Auto-calibration method for k-t-SENSE: Using TGRAPPA to calculate the training data

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Introduction

Parallel imaging techniques have been developed to speed up the acquisition by taking advantage of spatially varying sensitivity information of a multi–coil receiver array. In accelerated dynamic MRI, several methods have been proposed to reconstruct the missing data based on static region assumptions and/or prior knowledge about the motion. The k-t SENSE [1] method utilizes both coil sensitivity variations and correlations in k-space and time to reconstruct missing data. However, k-t SENSE requires an additional training data acquisition to obtain prior information about the dynamics of the object. It has previously been shown that temporal blurring may result from insufficient spatial resolution of the reference training data [2].This work removes the requirement of an additional training data acquisition in k-t SENSE by employing a TGRAPPA [3] reconstruction on the undersampled dynamic dataset which then can be used as training data for the actual k-t SENSE reconstruction. TGRAPPA produces images with high spatial and temporal resolution without inherent temporal filtering effects and is therefore fully applicable for producing high-quality training data for k-t SENSE.

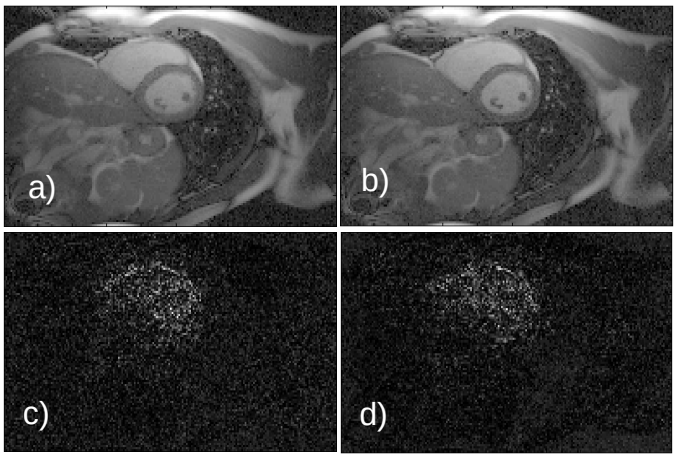

Figure 1. Simulation results: a) Auto-calibrated k-t SENSE reconstruction (R=8, 32 channels) and b) conventional k-t SENSE reconstruction (R=8, 32 channels) with 32 training profiles resulting in an effective acceleration of R_{eff} = 2.6 and, c) error between auto calibrated k-t SENSE and Reference Data and d) error between conventional k-t SENSE and Reference Data.

Methods

In this work we have combined the benefits of TGRAPPA and k-t SENSE for further reduction of the acquisition time. In-vivo gated cardiac cine experiments were performed on a 1.5T whole body scanner (Siemens Medical Solutions, Erlangen, Germany) using 32 receiver channels for data reception.
Several data sets have been acquired on healthy volunteers with acceleration factors R =1, 4, 6 and 8. The data set with R = 1 serves as a Reference Data (RD) and was used to simulate undersampled datasets.
All reconstructions were done off-line using the MATLAB programming environment. In a first step, TGRAPPA was applied to the undersampled data to yield the training data for each time frame. In a second step, k-t SENSE reconstruction was performed on the undersampled data using the resulting TGRAPPA reconstruction as prior information. The result was compared with conventional k-t SENSE reconstructions using 32 training profiles of the fully sampled RD.

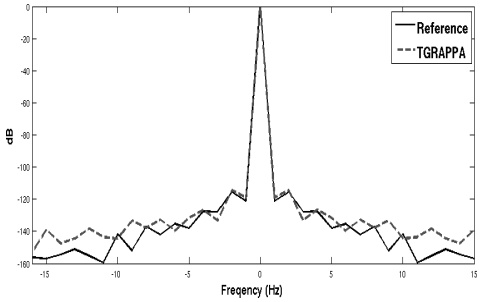

Figure 2. Temporal spectra for an 2x2 ROI placed in right ventricle.

Results

The series of images in Fig. 1 depict the behavior of k-t SENSE with simulated undersampling (R=8, 32 channels) a) using TGRAPPA result as prior information (auto-calibrated k-t SENSE) and b) using 32 training profiles of the RD set. Comparing the conventional k-t SENSE reconstructions with RD and our results also with RD we obtained the errors shown in the Fig. 1 c) and d) respectively. The measured mean square error was within 3% comparing the conventional and auto-calibrated k-t SENSE with the reference data. In Fig. 2, the good agreement between reference data and TGRAPPA (simulated R=4) reconstruction indicating that TGRAPPA has full temporal resolution without filtering is shown.
Additionally, in Fig. 3 R=8 fold accelerated a) TGRAPPA and b) auto calibrated k-t SENSE reconstructions are shown.

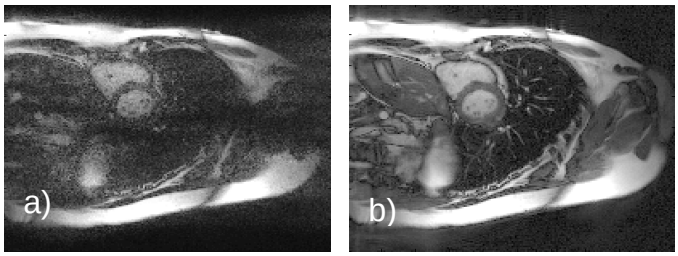

Figure 3. Reconstructions from an accelerated (R=8, 32 channels) experiment: a) TGRAPPA and b) Auto-calibrated k-t SENSE. Please note that the conventional k-t SENSE could not be performed because of missing training data.

Conclusions

In this work, an auto-calibrating method for k-t SENSE is proposed that does not require the acquisition of separate training data, thereby simplifying the scan and reducing overhead without compromising the image quality. The auto-calibration is performed using full spatial and temporal resolution data reconstructed with TGRAPPA. The higher spatial resolution auto-calibration data is expected to yield performance improvement. Rate 8 accelerated cardiac cine imaging is demonstrated with excellent image quality.

Reference

[1].Tsao J., Boesiger P., et al.. Mag Reson Med 2003; 50:1031-42.
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[3] Breuer F., et al.. Mag Reson Med 2001;53:981-5.

Acknowledgements

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