Parallel Imaging of Supine Breast for Recovery of Motion-Corrupted Data

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Introduction: Dynamic contrast enhanced (DCE) MRI provides good visualisation of breast cancer, and is typically performed with the patient lying in a prone position[1]. Currently DCE-MRI plays a limited role in the guidance of breast surgery due to the difficulty of registering images to the supine orientation inherent to breast surgery. The registration problem can be alleviated by performing supine breast imaging, but this worsens the problem of breast motion due to respiration. Supine breast MRI has been implemented[2] with the effects of respiratory motion minimised using the zonal motion-adapted acquisition and reordering technique (ZMART)[3], which is a combination of gating and k-space reordering based on respiration state. However, ZMART cannot correct motion unrelated to respiration, which may occur during the high resolution scans needed for surgical use. Here we propose the use of parallel imaging as a safety mechanism for non-respiratory motion during image acquisition. Specifically, the image acquisition can be protected against motion events by grouping the acquisition of even and odd phase encoding steps. Then non-corrupted images can be reconstructed from the half of the data (either even or odd) during which motion did not occur.

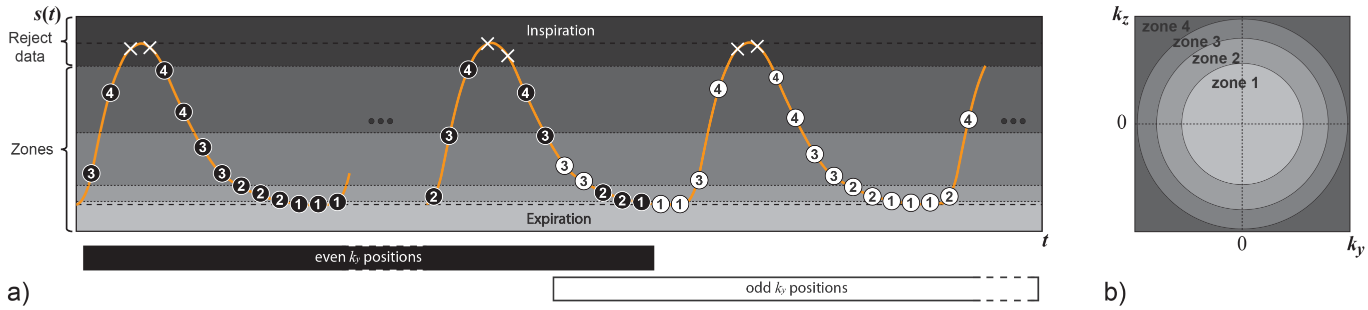

Figure 1: Data acquisition scheme; (a) the respiratory cycle (orange line) was separated into zones (gray scale) and even k_y phase encode lines (black) were acquired before odd k_y phase encodes (white) for each zone (data acquired close to inspiration were discarded (crosses)), and (b) the distribution of respiratory zones in the phase encoding plane of k-space.

Methods: Experiments were conducted using a General Electric 1.5T Signa Excite system and data were processed in Matlab. Two custom-built receive coil elements with sensitivity variation in the superior-inferior (SI) direction were fixed above the area of interest. Coronal images were acquired using a 3D gradient echo sequence with the first phase encoding direction (k_y) SI. The left breast of a volunteer was imaged while she breathed freely in the supine position. Respiration was monitored using a respiratory belt. Gating and real-time zonal reordering of k-space were used so that phase encoded data nearest the centre of k-space were acquired closest to expiration in the respiratory cycle. In addition, the phase encode acquisition order was altered so that the even k_y lines were acquired before the odd k_y lines (fig. 1). Noise samples for SNR optimisation of the reconstruction and coil sensitivity data (matrix: 32x32x36, NEX=4) were acquired prior to image data. Image datasets (FOV: 18x18x90cm, matrix: 192x192x36, NEX=1) were then acquired; with (1) the volunteer motionless except for respiration and (2) the volunteer moving during the second half of the acquisition. The fully sampled data was split into even and odd k_y lines and SENSE[4] (R=2) was used to reconstruct each subset separately.

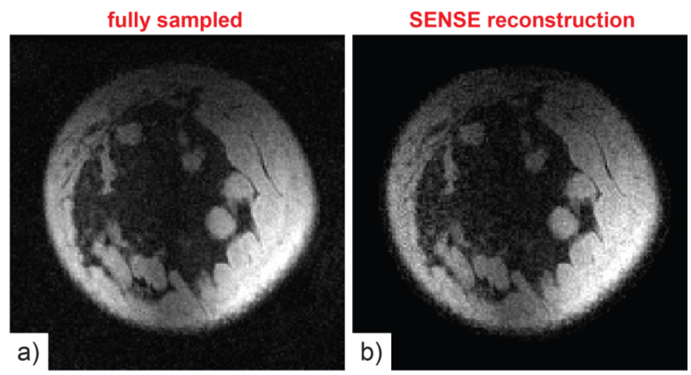

Figure 2: Data acquired with the volunteer motionless except for respiration; (a) a fully sampled image and (b) the SENSE reconstruction of only the even k_y lines of the same dataset.

Results: Data acquired with the volunteer motionless (except for respiration) is shown in figure 2; (a) a fully-sampled image (gold standard) and (b) the SENSE reconstruction of the even k_y lines only. Figure 3 shows images reconstructed from the dataset where the volunteer moved during the second half of the scan as odd k_y lines were acquired; (a) a fully-sampled image with motion artefacts and (b) the SENSE reconstruction of the viable even k_y lines of the same dataset (cf. fig 2(a)).

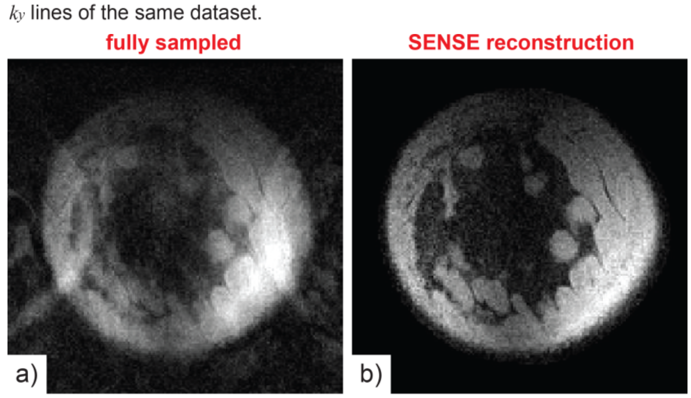

Figure 3: Motion-corrupted data; (a) a fully sampled image and (b) the SENSE reconstruction of the uncorrupted even k_y lines.

Discussion and Conclusions: Parallel imaging allows usable images to be reconstructed from a motion-corrupted dataset, providing that one of the data subsets (even or odd k_y lines) remains viable. This method can deal with any type and severity of motion because corrupted data is omitted from the reconstruction. The proposed method would acquire coil sensitivity and noise data both before and after the image acquisition in order to have relevant coil information to reconstruct either data subset. We have demonstrated parallel imaging of supine breast and its use to recover motion-corrupted data. In the future, the addition of more coil elements could be used either to make the reconstruction more robust and/or to divide the acquisition into more than two subsets.

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References:
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