Prospective Optical Motion Correction for Susceptibility-Weighted Imaging

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Target Audience: Clinicians and researchers interested in improving SWI image fidelity using an optical motion correction approach.

Purpose:

Prospective motion correction systems that use optical tracking have an advantage over navigator-based techniques, due to their fast response time and applicability to any MR imaging protocol without increasing the scan time [1-5]. In particular, imaging sequences such as time-of-flight (TOF) angiography [6] and susceptibility-weighted imaging (SWI) [7,8] are typically implemented with the minimum TR and therefore lack sufficient "idle" time that would allow the insertion of a navigator readout. For such sequences, an external tracking technique such as optical motion correction is an attractive candidate for allowing a full 6-DOF motion correction. In this study, we demonstrate the application of prospective optical motion correction using an external optical tracking system on a SWI acquisition.

Methods:

Prospective Optical Motion Correction

An MR-compatible camera was mounted on an 8-channel head coil [3,9]. The camera took a live video of a self-encoded checkerboard marker [9] that was mounted on the patient's forehead. The self-encoding of the checkerboard ensured continuous tracking of the head, even when the rungs of the coil occlude part of the marker. Video frames showing the marker were then sent to a laptop where the pose (i.e., the rotation and orientation of the marker) was estimated. The pose of the marker was sent to the scanner controller, where the scan-plane was adjusted in real-time to follow the motion of the head.

Experiment

The following parameters were used for the SWI scan: TR/TE = 41.5/24.4ms, FOV=240mm, flip angle= 15°, echo train length = 6, slice thickness=2mm, acquisition matrix size: 320x224, ASSET factor=2. A volunteer was asked to perform deliberate head shaking motion throughout the scan. Three scans were carried out: 1) Subject performing deliberate motion and optical prospective motion correction turned off, 2) Subject performing deliberate motion and optical prospective motion correction turned on and 3) No subject motion, to serve as a reference. In order to ensure the repeatability of motion between the motion-affected scans, the subject was instructed (through the intercom of the scanner) to move every 30 seconds. The SWI images were produced by generating a phase mask using a 2D Hanning window for each individual coil, a multiplication of the phase mask by the magnitude coil by 5 times, followed by the sum of squares over coils. A minimum intensity projection (MinIP) was then taken over a 10mm thick stack of partitions.

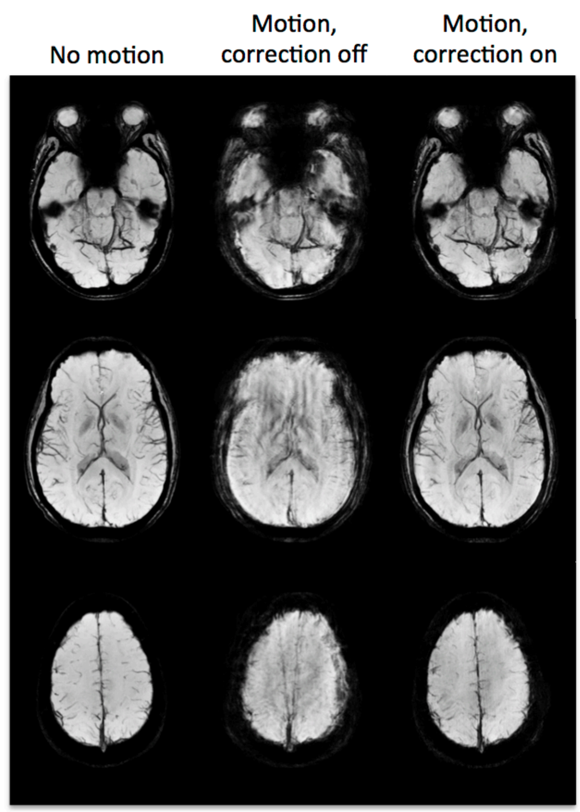

Figure 1: Post-processed minimum intensity projection SWI images with and without prospective motion correction. The "no motion" image serves as a reference.

Results:

Figure 1 shows the SWI images from three different slices. The loss of venous structures in the motion-corrupted image is obvious – especially in the frontal lobe (Fig1, middle column). These motion artifacts were significantly reduced by the application of prospective optical motion correction (Fig 1, right column), which yields an image resembling the reference data (Fig 1, left column). Figure 2 shows the rotation (Fig 2, left) and translation (Fig 2, right) of the subject as detected by the optical system during the motion-corrected experiment.

Discussion & Conclusion:

In this study, we demonstrated the application of prospective optical motion correction to SWI. An advantage of coupling SWI with optical prospective motion correction is that SWI does not contain any "idle" time that would allow the insertion of a navigator echo, making navigator-based techniques like PROMO [10] less suitable. In addition to the full 6-DOF motion-correction capabilities of this optical prospective correction approach, it can increase the effective resolution [4]. These attributes benefit SWI through the acquisition of high-resolution phase maps used in the post-processing.

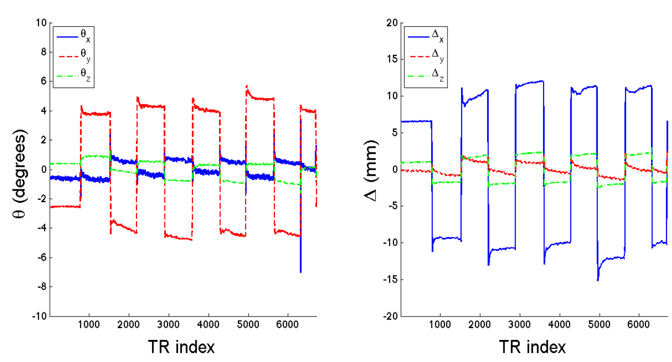

Figure 2: Motion of the marker as detected by the optical system. Both rotations (left, in degrees) and translations (right, in mm) are shown.

References: [1] Zaitsev et al, Neuroimage, 2006 [2] Qin et al, Magn Reson Med, 2009 [3] Aksoy et al, Magn Reson Med, 2012 [4] Maclaren et al, PloS ONE, 2012**.** [5] Schulz et al, Magn Reson Mater Phy, 2012 [6] Kopeinigg et al, 2013, MRM [7] Reichenbach JR *et al*. Radiology 1997;204:272-77. [8] Hacke EM *et al*. MRM 2004;52:612-18. [9] Forman et al, Med Imag Anal, 2011 [10] White et al, Magn Reson Med, 2010
Acknowledgements: NIH (2R01 EB00271108-A1, 5R01 EB008706, 5R01 EB01165402-02), the Center of Advanced MR Technology at Stanford (P41EB015891), Lucas Foundation