Variable Gradient Delay Correction for Spiral MRI

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INTRODUCTION: Spiral trajectories are susceptible to the effects of gradient delays due to high demands of the hardware system, resulting in image artifacts [1-2]. Previous methods used to measure system delays require either a modification of the pulse sequence code or the use of specialized phantoms [1-3]. A new method is proposed to estimate time-varying gradient delays for certain spiral-based trajectories with little or no modification to the pulse sequence design. This method includes gradient coupling effects, estimating independent, continuous delays for each gradient channel as a function of the ADC time.

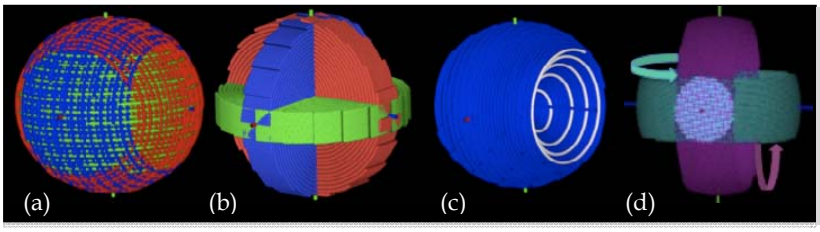
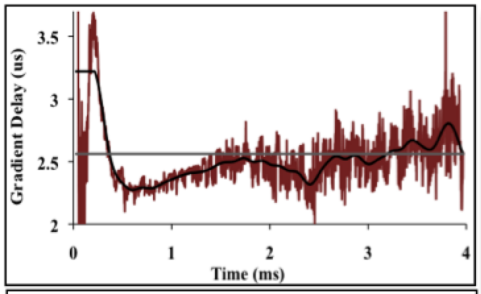


Fig. 1: (a) shows FLORET Trajectory (b) Stack of Spirals trajectory (c) a single interleaf along a 3D hub (d) overlapping region by two orthogonal hubs. Arrows show direction of trajectory shift.

METHODS: A 3D center out spiral trajectory FLORET [5] (fig. 1(a)) was used to estimate the gradient delays. FLORET is a variant of the stack of spirals trajectory in (fig. 1(b)). For every TR, a spiral arm is collected on a unique cone and rotated about a single axis. Multiple cones stacked on a single axis form a band called a "hub" [5] (fig. 1(c)). Gradient delays shift the data on each hub azimuthally about the hub axis [5]. These data shifts can be estimated using Fourier correlation [4] at the overlapping regions, which in turn provide an estimate of the gradient delay (fig. 1(d)). Continuous delays were acquired by taking estimates at different radii of the trajectory. *In-vivo* data were collected at 1mm high resolution using FLORET in a T1-weighted SPGR sequence. For multi-coil data, delays for each coil were acquired to get a median delay estimate. A variable time shift was applied to phantom simulated data to validate the method. Both *in-vivo* and phantom images were reconstructed using variable and constant delay correction



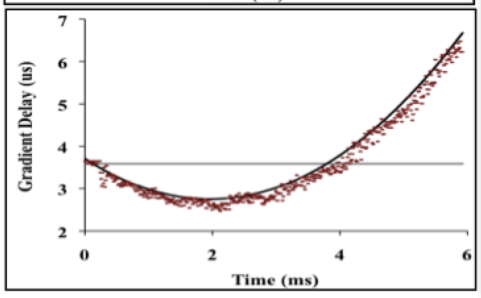


Fig. 2: (top-left) shows the measured delay estimates for (*in-vivo)* data vs. time (red). Delays correspond to the x gradient channel. Measured delays were smoothed (black) for variable delay correction and then averaged for constant delay correction (grey) for all three gradient channels

Fig. 3: (bottom-left) shows the variable time shift applied to the simulated phantom data (black). Delays correspond to the x gradient channel. Measured delays were smoothed for variable delay correction (red) and then averaged for constant delay correction (grey) for all three gradient channels.

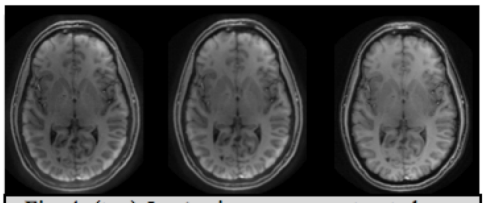


Fig. 4: (top) *In-vivo* images reconstructed (left) without delay correction (middle) constant delay (right) variable delay correction.

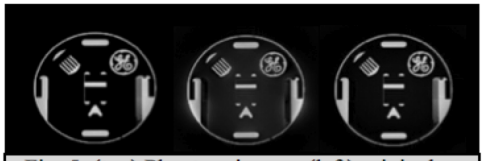


Fig. 5: (top) Phantom images (left) original image (middle) uncorrected image (right) reconstructed using variable delay correction.

RESULTS & DISCUSSION: A good agreement between the actual and the measured delays in (fig. 3) verified the method. The image reconstructed without delay correction in (fig. 4) showed a bright rim artifact near the occipital cortex of the brain. Constant delay correction method showed some improvement over the uncorrected image. However, variable correction method showed a significant reduction of the artifact. For phantom simulations, constant delay correction gave comparable results to variable correction method based on selection of offset (fig. 5).

CONCLUSION: The proposed method accounts for time-varying gradient delays and can easily be applied to any stack of spirals based trajectory.

References: [1] Mag. Res. Med. 63, (2010) 1683–1690 [2] Mag. Res. in Med. 132, (1998) 150-153 [3] Mag. Res. in Med. 39, (1998) 581-587 [4] Mag. Res. in Med. 42, (1999) 963–969 [5] Proc. ISMRM 2010, Abstract 4974