Improved Prospective Optical Motion Correction for DTI Using an Extended-Field-of-View and Self-Encoded Marker

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INTRODUCTION – Due to the prolonged acquisition time, correction for rigid-body motion artifacts is essential for diagnostic image quality in DTI. Prospective motion correction using a monovision camera system and a checkerboard marker has previously been used to correct for rigid head motion artifacts [1,2]. In this study, we use a more sophisticated marker design to improve prospective optical motion correction in DTI. Improvements over previous work include fast calibration, more accurate motion tracking, and correction of both small and large ranges of head motion.

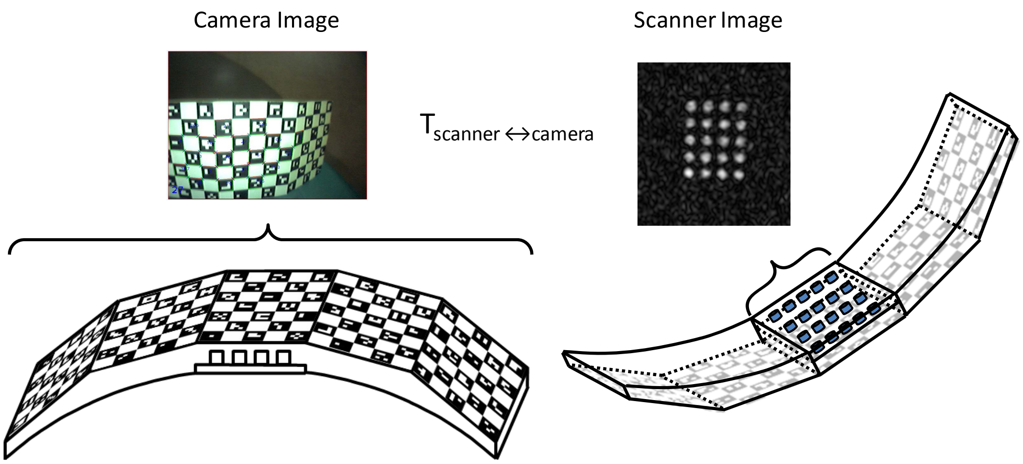

Figure 1. *The self-encoded & extended field-of-view marker design.* Each square on the checkerboard pattern is encoded with a unique, rotational invariant ID that identifies a particular square's position within the marker geometry. This allows for larger patient motion to be corrected and – due to the 3D geometry and better conditioning of the inverse problem – gives greater accuracy compared to a planar marker. The marker is mounted on patient's forehead and is tracked by a single camera mounted on the head coil. The marker has agar-filled holes in the middle that are used to find the relationship between the frame of references defined by the MR scanner and camera geometries (i.e. scanner-camera cross calibration).

MATERIALS and METHODS – (a) The marker design: We used the 3D marker shown in Fig.1. The top layer of the marker contained a checkerboard pattern. Each square on the marker was encoded with a unique ID so that the location of the corresponding square with respect to the marker geometry was known. This marker was attached to the patient's forehead and was tracked by a single camera that was mounted on the head coil. The camera transferred the images of the marker to an external processing laptop where the intersections of the squares were determined. Thereafter, the pose of the marker with respect to the camera reference frame was determined and the scanner geometry was updated in real time to track the slice [2]. The middle portion of the marker was filled with 5% agar solution to perform scanner-camera cross-calibration (Fig.1). **(b) Experiments**: *In-vivo* experiments were carried out on a 1.5T GE Signa scanner. A multi-shot spiral DTI sequence was used. Imaging parameters were: TR/TE=3000/55ms, FOV=24cm, 128x128 acquisition resolution, variable density spiral-out readout with a pitch factor α=3.0, 8 interleaves, 11 slices, slice thickness=7mm, 1mm gap, b=800 s/mm^2, 7 directions, NEX=2. The patient was asked to perform head rotations throughout the scan. Experiments were repeated with and without the motion-correction system running. The image reconstruction was performed using a modified SENSE algorithm [3].

RESULTS – The results of the *in-vivo* experiments are shown in Fig. 2. It can be seen that without the motion-correction system running, both the FA maps and the isoDWI images show significant artifacts. The source of these artifacts was from both image misregistration and the signal loss that occurred due to the motion sensitivity of the diffusion gradients [4]. These artifacts were significantly reduced when the real-time adaptive optical motion-correction was running. The range of patient motion was ~15° and ~7mm.

DISCUSSION – In this study, we presented the application of an optical rigid head motion correction system for DTI using a single camera and a self-encoded marker that enabled an extended 'tracking field-of-view'. The new marker design provided better accuracy due to the 3D geometry, and the self-encoding allowed larger patient motion to be corrected compared to the previous design using a planar checkerboard marker [2].

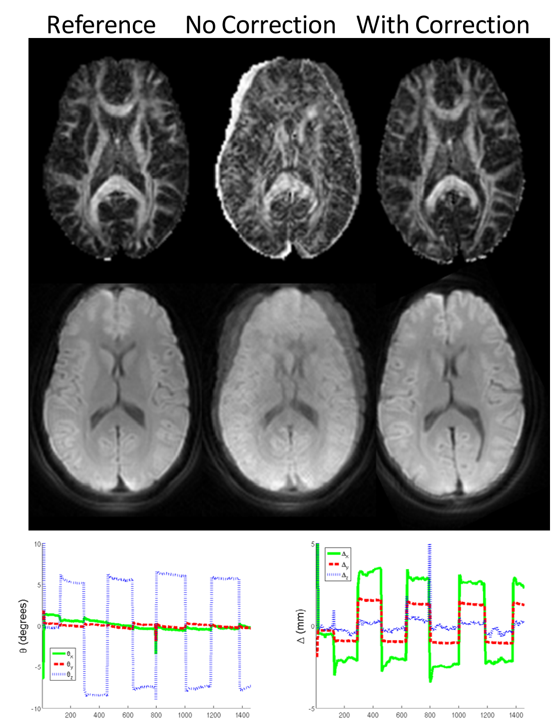

Figure 2. *Results of in-vivo experiments.* Without the optical tracking system running, there are significant artifacts both on the FA maps and the iso-DWI images. These are significantly reduced when the motion correction system was running. The motion detected by the optical tracking system is shown at the bottom.

References [1] Aksoy et al, ISMRM, 2009. [2] Aksoy et al, ISMRM, 2008. [3] Liu et al, MRM, 54:1412-1422, 2005. [4] Aksoy et al, MRM, 59:1138–1150 (2008)
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