Referenceless Multi-Coil Reconstruction

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Introduction Referenceless proton resonance frequency (PRF) shift thermometry [1] is inherently robust to tissue motion because the subtraction of a baseline phase image acquired prior to heating is not necessary. Instead, the background phase is estimated in every individual image from a frame region of interest (ROI) surrounding the heating region. The background phase is estimated by fitting a polynomial to the phase in the frame region or by fitting a complex polynomial to the complex data [2]. It is necessary that the phase vary slowly without discontinuities (2π-phase wraps can be easily removed by phase unwrapping). Phase images from single coils generally meet this requirement and can be processed with referenceless reconstruction.

Referenceless processing of phase images acquired with multiple coils is problematic if a coil is not sensitive over the whole frame region. In this case, the polynomial is fit preferentially to the high signal region within the frame ROI. This problem is avoided if the phase images of the different coils are combined into a single image before referenceless reconstruction. However, unknown, per-scan phase offsets are expected between each receiver channel, due to coil geometry and position, coil electrical properties, such as opposing-phase wiring, and receiver time delays. Predetermined solutions are undesirable, as coil loading will change phase offsets, and are incompatible with coil arrays that are flexible or are not in a fixed geometry. Therefore, the data of the different coils has to be combined taking the offsets into account such that the combined image has a smooth phase without phase discontinuities. Here, we demonstrate a coil combination that determines and eliminates the coil dependent phase offset and generates combined images with a smooth background phase that can be used for temperature estimation with the referenceless method.

Methods Focused ultrasound (FUS) heating spots were created in an ultrasound gel phantom using an InSightec ExAblate 2000 system installed on a 3T GE Signa magnet. Temperature images of the heating region were acquired with a flexible 2-channel coil and a 4-channel cardiac phased array in axial and coronal planes. Imaging parameters were TE=12.7 ms, TR=25.5 ms, flip angle = 30°, FOV=24 cm for coronal images and 32 cm for axial images, matrix size 256x128, BW = 11.3 kHz. The multi-coil combination and referenceless processing was performed in MatLab. Receiver coil phase offsets \( R=(\theta_1, \theta_2, \ldots, \theta_{N-1}) \) from an arbitrarily chosen individual coil in an N coil array were determined using a least-squares solution. In an ideal system, the phase offset between any pair of coils can be determined by estimating the constant phase difference for all pixels where both coils have an arbitrarily chosen individual coil in an N coil array were determined using a least-squares solution. However, better noise tolerance and coil phase estimation between coils that do not have much, or any, sensitivity overlap can be achieved by using a linear differential model of coil phase offsets. That is, the offset from coil 1 to coil 4 is also the offset from coil 1 to coil 3 and 3 and 4. For N coils this results in N(N+1)/2 - 1 comparisons. Once the differential coil offsets of overlap can be achieved by using a linear differential model of coil phase offsets. That is, the offset from coil 1 to coil 4 is also the sufficient signal. However, better noise tolerance and coil phase estimation between coils that do not have much, or any, sensitivity overlap can be achieved by using a linear differential model of coil phase offsets. That is, the offset from coil 1 to coil 4 is also the offset from coil 1 to coil 3 and 3 and 4. For N coils this results in N(N+1)/2 - 1 comparisons. Once the differential coil offsets of

Conclusions Combining the phase of multi-coil acquisitions after removing the coil dependent receiver phase offset generates phase images without discontinuities that can be processed with the referenceless method. This allows referenceless reconstruction to be utilized for temperature estimation without restriction of the coil types used for imaging.


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