COMPARISON OF NON-RIGID MOTION COMPENSATED RECONSTRUCTIONS FOR 3D ABDOMINAL MRI

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INTRODUCTION: Respiratory motion is a major challenge for 3D abdominal MRI. Respiratory navigator gating is commonly used to compensate for motion, but leads to low scan efficiency. Recently, a free-breathing motion compensated technique was proposed that estimates 3D non-rigid motion from undersampled reconstructed images. This technique compensates motion by warping the undersampled images to a common respiratory position[1-2] (image warping). An alternative approach is to use the estimated motion fields to correct the corrupted k-space directly in the reconstruction process, using a general matrix description (GMD) of the acquisition[3]. Here we propose to use the GMD approach to compensate for motion in 3D abdominal MRI and compare its performance with the image warping framework. Results on 5 volunteers show that the GMD approach yields sharper images and correctly reconstructs small structures in comparison with the image warping approach and gated reconstruction.

METHODS: (Fig.1) **1.Image Acquisition** Data is acquired using a self-gated G-RPE trajectory[4]: a combination of Cartesian readout (*kx*) with radial phase encoding (*ky, kz*), with an angular step of 111.25° between consecutives profiles. This guarantees quasi-uniform profile distribution for arbitrary number of angular profiles. **2.Data Binning:** The central spoke of each profile is used to derive a respiratory signal, which allows combining data at similar respiratory positions into bins. **3.Undersampled Reconstruction:** Each bin is reconstructed using non-Cartesian iterative SENSE[5], resulting in a set of undersampled images (I_b) at different respiratory positions. **4.Motion Estimation:** Non-rigid registration (LREG)[6] is used on the set I_b to obtain a respiratory motion model. **5A.Image Warping:** The motion model is used to warp each I_b to a common respiratory position, where they are averaged[2]. **5B.Image Reconstruction:** The estimated motion is incorporated into the reconstruction process by solving the equation $(g^H g)s_0 = g^H s$ where s_0 is the ideal image, **s** the motion corrupted image and g the encoding matrix that incorporates the motion model. The equation above was solved with the conjugate gradient method.

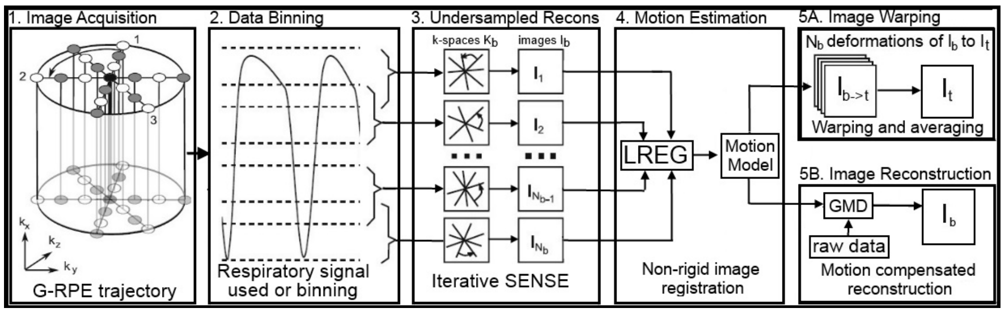

Fig.1: Motion compensation framework: 1) acquisition with G-RPE, 2) binning data into similar respiratory phases, 3) reconstructions of binned data, 4) non-rigid motion estimation, 5A) motion model used to warp all I_b to the same phase, 5B) motion correction directly in the reconstruction from raw data.

EXPERIMENTS: Five healthy volunteers were scanned under free-breathing on a 1.5T Philips scanner using a 32 channel coil (b-SSFP, FOV = 287mm isotropic, resolution = 1.75mm isotropic, *TR/TE* = 3.0/1.4ms, flip angle = 30°, radial undersampling = 2). Three reconstructions were performed from the same acquired data: GMD approach, image warping and 5mm gated reconstruction. The same number of profiles was used for each of the three reconstructions to allow comparison. 5 bins (2.92±1.00mm) and 723±91 profiles were employed to allow adequate motion estimation. Methods were compared using measures of vessel sharpness (VS) and liver sharpness (LS)[1], apparent SNR and scoring of image blurring from 0 (extreme blurring) to 4 (no blurring) by 6 experts.

RESULTS: Reconstructions results for the proposed, image warping and gated approaches are shown in Fig.2. The respective measures obtained were: VS = 0.77±0.13, 0.69±0.08 and 0.72±0.09; LS = 1.27±0.32, 1.09±0.26 and 1.10±0.29; apparent SNR = 8.51±3.99, 14.41±5.86 and 10.11±4.02; qualitative evaluation = 3.10±0.89, 2.28±0.64 and 2.73±0.93. The GMD and image warping approach had a scan efficiency of 88±11%; the gated reconstruction had 63±13%.

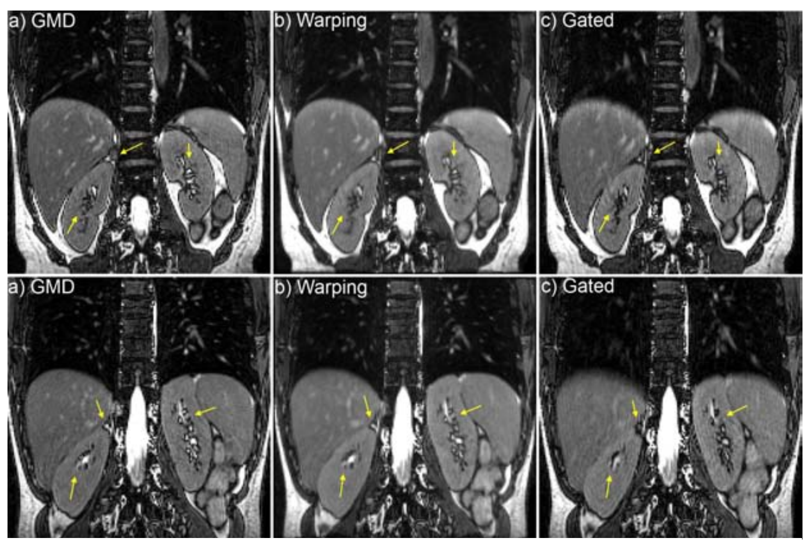

Fig.2: Coronal slices of 3D isotropic motion compensated reconstructions for two volunteers: **a)** Proposed GMD; **b)** image warping; **c)** 5mm gated reconstruction.

CONCLUSION: We have shown that the proposed GMD approach yields sharper images and correctly reconstructs small structures in comparison to the image warping and gated reconstructions, whereas image warping lead to higher apparent SNR. GMD shows an increase of ~12% in VS, ~17% in LS and ~36% in qualitative evaluation relative to the image warping approach. Both GMD and image warping approaches improve scan efficiency by ~25%. Future work will optimize the binning and motion estimation processes to further improve accuracy and scan efficiency of the motion compensated reconstructions.

REFERENCES: [1] Buerger et al, *IEEE* 2012; [2] Buerger et al, MagMa 2013; [3] Batchelor et al, *MRM* 2005; [4] Prieto et al, MRM 2010; [5] Pruessman et al, MRM 2001; [6] Buerger et al, *MedIA* 2011.