Optical prospective motion correction for high resolution quantitative MRI (qMRI) of the brain

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Target Audience: Those interested in prospective motion artefact correction and quantitative magnetic resonance imaging (qMRI)

Purpose: qMRI aims to produce measurements directly related to tissue microstructure with high diagnostic and research value that are independent of scanner and acquisition protocol. The quality of such measurements is degraded in the presence of motion. Correction schemes are vital for high resolution, whole brain coverage approaches that have long acquisition times and greater sensitivity to motion. Prospective motion correction[1] (PMC) uses external optical tracking to track volunteer motion in real-time and dynamically update the imaging gradients during the acquisition. Here we investigate the capacity of a PMC system (Kineticor, USA) to improve the quality of high-resolution quantitative parameter maps, including in the presence of pronounced subject motion.

Methods: Spoiled multi-echo 3D fast low angle shot (FLASH) acquisitions were acquired on six volunteers with predominantly PD- (6^o) or T_1- (21^o) weighting at 800um isotropic resolution and with whole brain coverage on a 3T whole body system (TIM Trio, Siemens Healthcare). Gradient echoes were acquired with alternating readout gradient polarity at eight equidistant echo times ranging from 2.34 to 18.44ms using a 488Hz/pixel readout bandwidth and a repetition time (TR) of 25ms. Partially parallel imaging, using the GRAPPA algorithm with a speed up factor of two and forty reference lines, was employed in each phase-encoded dimension (AP and RL) to accelerate the acquisition. Each FLASH volume was acquired with a two-by-two factorial design with factors *motion/no motion* and *PMC on/ off*. Quantitative maps of effective transverse relaxation rate (R_2*) were generated via linear regression of the log of all signal intensities across echo times[2]. Quantitative R1 maps were estimated from the PDw and T1w images according to the formalism developed by Helms et al.[3] and accounting for inhomogeneities in the transmit field[4].

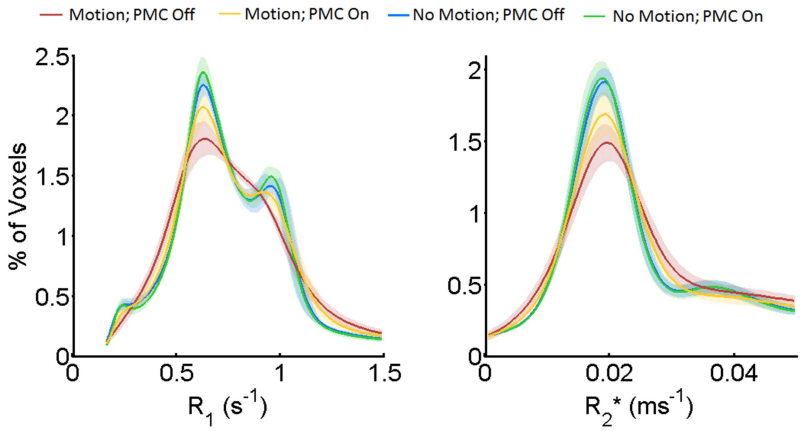

Fig.1: Histograms of R_1 and R_2* are sharpened using PMC. The shaded area indicates the standard deviation across all six volunteers.

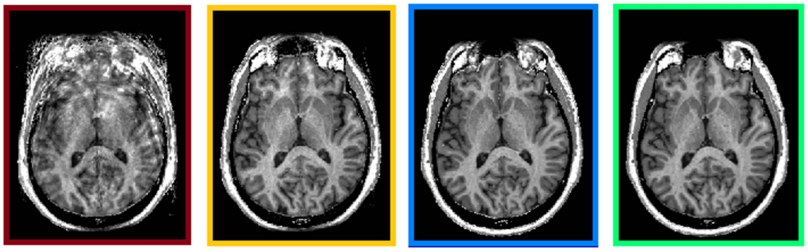

Fig.2: Quantitative R_1 maps across conditions (colour coded as in fig. 1).

Results: Histograms (fig. 1) of quantitative R_1 and R_2* values exhibit broadening in the presence of motion (red) causing the gray and white matter peaks to converge. Under equivalent motion conditions, the PMC system sharpens the histogram peaks (yellow), approaching the level of no motion/no PMC (blue). The histograms are further sharpened when PMC is used with no deliberate motion (green) suggestive of the fact that PMC can address artefact introduced by physiological motion. Fig. 2: exemplar quantitative R_1 maps for the 4 cases permuting *motion*/*no motion* & *PMC On*/*Off.*

Conclusions: PMC shows great potential to mitigate motion artefacts induced by intra-volume volunteer motion and increase the robustness of qMRI. Such robustness is crucial for the translation of quantitative imaging to a clinical setting. Future work will focus on quantifying the degree to which both overt and involuntary physiological motion, e.g. due to breathing, can be alleviated.

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References: 1.Maclaren, J. *et al. PLoS One* **7,** e48088 (2012); 2. Weiskopf, N., *Front. Neurosci.* **8,** 1–10 (2014); 3. Helms, G., *Magn. Reson. Med.* **59,** 667–72 (2008); 4. Lutti, A. *et al. PLoS One* **7,** e32379 (2012).