Reconstruction of Dynamic Contrast-Enhanced Lung MR Imaging using k-t BLAST

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Introduction: Current lung imaging needs higher temporal resolution and spare time for extra slices.This work is to demonstrate a simulated result of lung imaging with contrast agent with 5-fold acceleration using k-t BLAST[1].

Method: Dynamic CE-MRI was accomplished using an inversion-recovery-prepared, segmented EPI technique with TI/TR/TE/ETL =180/ 6.5/1.2/4, matrix 256 x256, and slice thickness =10~12 mm with two coronal slices acquired. Unlike the original k-t BLAST where a set of training data is acquired for estimation before the real sampling, the sequence for lung imaging should undersample high frequency components yet full-sample the central low-frequency components, which serves as training data(See fig 1 for a conceptual illustration). Subsets of these fully sampled datasets were then used in the reconstruction to simulate reduced acquisition.

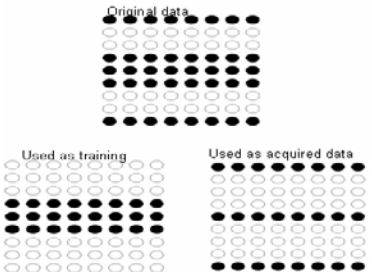

Figure 1: Sampling pattern of 5-fold acceleration. Though central lines are fully-sampled to provide training data, datasets applied in the reconstruction of acquired data remains u ndersampled at the central part of k-space to maintain lattice consistency

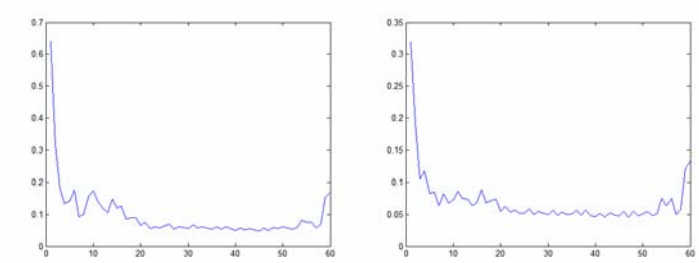

Figure 2: RMS error of (a) slice 1 (b) slice 2. Both depicts higher error at the first few time frames due to sudden contrast change induced by contrast agent

Results: Figure 2 depicts the reconstruction error of the proposed method simulating 5-fold undersampling. Reconstruction error was calculated by:

$$E_{RMS,t} = \sqrt{\frac{\sum_{i=1}^{N} |r_{i,t} - o_{i,t}|^2}{\sum_{i=1}^{N} |o_{i,t}|^2}}$$

Where $r_{i,t}$ and $O_{i,t}$ denote the i'th pixel value at time frame t of the reconstructed and original images, respectively. The reported error is the mean of all examinees. The result from slice 1 shows that the relative RMS error is larger at the initial stages, which is due to the steep change of image strength caused by the injection of contrast agent. Results from slice 2 reveals similar phenomenon. Mean RMS of both slices ranges around 11-13%, yet the contrast between targeted images and surrounding muscle remains substantially distinguishable as in the full-sampled images. Higher resolution of training data only makes a diminutive improvement to reconstruction accuracy, which is consistent with the counterpart of cardiac imaging in the previous reports.

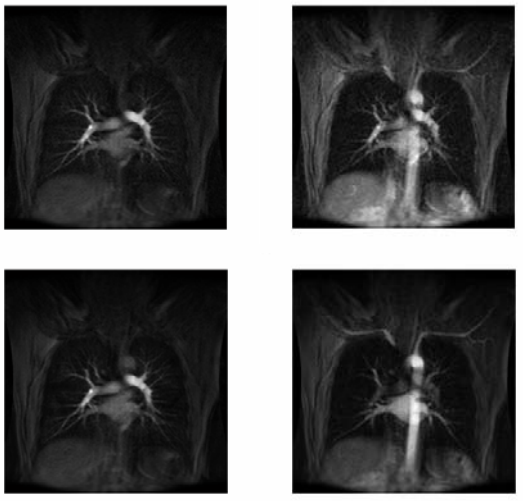

Figure 3: Time frame 15(left) and 31(right) of slice 1. Notice That the contrast in the reconstructed image(bottom row) is apparently lower for frame 31, while some details from finer vessels were incomplete in both frame

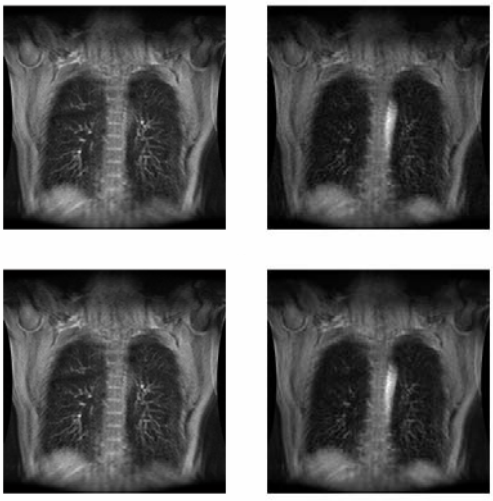

Figure 4: Time frame 15(left) and 31(right) of slice 2. The partial loss of finer vessels remains apparent in frame 15, and lowered contrast becomes more distinguishable with presence of denser vessel

Discussion: The somewhat similar x-f characteristic between lung and cardiac images enables the potential application of k-t BLAST toward lung imaging. Nevertheless, the drastic and frequent variation caused by multiple passes of contrast agent complicates the issue in lung imaging, which elevates the reconstruction error. An alternative is to consider only the images from the first pass to minimize variation frequency. This is done at the cost of reduced bandwidth with potential aggravation of x-f aliasing.

Reference:

1. Tsao J, Kozerke S, Boesiger P, and Pruessmann KP, Magnetic Resonance in Medicine 53:1372–1382 (2005)
2. Comparison of Arterial Spin Labeling and First-Pass Dynamic Contrast-Enhanced MR Imaging in the Assessment of Pulmonary Perfusion in Humans:The Inflow Spin-Tracer Saturation Effect: Yi-Ru Lin et al.