Fast Inter-scan Motion Detection and Compensation

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Introduction In a typical MRI exam multiple scans are performed which often differ in contrast. The geometry of these scans is planned on a survey which is one of the very first scans that is performed. If the patient moves after the acquisition of the survey the scanned location is different from the planned location [1]. As a consequence, the total time of an exam may be prolonged because scans need to be repeated in the correct geometry. This is a particular concern for long neuro exams where patient motion may occur gradually when the patient relaxes. Here, we present a fast method to detect and correct for motion between individual scans of an exam. This ensures a consistent scan geometry during the entire examination, which is important if results from different scans are to be compared.

Materials and Methods We use sets of three orthogonal slices with low resolution (called "tracker" in the following) to determine and track the head position [2]: Immediately after the survey a tracker is acquired which serves as a position reference for the entire exam. Then, before starting each scan of the exam another tracker is acquired and registered to the slices of the reference tracker using rigid registration. If the registration determines a shift or rotation, the scan geometry is corrected accordingly and another tracker is acquired in the new geometry. This process is repeated until it converges. Finally, the geometric transformation between reference and current head position is applied to correct the scan geometry of the subsequent diagnostic scan.

This approach is similar to the **intra**-scan motion correction in [2] except here it is used to correct **inter**-scan motion. This relaxes the timing constraints on the tracking significantly: it allows acquiring higher resolution tracking images and also acquiring enough trackers to ensure the iterative position finding converges, resulting in an improved accuracy.

Each tracker is acquired in 280 ms using a fast, steady state gradient echo sequence: FOV 270x270 mm^2, 64^2 matrix, slice thickness 20 mm, half-Fourier acq., flip angle 15°, TR/TE 1.93/0.96 ms, 5 start-up echoes. Rigid registration is performed in 10 ms per slice using cross-correlation as similarity measure.

The feasibility of this approach to correct for motion during neuro exams was investigated in a study with 8 healthy volunteers. After the survey and the reference tracker, a volume of the head with 2 mm isotropic resolution was acquired (3D T1w gradient echo, flip angle 30°, TR/TE 25/4.6 ms). Subsequently, the volunteer was instructed to move the head to a new position. The motion transformation was iteratively determined as described above. Finally, the volume scan was repeated with and without correcting the scan geometry based on the tracker data. All experiments were performed on a clinical 1.5 T scanner (Achieva, Philips Healthcare) using an eight channel head coil.

Results The motion determination converged very quickly: only 3-4 iterations of tracker acquisitions (<2s) were necessary to reliably estimate the new position. Figure 1 illustrates the first three iterations of the tracking: Each column shows the three slices of a tracker. Note the large change in scan geometry between the first and second iteration and the small change between the second and third iteration.

Figure 2a shows a sagittal slice of the volume scan before motion, 2b and 2c depict the same slice after motion without and with correction of the acquisition geometry, respectively. Images 2b and 2a differ significantly, whereas 2c and 2a are in good agreement. This demonstrates that the approach was able to ensure a consistent scan geometry between scans in spite of motion. The residual error of the motion compensation approach was investigated by registering the isotropic volume scans which were acquired before motion and after motion correction. The standard deviations of the angulation and translation errors were 0.8°/0.6 mm (LR), 0.3°/0.3 mm (AP) and 1°/0.6 mm (FH). These errors are small compared to the actual motion between scans which had a mean angulation/translation of 6°/4 mm (LR), 3°/2mm (AP) and 16°/4mm (FH).

Summary This tracking method is a simple and efficient approach to cope with rigid inter-scan motion in neuro exams. It requires no user interaction and does not interfere with the clinical workflow.

References [1] Welch, et al., MRM 52: 1448 - 1452 (2004); [2] White et al., MRM 63: 91 - 105 (2010);

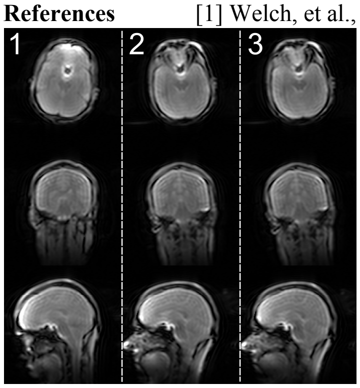

Figure 1: First 3 iterations of the tracking scan.

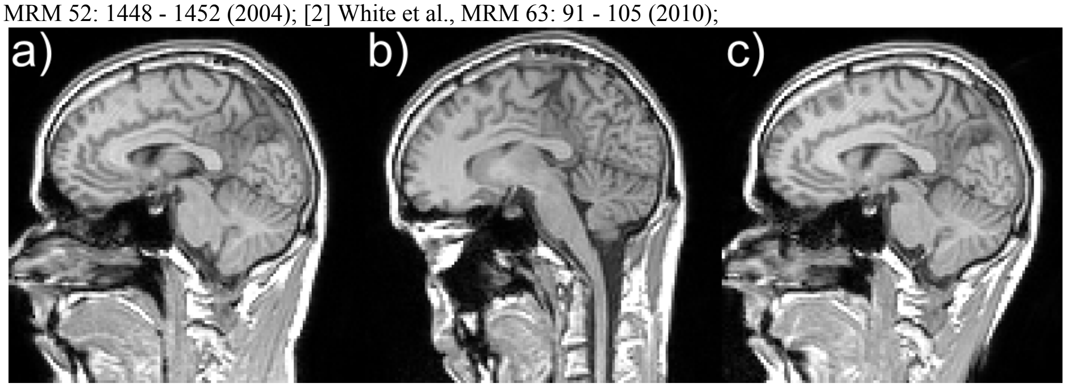

Figure 2: The same sagittal slice of the 2 mm isotropic volume scan. a) before motion, b) after motion without correction, c) after motion with correction.