual perfusion scan and its sensitivity map (32 channel coil array). The reconstruction matrix was 192x140 with 30 dynamics. Perfusion curves for the different anatomical regions were extracted from the same scan and intensity variations in the model were simulated accordingly. Uncorrelated Gaussian noise was added to the sample *k-t* space data with standard deviation equal to 0.2% of the maximum signal level in the center of *k*-space of all frames. To allow for a quantitative assessment of the reconstruction result, the model was decimated to simulate a 10x nominal acceleration. The training data consisted of nine profiles acquired either at full field-of-view or with two- and three-fold reduced field-of-view and subsequent SENSE reconstruction (Figure 1). The net acceleration factor was therefore 6.33.
In order to reduce noise amplification resulting from non-orthogonality of coil encoding in parallel imaging, anisotropic diffusion filtering (λ=3, σ =1) [7] was applied to the SENSE reconstructed training data. These filters are characterized by the fact that they remove noise while preserving the edges of an image. Considering the necessity to preserve temporal fidelity in *k-t* SENSE, anisotropic diffusion filters are particularly fitted for this purpose.

Results

Figure 2a compares the perfusion curves acquired from a 3x3 septal region of a fully sampled acquisition (reference) and 10x *k-t* SENSE using different training data acquisition strategies. It is seen that applying 2x and 3x SENSE to the training data results in a reduced variation of the perfusion curves and higher temporal fidelity. This observation is confirmed by a lower mean absolute difference between the modified *k-t* SENSE and the reference curves in comparison to the conventional reconstruction. Figure 2b illustrates the advantage of using anisotropic diffusion filtering to the SENSE reconstructed training data. The resulting noise reduction is also reflected to the perfusion curves of the filtered training, which deviate less from the reference curve (lower mean absolute difference).

Discussion

A modification of the *k-t* SENSE method and its application to perfusion imaging has been demonstrated. Undersampling the training and reconstructing it using SENSE results in data of higher spatial resolution which, when fed to the *k-t* SENSE algorithm, improve the fidelity of the reconstructed image series. In perfusion imaging, the potential of the method could be confirmed by curves with higher temporal fidelity (significantly lower error). Further work will address residual folding artifacts occurring due to coil sensitivity variations across the large voxels in the training data [8].

References

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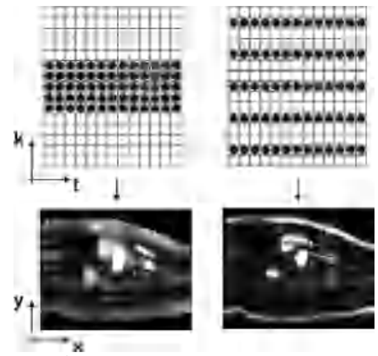

***Figure 1**. Conventional sampling scheme for the training data and corresponding low resolution image (left column); modified (under-)sampling scheme for the training data and corresponding higher resolution SENSE reconstructed image (right column).*

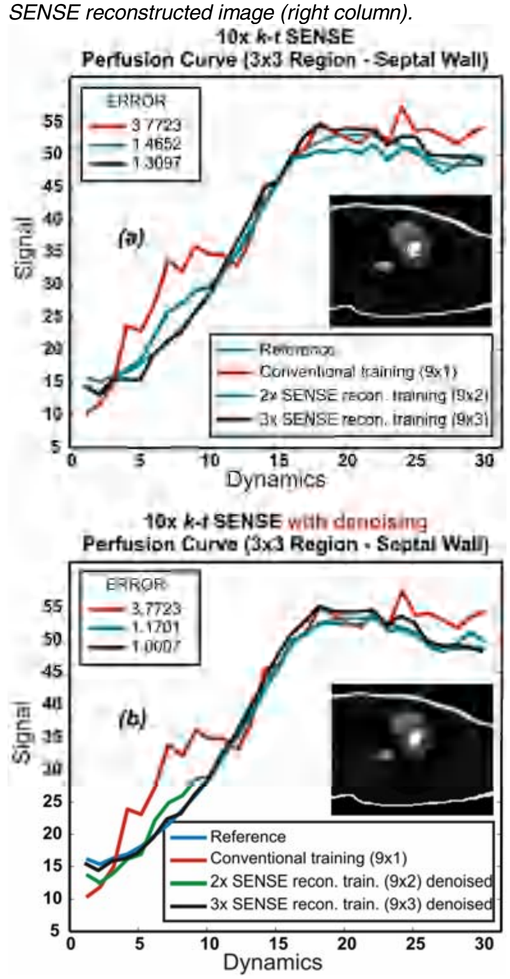

***Figure 2**. Upper figure: Comparison of perfusion curves from a 10x k-t SENSE reconstruction using the conventional (9 profiles) and the SENSE reconstructed training data (9x2 and 9x3 profiles undersampled by a factor of 2 and 3 respectively) along with the corresponding absolute error. Lower figure: The same comparison, this time using anisotropic diffusion filtering of the SENSE reconstructed training data.*