Self-Consistency Driven Data Rejection for Reduction of Motion Artifacts

T.Nielsen and P.Börnert
Philips Research Laboratories, Hamburg, Germany

Purpose: Motion during MRI data acquisition can cause artifacts which compromise the diagnostic value of images. Multi-slice high-resolution fast spin-echo imaging, routinely used in brain imaging, is particularly sensitive to motion since the data for one slice are acquired over a rather long time-span of approximately one minute and already sub-voxel size motion during this time-frame can create visible ghosting artifacts. Sources of motion artifacts in these scans include eye movement, swallowing, coughing or pulsation. Purpose of this study is to investigate if image quality can be improved by identifying which part of the data set is corrupted by motion and ignoring the motion-corrupted data in the image reconstruction. We used self-consistency of the data set [1, 2] to identify motion corrupted data. This is possible since the reconstruction problem is over-determined because multiple receive channels are used simultaneously and the full k-space is sampled.

Methods: Data acquisition: A standard fast spin-echo sequence was used on a 3T clinical scanner to acquire brain images from several volunteers using a 13-channel head coil. (3 mm slice thickness, 0.65 mm in-plane resolution, FOV 230x180 mm², TE/TR 100/2000 ms, echo train length 13). Only the ordering of interleafs was changed to golden section ordering to separate successive interleafs as far as possible in k-space. This improves the condition of the image reconstruction from partial k-space data, in the case when several consecutive interleafs have to be rejected. The volunteers were instructed to swallow or cough at a random time during the scan.
Image reconstruction: An iterative SENSE reconstruction with additional image regularization was used to reconstruct images from incomplete k-space data. The algorithm was initialized with the image reconstructed from the full data set to achieve sufficiently fast convergence. Interleafs were removed up to a maximum number of 4 interleafs (20% of the data set) if indicated by inconsistency. The difference between the projected image at the end of the iterative reconstruction and the measured data was taken as a measure of data inconsistency (see further details in [1, 2]).

Results and Discussion: Motion corrupted data can clearly be identified by an increased data inconsistency. This is enabled by the high redundancy in the data set. Even after data rejection the image reconstruction is still highly over-determined due to the large number of independent receive channels.
In the calculation of the inconsistency it was assumed that the coil sensitivity maps are without error which is reasonable to a certain limit, since the head coil has a rigid geometry.
Data rejection significantly reduced image artifacts due to motion (see Fig.1). The images reconstructed from partial data sets show less ghosting. Also the sharpness was increased in regions of the anatomy with more soft tissue. Data rejection decreases signal-to-noise ratio (SNR) in the reconstructed image in a way similar to accelerated parallel imaging. But on the other hand SNR is also gained because the improved data consistency results in a reduced artifact level, which can be perceived a pseudo noise. These two opposing trends can be balanced by varying the number of interleafs which are rejected.
Convergence of the iterative reconstruction was very fast: Only a maximum of eight iterations of regularized iterative SENSE were necessary for convergence.

Conclusion: A significant reduction of motion artifacts could be achieved by using only a sub-set of data in the reconstruction. The method presented here could be applied as an optional post-processing step after a standard exam.

References: [1] Samsonov, et al. MRM **63**:1104–1110 (2010); [2] Mendes and Parker, MRM**65**:1085–1090 (2011);

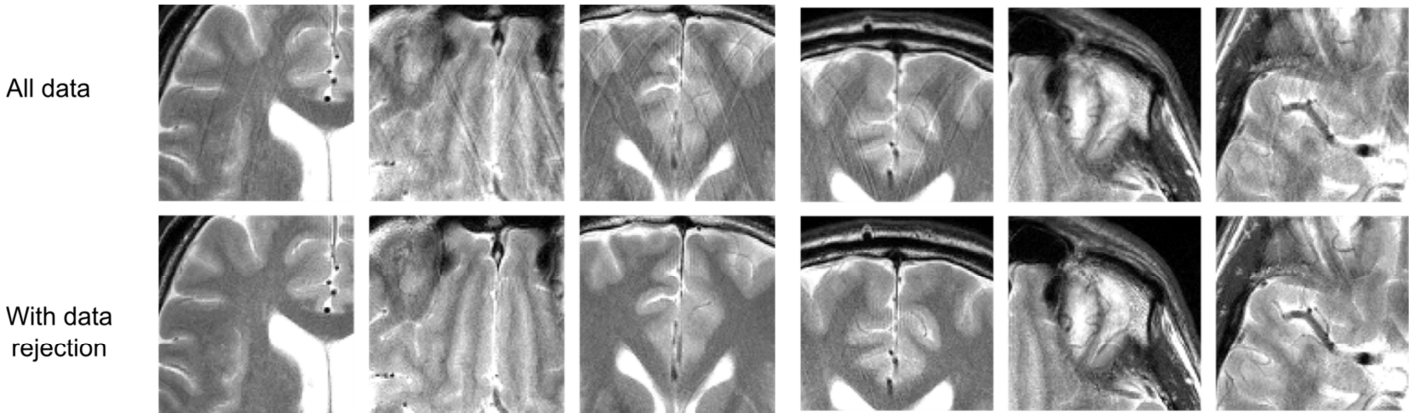

Figure 1: Examples from several volunteer scans for image quality improvement due to self-consistency based data rejection: The top row shows the reconstructed image using all data. Only a zoomed region of the reconstructed image is shown for better comparison. The bottom row shows the same image region with parts of the data set rejected. Data rejection significantly reduces ghosting artifacts and may also increase sharpness.