Method for Estimating k-t Sensitivity from Under-Sampled Data with No Training Scans

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Target Audience: Researchers involved with image reconstruction in magnetic resonance imaging.

Purpose: By using k-t SENSE[1] and improved versions of this technique, a high reduction factor (typically $R \geq 4$) can be achieved in dynamic MRI. However, calibration data must be acquired to estimate k-t coil sensitivity maps. The number of calibration samples is relatively high when the number of phase encodes (PEs) is small or when the reduction factor is high. While a k-t prior[2] can be trained using a large set of similar k-t data,[3] generic k-t frameworks without any training data are not known. The purpose of this research is to reconstruct k-t data with no training data.

Methods: This paper presents a novel calibration method for estimating the k-t sensitivity. The proposed method removes aliased signals in the binarized sensitivity, estimates the unreliable part of the non-binarized sensitivity, and merges them to estimate the final k-t sensitivity. A flowchart of the proposed method is shown in Figure 1. The proposed method consists of the following steps. Step 1: Compute the x-f data by applying k-t Fourier transform to the input k-t data. Step 2-a: Compute the x-f sensitivity using the x-f data. Step 2-b: Based on the assumption that the time-dependent part of the x-f sensitivity can be ignored, estimate the unreliable part of the x-f sensitivity. Step 3-a: Binarize the x-f data and merge all channels. Step 3-b: Apply an LPF to the binarized data. Step 3-c: Detect moving regions in the binarized data and modify the binary values in these regions. Step 4: Compute the final x-f sensitivity by applying the output of step 3-c to the output of step 2-b. After the x-f sensitivity is estimated, a SENSE method is applied to the x-f data in x-f space.

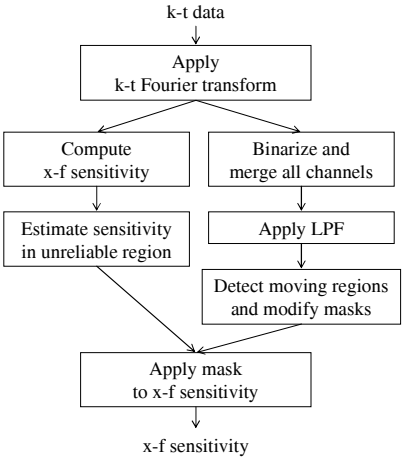


Figure 1. Flowchart of the proposed method.

Results: To compare the proposed method with SENSE and k-t SENSE (32 phase encode steps for auto-calibration), down-sampled data with reduction factor 6 were simulated from 8 full-sampled data using retrospective, breath-holding, 2-dimensional steady-state free precession (SSFP) cine images. The scanning conditions were 256 readout encoding steps, 96/R phase encoding steps, 16 coils, and 24 frames. The reconstructed images are shown in Figure 2. The processing time is shown in Figure 3. To confirm the effectiveness of the proposed method, single-shot, free-breathing, 2-dimensional SSFP cine images with reduction factor 4 were acquired using a 1.5-T MRI scanner. The scanning conditions were 256 readout encoding steps, 96/R phase encoding steps, 32 coils, and 96 frames. An image reconstructed using the proposed method is shown in Figure 4. The processing time of the proposed method was about 11.6 seconds.

Discussion: The images reconstructed by the proposed method are as clear as those reconstructed by k-t SENSE. The processing time of the proposed method is comparable to that of existing methods. In addition, the proposed method makes it possible to reduce the acquisition time for calibration.

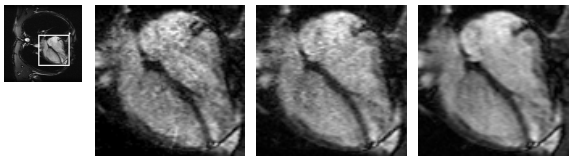
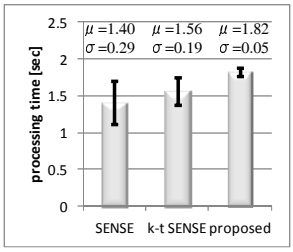


Figure 2. Reconstructed retrospective cine images.

Conclusion: It has been confirmed that the proposed method can estimate k-t coil sensitivity maps from only the k-t data to be reconstructed. Evaluation of the clinical usefulness of this method (e.g., in cardiovascular imaging) is a topic for future research.



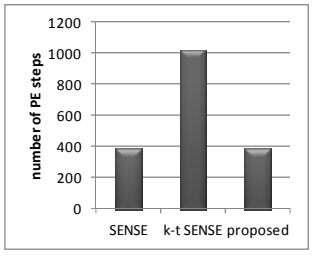


Figure 3. (left) Processing time. (right) Number of PE steps to be acquired.

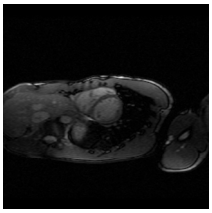


Figure 4. Reconstructed single-shot cine image.

References:

1. Tsao J. et al. k-t BLAST and k-t SENSE: Dynamic MRI with High Frame Rate Exploiting Spatiotemporal Correlations. Magnetic Resonance in Medicine. 2003; 50: 1031-1042.

2. Pedersen H. et al. k-t PCA: Temporally Constrained k-t BLAST Reconstruction Using Principal Component Analysis. Proc. ISMRM. 2009; 17: 559.

3. Chu M. et al. Spatiotemporal Acceleration of Dynamic MR Imaging without Training Data: Prior-data-driven k-t PCA. Proc. ISMRM. 2012; 20: 2246.