Rapid Concomitant Field Correction for 2D Spiral Imaging

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INTRODUCTION: Imaging gradients necessary for spatial encoding also generate[1,3] a high-order spatially varying magnetic field. These fields (concomitant fields, B_c) are predicted by Maxwell's equations. The ensuing in-homogeneities in the effective B_0 result in additional phase accrual in k-space during spatial encoding. The effect of this additional phase on image quality is similar to susceptibility blurring. It has been demonstrated[1] that de-blurring algorithms for spiral trajectories can be modified to account for the effects of B_c. An investigation of the phase accrual in k-space reveals that it is approximately quadratic (Fig 1.), permitting the use of rapid de-blurring via separable de-blur kernels[2].

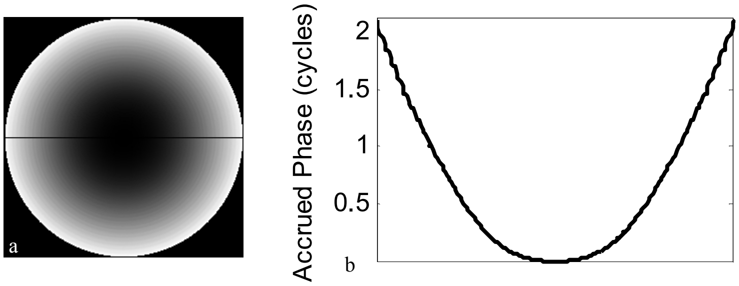

Fig 1. Phase accrual in k-space (a) for a sagittal spiral trajectory and a single pixel (x=2cm; y=2cm; z=12cm) and the profile the origin (b). The trajectory had 4 interleaves, Gmax of 4G/cm and adc time of 42.5ms.

METHODS: Like all de-blurring algorithms an off-resonance frequency field map is needed for rapid de-blurring. Though concomitant fields cannot be measured, an analytical expression for the lowest order fields in a typical MR scanner have been derived[3] and shown to be a adequate estimate of the actual field variations[1,3]. This expression is, however, time dependent. Since the phase accrual is quadratic, each pixel can be assumed to have off-resonance frequency of (max k-space phase accrual)/(adc time). The resulting virtual field map is time independent permitting the use of the rapid de-blurring algorithm.

The analytical expression for B_c also forecast a constant off – resonance[1] for axial spiral scans and has a straight forward solution[1]. The proposed approach was validated on the more demanding sagittal spiral scans.

RESULTS:

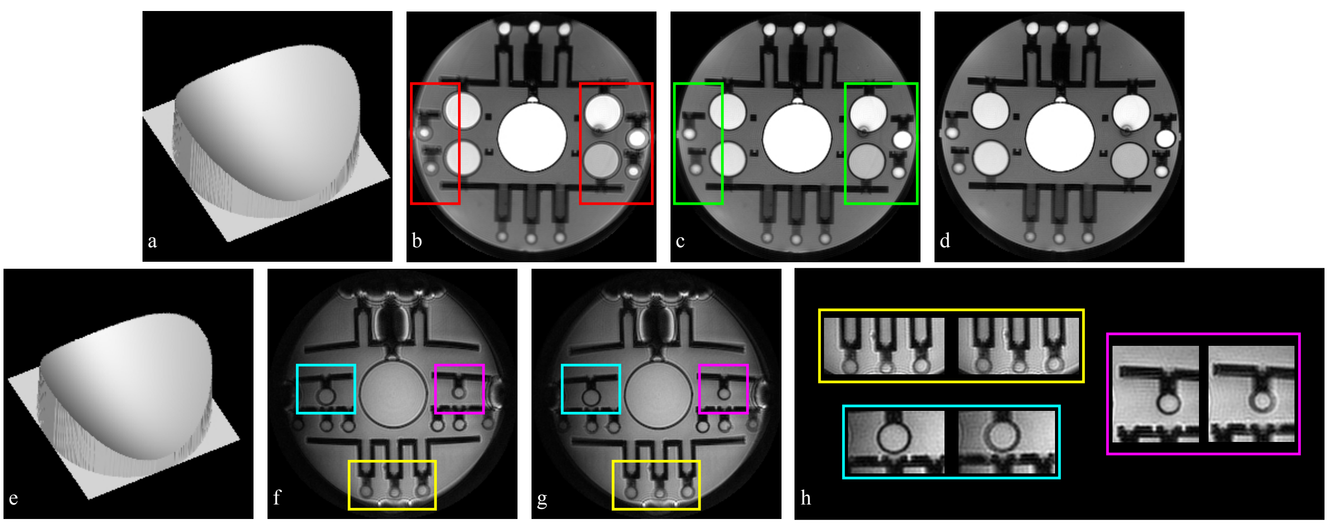

Fig 2. Concomitant field correction results for simulated sagittal images [virtual field map (a); uncorrected image (b); de-blurred image (c) and original image (d)] and phantom sagittal images [virtual field map (e); uncorrected image (f) and de-blurred image (g) with portions zoomed-in for easy comparison (h)]. The simulation trajectory (24cm Fov; 5 interleaves; 28.28ms adc time; 4.00G/cm Gmax) resulted in a virtual field map with max off-resonance of 53hz. The phantom images were collected on 3T GE Signa scanner with a trajectory (22.4cm Fov; 7 interleaves; 27.88ms adc time; 2.25G/cm Gmax) producing a max off-resonance frequency of 20.3 hz.

CONCLUSION: The results demonstrate that the generated virtual field maps (Fig. 2a,e) are successful in accounting for concomitant fields. The phase accrual for 3D spiral trajectories like spiral projection imaging (SPI) has also been verified to be quadratic and extensions of the presented approach is being pursued to include both B_c and off-resonance correction.

REFERENCES: **[1]** Mag. Res. Med. (1999) 41, 103-112 **[2]** Mag. Res. Med. (2000) 44, 491-494 **[3]** Mag. Res. Med. (1998) 39, 300-308