A Practical Tracking System to Avoid Motion Artifacts

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Introduction: Prospective motion correction uses head tracking data to modify the imaging volume during data acquisition. This reduces motion artefacts during brain imaging [1]. Despite its effectiveness, and the fact that patient motion remains a problem in MRI, the technique has not made the transition into clinical use. Although a range of different tracking systems have been used [1-5], none appear to be reliable or convenient enough for use in regular clinical MRI. For example, optical tracking with multiple cameras is sufficiently accurate [1], but requires an unrestricted view into the magnet bore, which presents a problem in practice. The goal of this work was to assess any new tracking technology with the potential to make prospective correction more practical. One possibility identified is bend sensitive fibre optic tape used in the computer animation industry. Here we present first results using the system to reject and reacquire corrupted k-space data.

Method: ShapeTape (Measurand Inc., NB, Canada) consists of bend-sensitive optical fibres laminated to a substrate. Pose information in six degrees of freedom for the end of the tape can be computed by combining information from all individual fibres. To resolve MR-compatibility the optical fibre is laminated to a non-ferromagnetic substrate made from beryllium copper. A 10 m fibre optic cable is attached to the active part of the tape, enabling easy transfer of the data out of the scanner room via a waveguide in the Faraday cage. Motion data is acquired at a rate up to 100 Hz; however, data communication with the scanner is currently restricted to about 25 Hz. The tape is secured with adhesive tape to the headcoil (Fig. 1). The end of the ShapeTape is attached to the head of the subject using double-sided tape. The tracking system is lightweight and does not impede movement or add to discomfort.

All experiments were performed on a 1.5 T Symphony (Siemens Healthcare, Germany). A gradient echo sequence modified for prospective motion correction was used to reject and re-measure parts of k-space that were motion corrupted. In the measurements presented the following sequence parameters were used: TR/TE = 150/4 ms, flip angle 30°, matrix 220×220, voxel size 1×1×5 mm. For motion rejection a threshold of 0.3 mm absolute movement between data frames was chosen.

Fig. 1: Setup of the tracking system and fixation of the tape on the headcoil and on the volunteer's head.

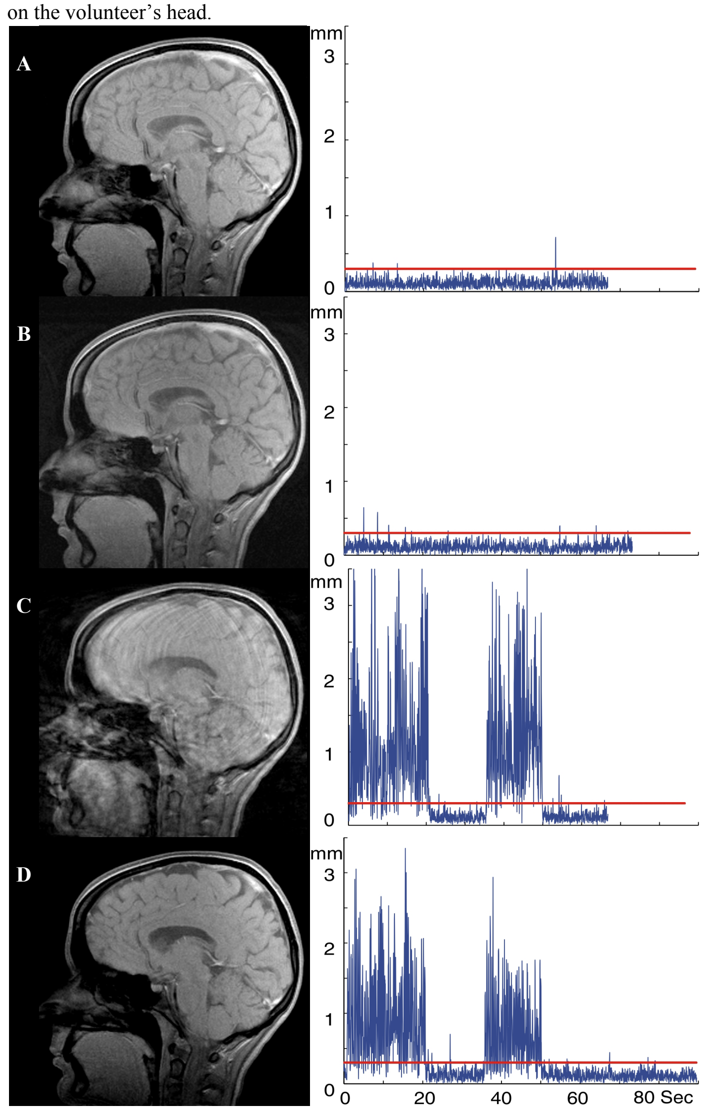

Fig. 2: Measurement results: (A) no intended motion, no rejection (B) no intended motion, motion rejection (C) motion, no rejection (D) motion, motion rejection. The corresponding motion data (displacement magnitude) from the tracking system are shown next to the respective image.

Results and Discussion: Fig. 2 shows images of four measurements where the volunteer was lying still (A and B) and performing head motion in the two following experiments (C and D). During the second (B) and the fourth (D) experiment motion rejection was used. The displacement magnitude between data frames coming from the tracking system is plotted aside each acquisition. Comparison between the motion corrupted measurement using motion rejection (D) and the acquisition without (C) shows that motion rejection using the tracking tape significantly reduces motion artifacts. In comparison with other tracking systems a major advantage of the tape is the setup time of the whole system, which takes only 1-3 minutes. No time consuming calibration step is necessary for motion rejection. As no direct line of sight to the patients head is required, the system could be used even with a very enclosed head coil. An obvious disadvantage of the method compared to prospective motion correction is that the image acquisition time extends depending on the amount of if corrupted parts of k-space are rejected and have to be reacquired (Fig.3). However, as the position information itself is computed from external tracking data, there is no need for additional sequence time, as would be the case using navigators. In addition, if no patient motion occurs, then the scan time remains unaffected. In further experiments the tape proved its applicability at 3T field. The use of the tape for motion correction instead of only rejecting corrupted data will be further investigated.

Conclusion: Optical tracking tape was used to identify motion corrupted lines of k-space for data rejection. This approach appears to be a practical alternative to other prospective motion correction strategies.

References: [1] Zaitsev et al., Neuroimage 2006; 31(3):1038-50. [2] Eviatar et al., Proc. ISMRM, p. 269 (1999). [3] Krueger et al., Proc. ISMRM, p. 3196 (2006). [4] Aksoy et al., Proc. ISMRM p. 3120 (2008). [5] Kober et al., ISMRM Motion Correction Workshop 2010

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