Motion Compensation for Free-Breathing Diffusion-Weighted Imaging (MoCo DWI) in Whole-Body Integrated PET-MRI

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Introduction

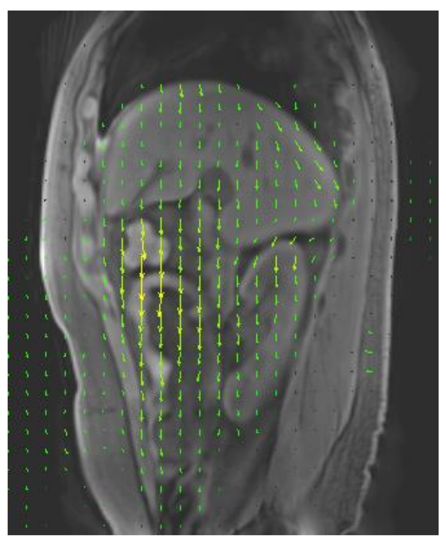
Diffusion-weighted imaging in the abdomen is a common diagnostic technique for detection, and characterization of lesions, treatment response of tumors and diffuse liver disease. However, the acquisition duration of several minutes may cause blurring artifacts due to respiratory motion. Prospective triggering prolongs the acquisition duration roughly two-fold and thus is unfavorable. We propose a new technique to reduce these artifacts in free-breathing which uses a motion estimation that is typically used for motion compensation of PET in PET-MRI measurements.

Workflow of Motion Compensated DWI Reconstruction

1 Motion Estimation

Using Joint-MoCo-HDTV[2] algorithm to estimate motion on the GRE measurement.

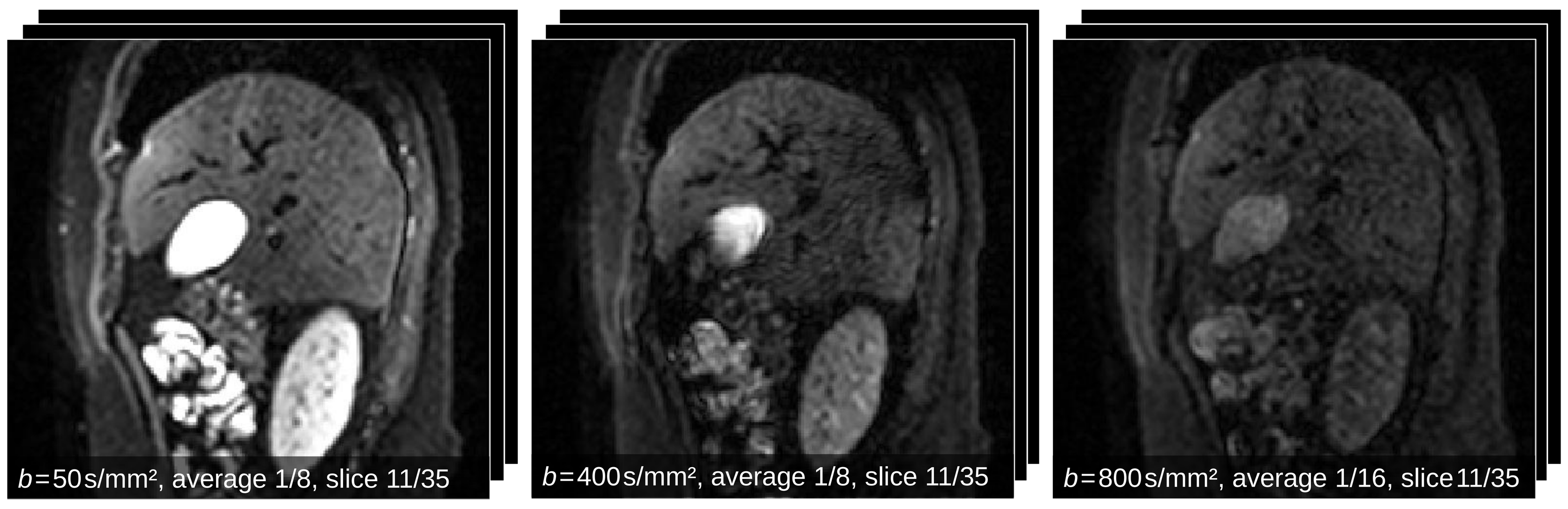
Results in 10 motion vector fields describing the motion between adjacent motion phases.



A representative slice of the 3D volume of the GRE measurement with an overlay of the motion vector field.

2

2D slices are acquired independently. Sorted by *b*-value and with several images acquired at the same *z*-position.



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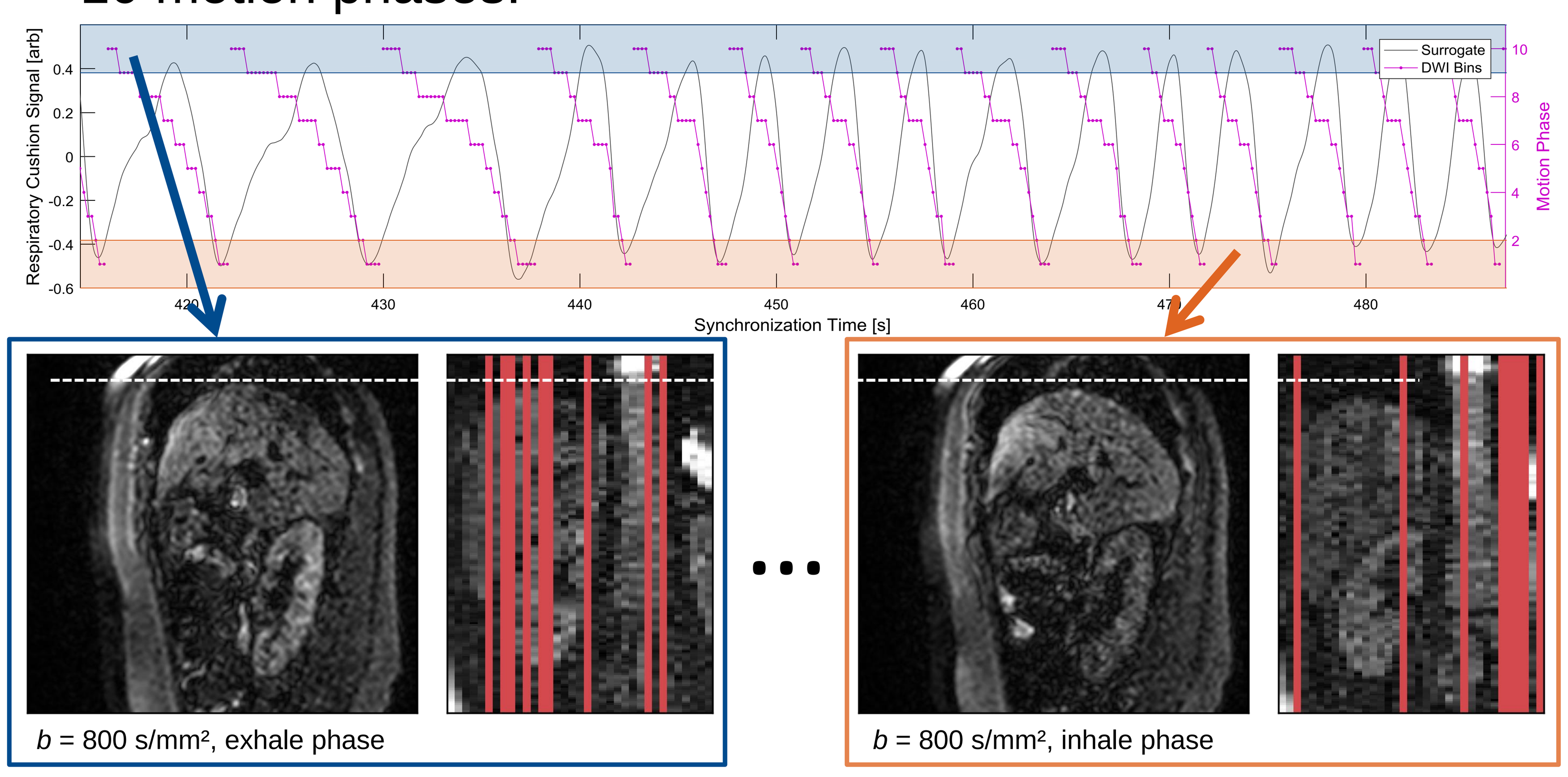
The cushion signal is used for retrospective gating into 10 motion phases.



The binned volumes typically contain gaps (red) because no information for that z-position was acquired in that particular motion phase.

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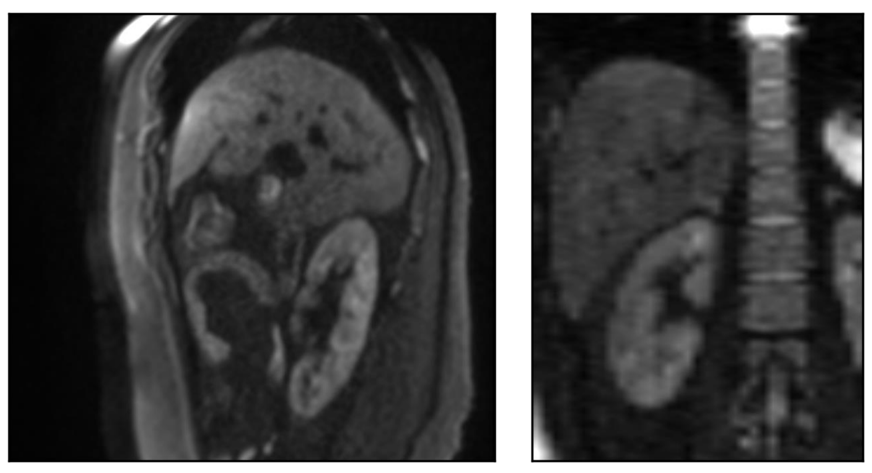
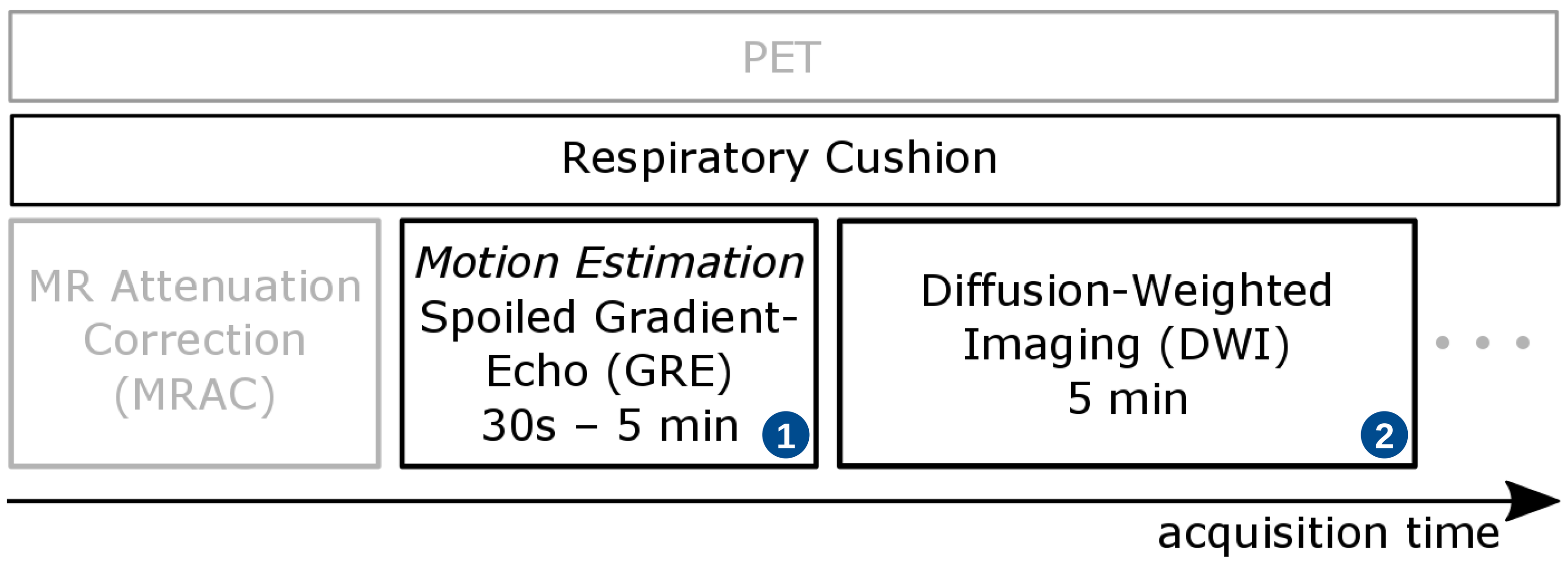
Deform gated images to reference phase using the motion estimation from 1.

These volumes are averaged to the final MoCo DWI volume.



Method



The motion is estimated using a GRE pulse sequence in common configuration for motion compensation in PET-MR. Then the DWI is acquired at free breathing.

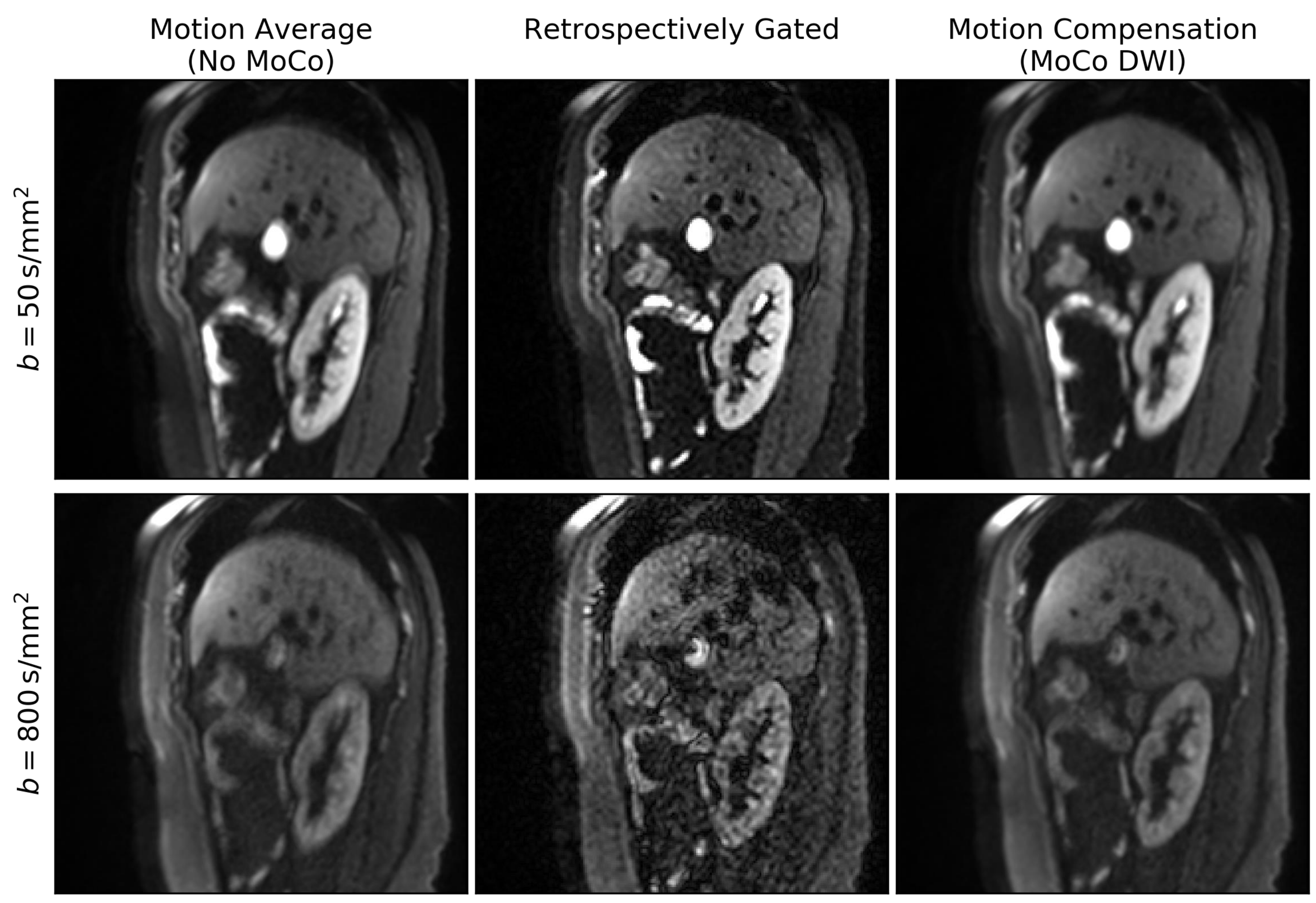
GRE: a golden-angle stack-of-stars prototype pulse sequence[1]. Radial views = 1300, TA = 287 s, FA = 12°, TR = 3.7 ms, FOV = 385×385×395 mm³, matrix = 256×256×80 with sagittal plane orientation for highest spatial resolution in the main motion direction. Self-gating is used to detect respiratory motion phases.

DWI: Prototype diffusion-weighted single-shot echo-planar imaging sequence with Cartesian k-space sampling, b ∈ {50, 400, 800} s/mm² and {8, 8, 16} averages in 3D diagonal mode, respectively, and sagittal slice orientation. TA = 227 s, FOV = 378×307×204 mm³, matrix = 256×208×35.

During the acquisition, the respiratory motion is tracked with a respiratory cushion.

Measured 10 volunteers on a 1.5 T MRI scanner (MAGNETOM Aera, Siemens Healthcare, Erlangen, Germany).

Results



The MoCo DWI shows SNR similar to an averaging without MoCo. The retrospectively gated volumes suffer from low SNR and cancelation artifacts but show high sharpness. This high sharpness is nearly reached by the MoCo DWI but without holes.

Conclusion

The proposed method allows free-breathing DWI without respiratory motion artifacts. This promises more accurate apparent-diffusion-coefficients (ADC) maps – especially for small lesions. In combination with PET-MRI motion compensation the measurement time is not prolonged.

References

[1] K. T. Block *et al.*, "Towards Routine Clinical Use of Radial Stack-of-Stars 3D Gradient-Echo Sequences for Reducing Motion Sensitivity," *J. Korean Soc. Magn. Reson. Med.*, vol. 18, no. 2, pp. 87–106, Jun. 2014.
[2] C. M. Rank *et al.*, "4D respiratory motion-compensated image reconstruction of free-breathing radial MR data with very high undersampling," *Magn. Reson. Med.*, Mar. 2016.

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