Prospective Optical Motion Correction for 3D Pseudo-continuous Arterial Spin Labelling

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Purpose:

Prospective motion correction systems that use optical tracking are gaining popularity, due to their fast response time and applicability to any MR imaging protocol without increasing the scan time [1-5]. Accurate and robust motion correction becomes especially important in quantitative MR imaging methodologies, such as 3D pseudo-continuous arterial spin labeling (3D-PCASL) where cerebral blood flow measurements are obtained. Recently, prospective motion correction in 3D-PCASL was demonstrated using an MR-based technique called PROMO [7]. In this study, we demonstrate prospective motion correction for 3D-PCASL using an external optical tracking system.

Methods:

Prospective Optical Motion Correction

An MR-compatible camera was mounted on the head coil and acquired a live video of a checkerboard marker on the patient's forehead [3,6]. The video signal from the camera was transmitted to a laptop through a fiber-optic link in order to reduce interference on the MR-images. The camera images were processed by the laptop, and motion parameters sent in real-time to the scanner via a network socket (Fig. 1). On the scanner side, the motion parameters were read from the network buffer right before the readout train started. An initial time of 10ms was inserted before the readout train to allow enough time for reading motion data from network and waveform calculation for updating the scan plane. Updating the motion data and scan plane just before the readout ensured that the most up-to-date pose of the marker was used, resulting in minimal delay between the motion detection and imaging readout. The 10ms was negligible as compared to the total readout time and did not increase scan time.

Figure 1 Integration of prospective optical motion correction in a 3D-PCASL sequence.

3D-PCASL scan

A 3D stack-of-spirals acquisition was performed using the following parameters: 8 in-plane interleaves, 36 kz phase encodes, echo train length=36, resolution=128x128, FOV=240mm, slice thickness=4mm, labeling duration: 1450ms, post-label delay: 2025ms, TE=11ms, TR=4870ms.

Experimental setup

A volunteer was asked to perform deliberate head shaking motion throughout the scan. Three scans were carried out: 1) With subject motion, optical prospective correction turned off, 2) With subject motion, optical prospective correction turned on and 3) No subject motion (reference). In order to ensure the repeatability of motion between the motion scans, every 30 seconds, the subject was instructed to move.

Results:

Figure 2 shows the ASL images obtained without and with prospective motion correction along with the reference, and Figure 3 shows the CBF maps for the three scans. It can be observed that motion causes visible artifacts especially at the frontal part of the brain (Fig 2,3 arrows). These motion artifacts were removed by the application of motion correction.

Discussion & Conclusion:

We have successfully demonstrated application of optical prospective motion correction in 3D PCASL. Optical prospective motion tracking provides a reliable correction method that is fast and does not require rescanning, thus adding no extra scan time. It is possible to provide a rapid response to motion by updating the scan plane between the readout pulses in the echo-train, which will be the subject of future work. Future studies should also include performing an interleaved study as done in [7] for a quantitative comparison between corrected and non-corrected scans, and comparing optical correction to correction performed using PROMO.

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, Magn Reson Mater Phy, 2012 [6] Forman et al, Med Imag Anal, 2011 [7] Zun et al, ISMRM, 2013
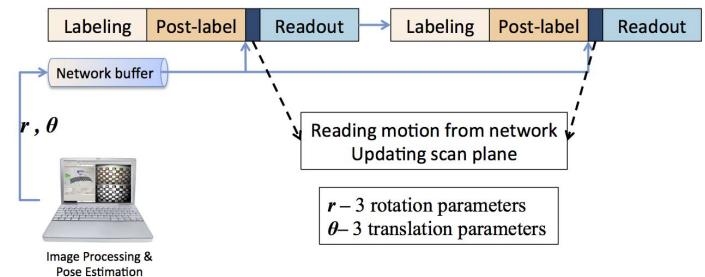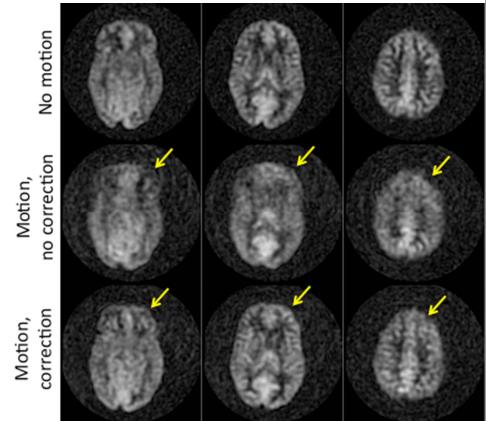
**Figure 2** Raw ASL images obtained with and without motion correction. The "no motion" image serves as the gold standard.
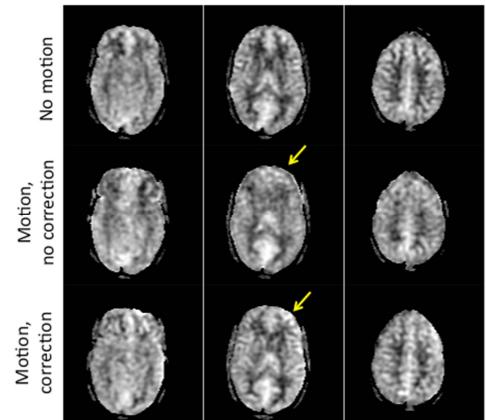
Figure 3 CBF maps obtained with and without motion correction.