Correction of B0 Phase Errors for Spiral-in/Spiral-out Acquisitions

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PURPOSE – Spiral-in/spiral-out acquisitions (figure 1) are of interest in BOLD MRI[1-2], dynamic B0 field map estimation[2], T_2-weighted, T_2^*-weighted, or balanced acquisitions. Eddy currents, non-ideal system behavior, and T_2^* decay can generate distinct artifacts and appearance for the spiral-in and the spiral-out halves of the acquisition. These artifacts are amplified upon full reconstruction of the spiral-in/spiral-out acquisition due to the disparate nature of its two halves. This work seeks to correct the artifacts arising from dynamic B_0-induced phase errors that vary over the period of data sampling.

METHODS – Spiral-in/spiral-out TSE data were collected on a Philips 3T Ingenia. Both the spiral-in and the spiral-out halves of the acquisition fully sampled k-space. Figure 2 parts a and b show separate reconstructions for the two halves of the acquisition. Time dependent B_0 phase errors introduce a relative geometric transformation between these two images, resulting in a lower resolution final image (figure 2c). The B_0 eddy current method of Brodsky et al.[3] was used to measure time dependent B_0 phase errors on the X and Y gradient axes independently. The total phase was used to correct the k-space data prior to gridding reconstruction.

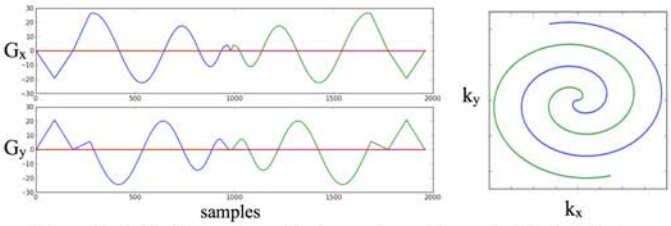

Figure 1: Left - Example gradient waveforms for a spiral-in/spiral-out acquisition (blue/green respectively). Right - resulting k-space trajectory.

RESULTS – The spiral-in/spiral-out images reconstructed without and with the B_0 phase correction are shown in figure 2, parts c and d respectively. The uncorrected image suffers a loss in apparent resolution compared to the separately reconstructed spiral-in and spiral-out images. The corrected image maintains the same apparent resolution as the spiral-in and spiral-out images. The estimated instantaneous off-resonant frequency shown in figure 3 demonstrates off-resonance values on the order of several hundred hertz.

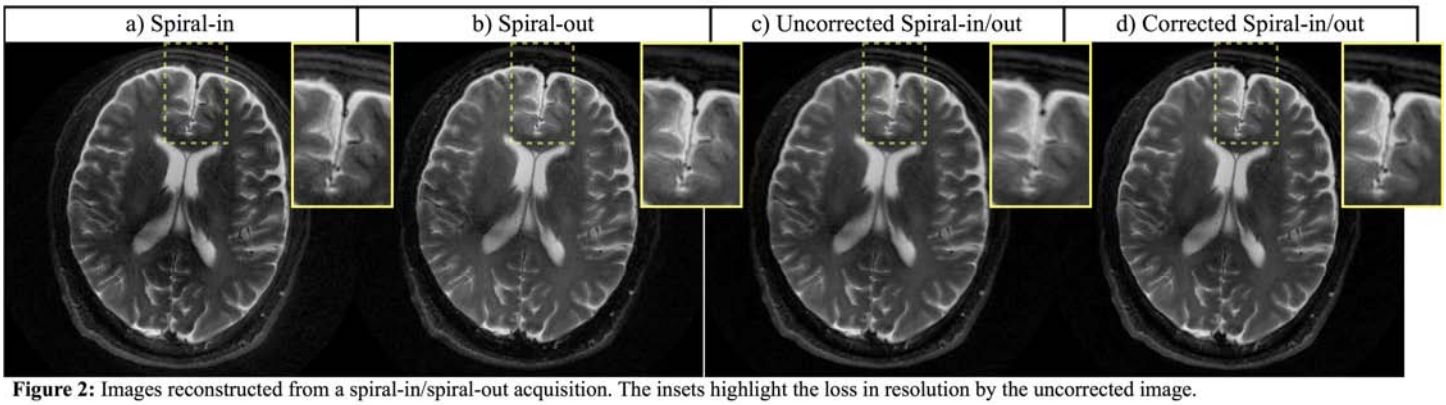

Figure 2: Images reconstructed from a spiral-in/spiral-out acquisition. The insets highlight the loss in resolution by the uncorrected image.

DISCUSSION - The B_0 phase errors appear to map into k-space in a manner that produces a transformation in the reconstructed image that is dependent upon the spiral direction (i.e. in or out). The most likely source of the measured B_0 phase error is eddy currents and/or B_0 eddy current correction that is mis-calibrated for a spiral acquisition. It may be possible to prevent B_0 phase errors by characterizing and compensating for B_0 eddy currents in a manner that is specific to spiral acquisitions.

CONCLUSION – The correction of B_0 phase errors is important in spiral-in/spiral-out acquisitions to preserve image quality. It also has important implications in the generation of dynamic field maps from the spiral-in and spiral-out images.

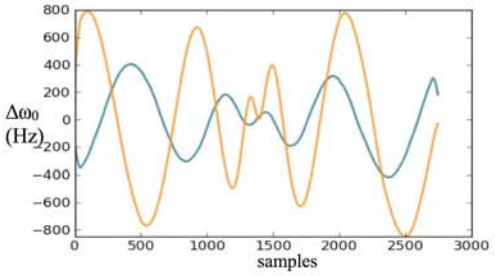

Figure 3: Instantaneous off-resonance frequencies measured on X (blue) and Y (orange) gradient channels.

REFERENCES

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ACKNOWLEDGEMENT – This work was funded in part by Philips Healthcare