A Simple B_1 Correction Method for High Resolution Neuroimaging

P. van Gelderen[1], A. P. Koretsky[2], J. A. de Zwart[1], J. H. Duyn[1]

[1]Advanced MRI, LFMI, NINDS, National Institutes of Health, Bethesda, MD, United States, [2]LFMI, NINDS, National Institutes of Health, Bethesda, MD, United States

Introduction: Developments in multi-channel detector arrays and increases in magnetic field strength have led to at least an order of magnitude sensitivity increase over the last decade. This can be applied to increase spatial resolution to well below 1 mm, which is expected to have a major impact for clinical diagnosis. However, non-uniformities in transmit and receive B_1 field lead to severe intensity variations over the image, complicating its interpretation. Transmit B_1 non-uniformities are partly caused by dielectric resonance and finite wavelength effects, difficult to quantify and correct for. Correction of reception B_1 non-uniformities, particular severe when small array elements are placed close to the object, requires a sensitivity reference map, often not available at high field. Here we present an alternative method for obtaining high resolution MRI with minimal intensity variations.

Methods: The method is based on the acquisition of a reference map with low tissue contrast, achieved through manipulation of acquisition parameters: In T_1-weighted imaging, T_1 weighting can be reduced by changing acquisition timing or omitting the inversion pulse. In T_2*- or T_2-weighted imaging, contrast can be reduced by shortening TE. The resolution of the reference map can be reduced to improve SNR and/or lower scan time. One caveat is that contrast dependence on flip angle should not change between reference and actual scan. The effectiveness of the proposed method is demonstrated in 3D MP-RAGE based T_1-weighted imaging. Experiments were performed at 7 T using a 24-element receive array [1], 16 of which were selected for reception. Acquisition parameters were: 430x430x1100 μm resolution, 1.2 s TI, 3 s TR, 9° flip angle, 19 min acquisition time. For the reference scan, inversion was omitted (3D SPGR, 19 ms TR) and resolution reduced to 860x860x1100 μm, resulting in 1 min acquisition time. Image reconstruction was performed by phase-sensitive noise-weighted channel combining [2]. The reference image was smoothed with a 2D Gaussian kernel with 27.5×27.5 mm^2 FWHM, normalized by division by a smoothed binary mask of the same data (correction for partial support of the smoothing kernel near edges). Intensity correction was performed by dividing the anatomical data by this smoothed and interpolated reference image.

Results and Discussion: An example of the effectiveness of the correction method is shown in the figures. Variation in reception sensitivity of a single coil can be observed in Fig. 1. After channels combining, substantial intensity variations remain (Fig. 2). The corrected image (Fig. 3) shows notably more uniform intensity. The presented method allows for an effective and simple way to correct for intensity variations resulting from B_1 non-uniformity, at the cost of a minimal increase in scan time. Alternatively, post-processing methods can be used based on low-pass filtering. However, such methods generally fail when spatial frequency of the B_1 variations approaches that of the anatomical structures. The presented method is comparable to a simplified version of the correction methods proposed in [3]. Although transmission and reception B_1 variations are not quantified here, their contribution to the image intensity can still be effectively eliminated in one step. For MP-RAGE, this works as long as T_1 saturation (by readout pulse) is similar to that of reference.

References: [1] other abstracts presented at this meeting; [2] Roemer, MRM 1990, 16:192; [3] Wang, MRM 2005, 53:408.

Figure 1: *Image from a single coil element of the 24-channel array.*

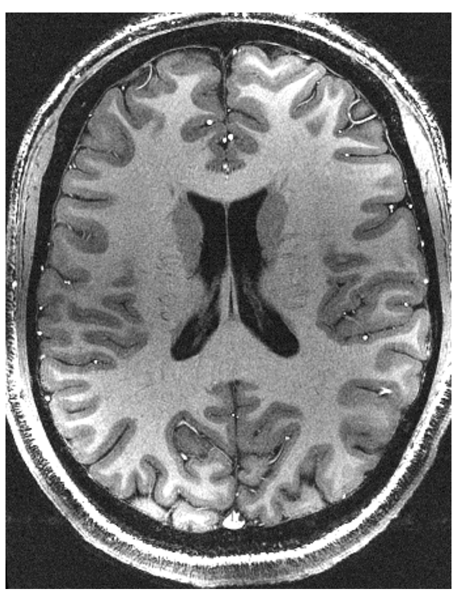

Figure 2: *Uncorrected combined image.*

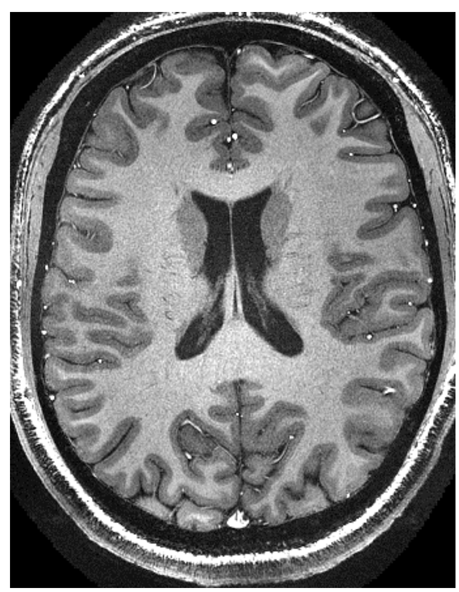

Figure 3: *Intensity-corrected image.*