Simulating changes in external magnetic field due to head motion in a 7T scanner

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Introduction: Head movement is problematic for high resolution MRI at ultra-high field [3] and a variety of methods for monitoring head position inside the MRI scanner have been developed and used for retrospective and prospective motion correction [4]. Using a fixed array of field probes to measure field changes produced outside the head by small changes in head position and angulation has been shown to be a viable method of monitoring head movement in the scanner. Here, we use field simulations [2] to carry out a detailed evaluation of the field changes produced by typical head movements in a 7T scanner.

Method: Simulations mimicked 7T experimental measurements in which the field variation was measured using 16 NMR probes [5] fixed in three co-axial rings around the head, and head movement was simultaneously monitored by optically tracking a Moiré Phase Tracking (MPT) marker rigidly coupled to the head via a dental mould [1]. A voxelated model of the subject's head and neck was formed from MRI data acquired at 3T, and positioned relative to the field probes using 7T images acquired during the same session as the field recordings. Repeated field simulations were carried out using a Fourier-based method [2] with the model translated and rotated based on the optical measurements, or moved by varying a single co-ordinate to evaluate the linearity of field variation with position.

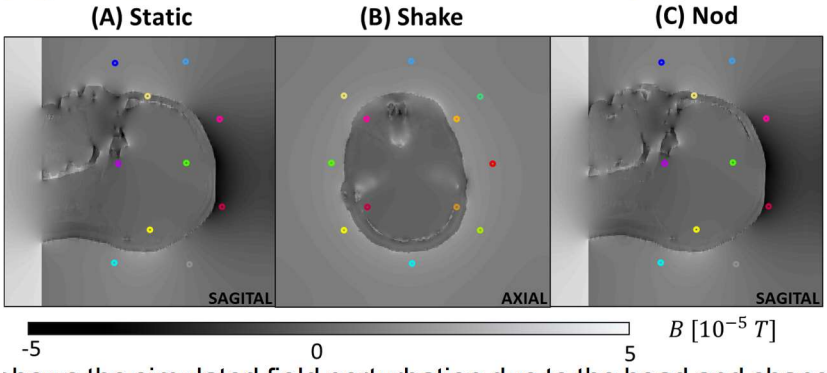

***Figure 1**: Results of the simulations (0.5 mm resolution & 700 x 700 x 700 array). Coloured circles show the field probe positions projected onto the central sagittal, or axial, slice. (A): Absolute field perturbation due to head. (B),(C): Field change due to head shake/nod by 10 degrees.*

Results and Discussion: Fig. 1 shows the simulated field perturbation due to the head and changes in field due to head rotation (shake and nod). Figure 2 shows simulated and experimental field variation at the probes due to real head movements. There is good agreement between measured and simulated field variation, with a similar pattern of variation of field change across probes. Other simulations indicated that the magnetic field variation was linear with position or angulation for small movements (R^2 >0.9 for movement < 1° / 1 mm). Simulated data is now being used to test the accuracy with which head movement can be derived from external field measurements.

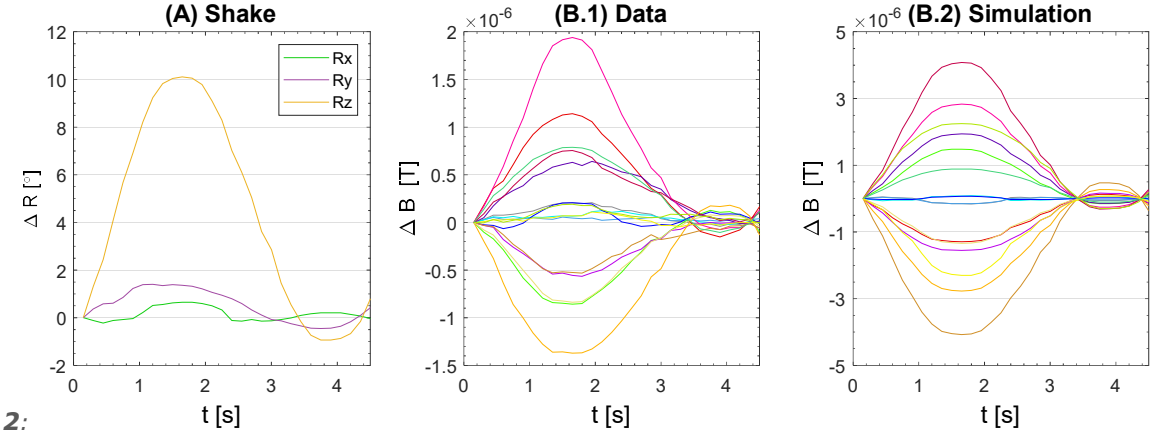

***Figure 2**: (A) Changes in head orientation measured using the optical system; (B.1) concurrent measurements of field variation at the 16 probe positions; (B.2) simulations of the field variation at the probe positions.*

References: **[1]** Bischoff et al, *Proc. ISMRM* 0303, *(2017)*; **[2]** Marques and Bowtell *Concepts in MR B, 25B*, 65 (2005); **[3]** Lusebrink et al, *Scientific Data*, 170032, (2017); **[4]** Maclaren J et al, *MRM*, 69, 621 36, (2013); **[5]** Duerst Y. et al, *MRM*, 73: 884 (2015).