Identification and correction of the intra-scan motion artifact using parallel imaging

N-K. Chen[1], Y-H. Chou[1,2], L. P. Panych[1]

[1]Radiology, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, United States, [2]Occupational Therapy, Fu Jen Catholic University, Taipei, Taiwan

Introduction

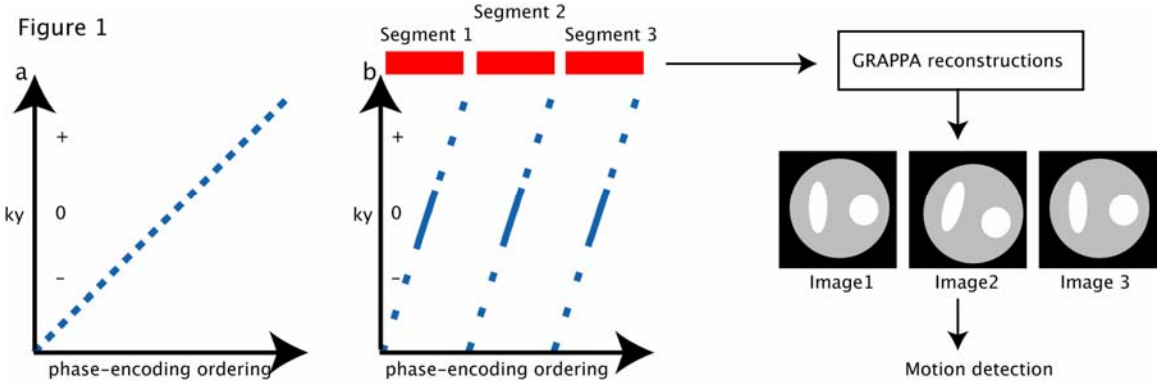
It has been shown previously that parallel imaging may be used to improve the spatial-temporal-resolution of dynamic MRI scans, or to reduce the effective echo time and geometric distortions in EPI. Here we propose a new application of parallel imaging technique*: identification and correction for the intra-scan motion artifact*. The phase-encoding in conventional 2D or 3D spin-warp imaging is re-ordered in such a way that the parallel imaging technique (e.g. GRAPPA in our implementation: ref.1) can be applied to detect and correct the intra-scan motion. Additional low ky lines are acquired so that the coil sensitivity corresponding to different subject positions can be properly estimated.

Methods

In order to detect the intra-scan motion with parallel MRI, the phase-encoding in conventional 2D or 3D imaging pulse sequences needs to re-ordered. For example, Figures 1a and 1b schematically compares the conventional 2D phase-encoding ordering and the modified ordering, which covers the same ky-sampling range as in conventional acquisition but further enables the parallel MRI reconstruction of multiple images from the partial ky segments (e.g. 3 segments in Figure 1b). Low ky lines in those segments are repeatedly acquired, so that coil sensitivity maps can be properly estimated in the presence of subject movement.

The images reconstructed from multiple segments are then processed to identify (a) inter-segment rotation, (b) inter-segment translation, and (c) through-plane motion and other un-correctable factors (ref.2). After characterizing the inter-segment motion, phase correction will be applied to the k-space data and the corrected data from different segments will then be combined. The k-space data corrupted by intra-segment will be considered "un-correctable" and abandoned. The abandoned segment will be replaced by the values calculated from other un-corrupted segment, using GRAPPA method. If no inter-segment motion is detected, k-space data from different segments will be simply combined for image reconstruction.

Figure 1

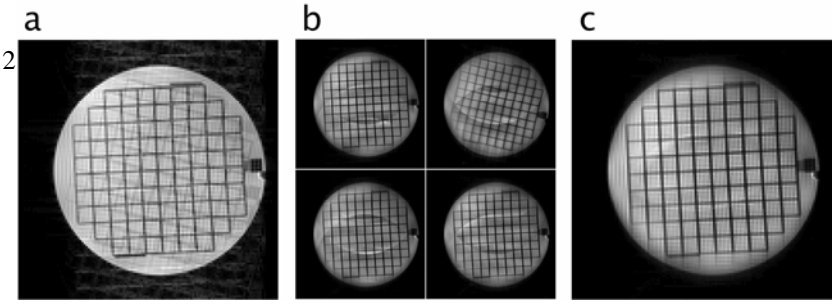


A phantom study was performed at 3T to evaluate the proposed intra-scan motion correction method. Data corresponding to different positions (manually controlled) were acquired with T1-weigthed spin-echo imaging pulse sequence. The phase-encoding was re-ordered so that four k-space segments were acquired. The inter-segment motion detection and correction procedures are similar to the approaches suggested by Pipe for the PROPELLER technique (ref.2).

Results

Figure 2a shows the image reconstructed without motion correction. It can be seen that the image is corrupted by intra-scan motion artifact. Using the GRAPPA method, four images are generated from partial k-space segments, as presented in Figure 2b. It can be seen that one of the segments corresponds to different position. Even though those segment images are affected by aliasing artifact due to imperfect parallel imaging reconstruction, the inter-segment rotations and translations can be reliably quantified. After characterizing the inter-segment motion, the original k-space data are phase corrected and integrated. The reconstruction image is shown in Figure 2c. In comparison to the uncorrected image (Figure 2a), the intra-scan motion artifact is significantly reduced in the corrected image (Figure 2c).

Figure 2



References:

(1) Grinwold M. A. et al. Magn Reson Med 47:1202, 2002. (2) Pipe J. Magn Reson Med 42:963, 1999.