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USING BRAIN IMAGING DATA TO DETECT AND CORRECT NON-RIGID SENSOR MOTION IN PROSPECTIVE MOTION CORRECTION

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TARGET AUDIENCE: Researchers performing prospective motion correction techniques that require the affixation of a sensor or marker.

PURPOSE: Many prospective motion correction systems currently used in MRI require a marker or sensor be affixed to the subject's head[1] and assume the two move rigidly together. When this assumption is violated, performance of the system is degraded. This abstract investigates the incorporation of position estimates from imaging data to detect and recover from non-rigid sensor affixation.

METHODS: We have used an external tracking system (Endoscout; Robin Medical, Baltimore MD) with a sensor that consists of 3 orthogonal pairs of parallel coils. The sensor's position can be inferred by 'blipping' the scanner's gradients to create a time-varying magnetic field across the sensors which induces an electric potential in each coil. We have modified a BOLD sequence to play these gradient 'blips' immediately after the EPI readout and adjust the imaging FOV before the next slice selective excitation pulse. Compared to using an image-based system, the advantage of external-tracker systems like Endoscout is its speed – it can generate a position estimate once per slice. The disadvantages of the system include a possible bias in the estimated sensor position and orientation, as well as the assumption that the sensor moves rigidly with the brain. In this work we consider the use the prospective image-based motion tracking system (PACE[2]) running on the scanner to mitigate these disadvantages. Compared to external trackers, PACE is slow: it generates one estimate per volume instead of one estimate per slice. However, PACE is more accurate when performing estimates on volumes with little motion. To recover from non-rigid sensor motion, we reset the sensor reference position after each PACE estimate. Ideally, all motion estimates would come with a quality metric to help us determine which one to trust, or when to reset the sensor reference position. Currently, PACE does not provide such quality metric. We therefore create a proxy for PACE's quality metric by measuring the sum squared displacement the sensor experiences within the volume. We only reset the sensor's reference position when this metric is less than a pre-defined value. The use of this quality metric, however, re-introduces the sensor-brain rigidity assumption. Three experiments were performed. In the first 2, the sensor was deliberately moved in a non-rigid manner with respect to the head. The sensor was attached to the subject using a headband. In the first experiment (tug), the subject was asked to lie still and pull on the sensor cable to displace the sensor. In the second experiment (non-rigid move), the sensor was attached loosely in the headband such that when the subject's head moved, it did not move rigidly with the sensor. These 2 experiments were performed with a human subject, having given informed consent. In the third experiment (pace proxy), the sensor-brain rigidity assumption was re-introduced and the derived PACE quality estimate was used to determine when to reset the sensor reference position. This experiment was performed on a phantom (pineapple). The phantom was still for 5 TRs, then underwent a slow but continuous oscillation for 5 TRs (a rotation about the z-axis by approximately 6° per TR). This pattern was repeated for the duration of the scan. All acquisitions were performed on a 3T TIM Trio (Siemens Healthcare, Erlangen, Germany) using the standard 12-channel head coil and an BOLD EPI sequence with the following parameters: TR 3000 ms, TE 22 ms, FA 90°, 40 slices, BW 2480 Hz/px\ and in-plane imaging matrix 72 x 72.

RESULTS: Figure 1 shows temporal signal to noise ratio (tSNR) maps for each condition in each experiment. Median tSNR values for each time series are superimposed on the figure.

DISCUSSION: The first 2 experiments validate that resetting the reference sensor position improves image quality when the sensor does not move rigidly with the head. The 3rd experiment shows that even under rigid head-sensor motion, there may be an advantage by incorporating imaging data to overcome any bias in the sensor's estimate.

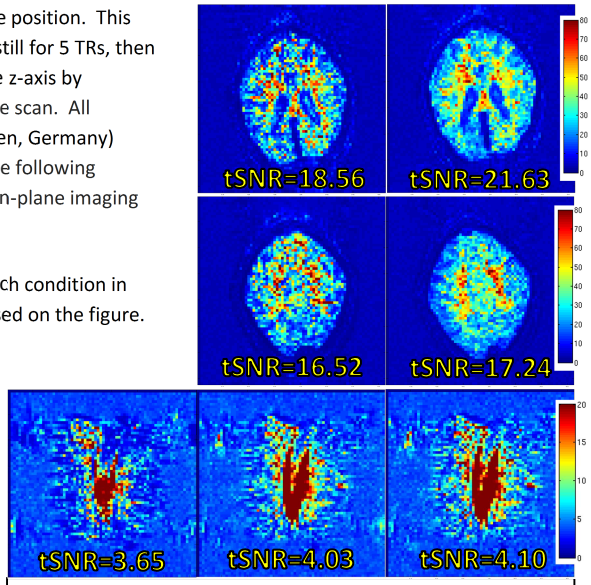

Figure 1: tSNR maps for each condition of each experiment. Top row (human): sensor tug experiment, left: endoscout only, right: endoscout+PACE. Middle row (human): non rigid motion experiment, left: endoscout only, right: endoscout+PACE. Bottom row (pineapple): Estimating a

REFERENCES: 1. Maclaren, et al. Magnetic Resonance in Medicine 69.3 (2013): 621-636. **2.** Thesen et al. Magnetic Resonance in Medicine 44.3 (2000): 457-465.

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