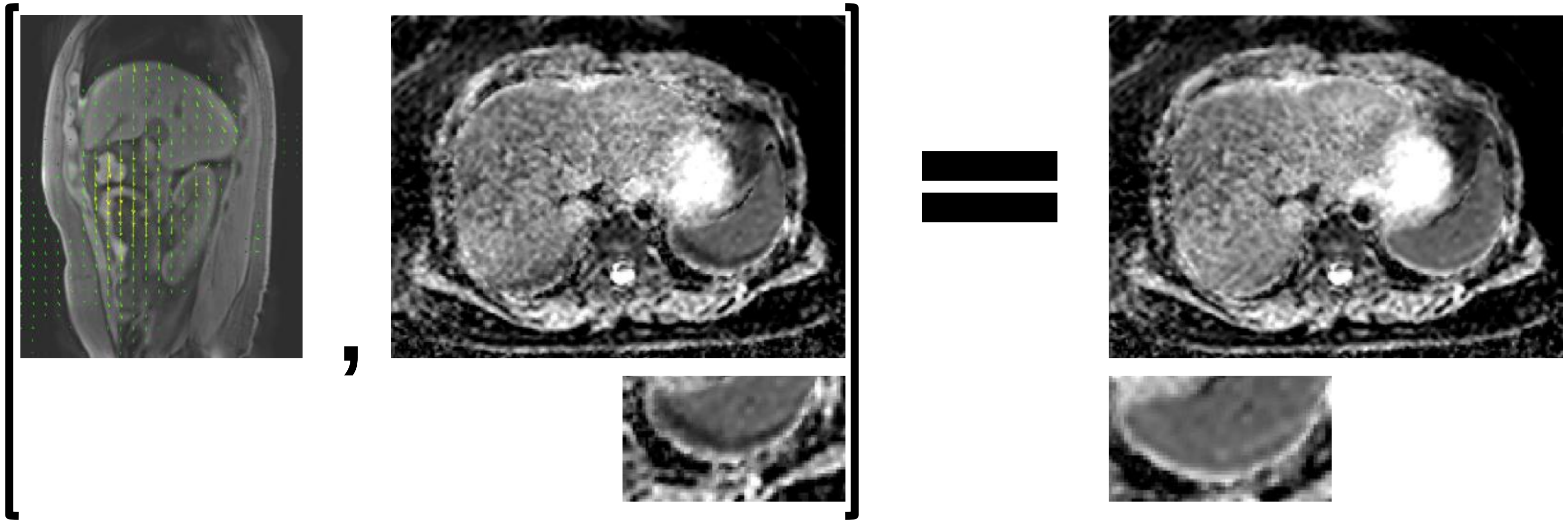
MoCo DWI



Motion Compensation for Free-Breathing Diffusion-Weighted Imaging (MoCo DWI)

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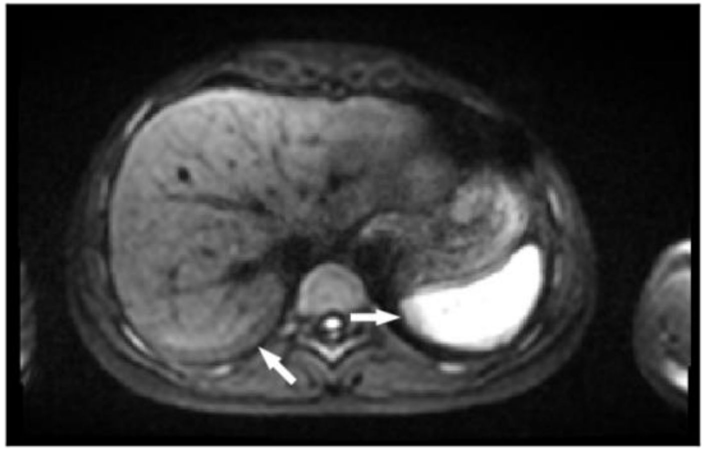
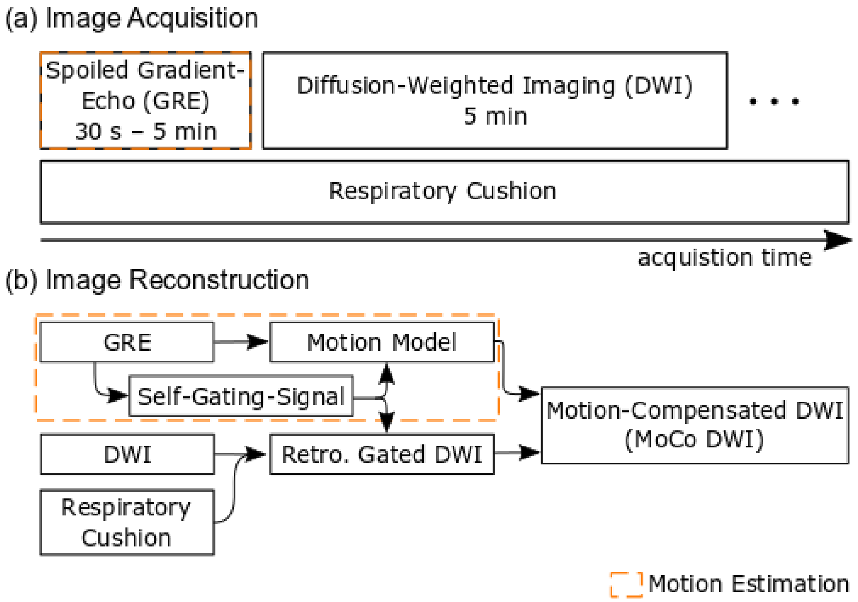
Introduction

- Typical DWI acquisition times require several minutes ⇒ respiratory motion occurs
- Can cause motion blurring or inconsistent motion phases between b-values
- (Prospective) triggering prolongs acquisition roughly three fold and is thus unfavorable
- Presenting a new method to estimate motion first using a GRE sequence with high contrast and highest resolution in main direction of motion for optimal motion estimation
- DWI images – especially with high b-values – show low SNR
  This makes motion estimation challenging, this issue is avoided in MoCo DWI
- The same GRE sequence can also be used for motion-compensated PET imaging in PET-MR

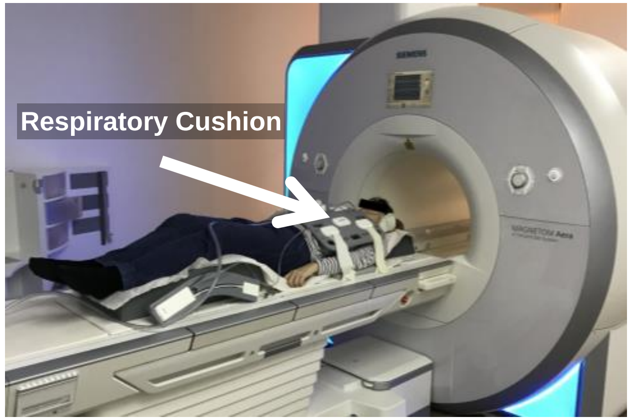


b = 400 s/mm² with 8 averages
without motion handling,
suffers from motion blurring

Methods



10 volunteer Measurements using a *pneumatic cushion* for detection of respiratory motion phases



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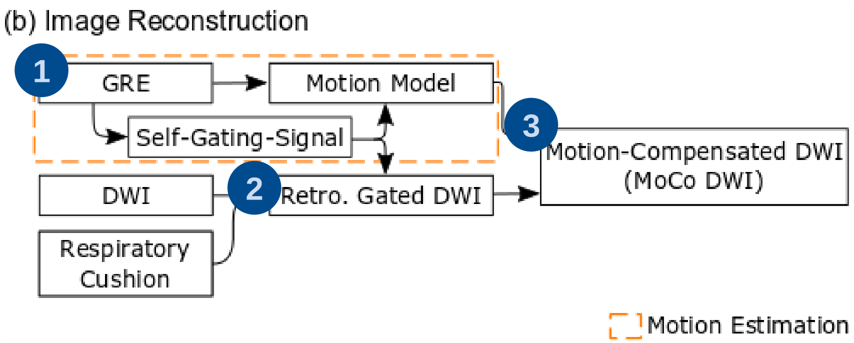
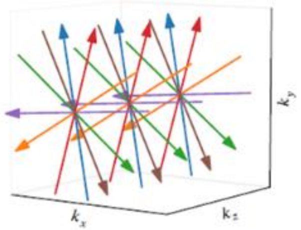


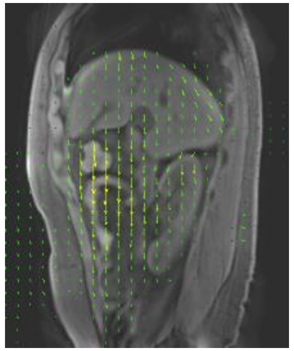
GRE: a golden-angle stack-of-stars prototype pulse sequence[1]. Radial views = 1300, TA = 287 s, FA = 12°, TR = 3.7 ms, FOV = 385 × 385 × 395 mm³, matrix = 256 × 256 × 80 with sagittal plane orientation for highest spatial resolution in the main motion direction. Self-gating is used to detect respiratory 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 axial 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 healthy volunteers on a 1.5 T MRI scanner (MAGNETOM Aera, Siemens Healthcare, Erlangen, Germany).

1 Motion Estimation

Using Joint-MoCo-HDTV² algorithm to estimate motion on the GRE measurement.

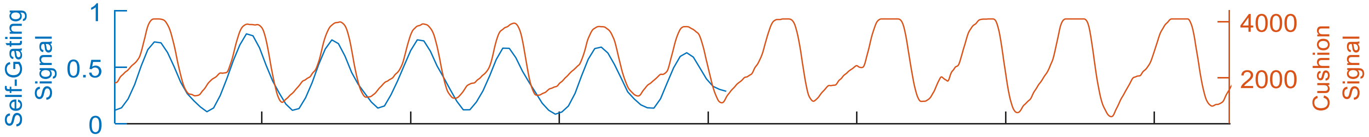


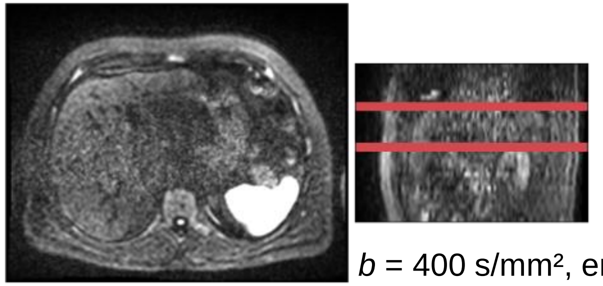
- High temporal resolution of respiratory motion phases with self-gating.
- Distinguishing in- and exhale.
- Sagittal plane orientation offers optimal resolution in main motion directions.

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

2

The cushion signal is used for retrospective amplitude-gating into 10 motion phases. Distinguishing between in- and exhale.





- Retrospectively gated images show low SNR.
- Volumes usually contain holes.
- Error prone to signal voids.
- No diagnostic value.

b = 400 s/mm², end-exhale, missing slices are red

3

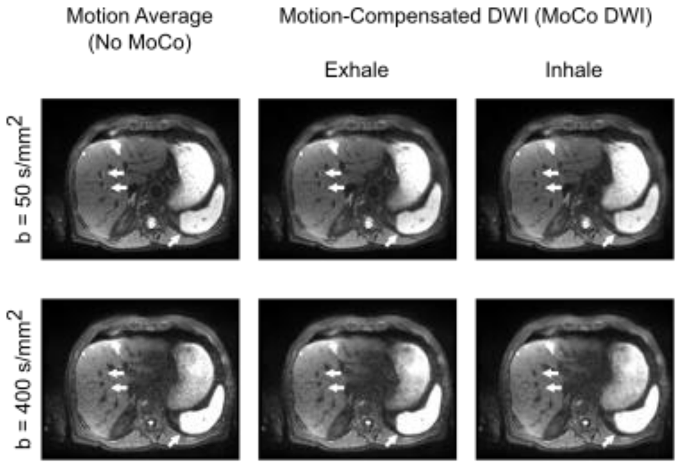
- Deform gated images to reference phase using the motion estimation from ❶.
- These volumes are averaged to the final MoCo DWI volume.

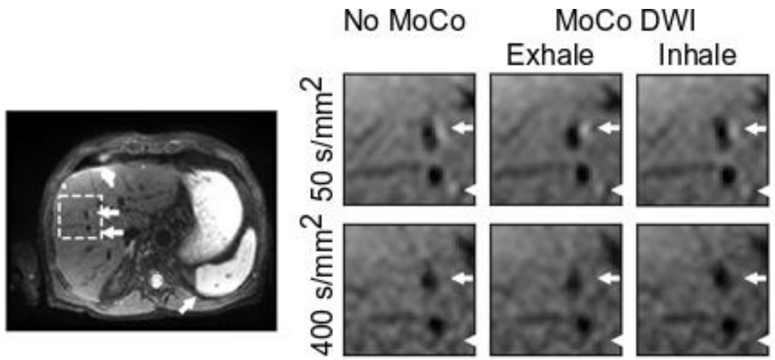
[1] K. T. Block *et al.*, "Towards Routine Clinical Use of Radial Stack-of-Stars 3D Gradient-Echo Sequences for Reducing Motion Sensitivity," *J. Korean Soc. Magn. Reson. Med.*, vol. 18, no. 2, pp. 87–106, Jun. 2014.
[2] C. M. Rank *et al.*, "4D respiratory motion-compensated image reconstruction of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

Results

MoCo DWI by b-Value

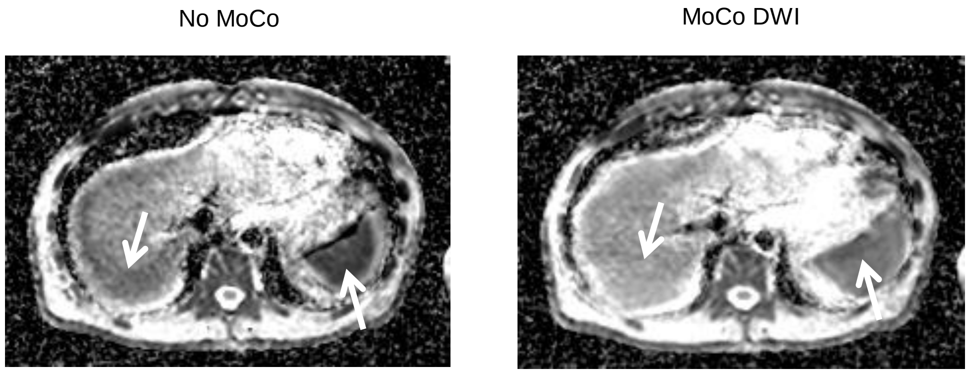
Comparison of the gold standard (No MoCo) with MoCo DWI for a volunteer. Motion blurring reduced in structures and especially edges.





Impact on Apparent Diffusion Coefficient (ADC) maps

- Often motion blurring is not dominant in the 5 mm thick axial slices
- Additionally, reproducibility of motion phase between b-values increases
- ADC maps profit from this reproducibility observed at increased homogeneity and less motion artifacts



Volunteer 10

Conclusion

- MoCo DWI in abdomen is feasible.
- Allows free-breathing, thus low patient compliance required.
- Improves motion blurring. However, motion blurring not dominant without MoCo.
- Noise not increased.
- Motion compensation independent from image quality of DWI to high extent.
- Reduces artifacts in ADC map, promises improvement in other derived volumes

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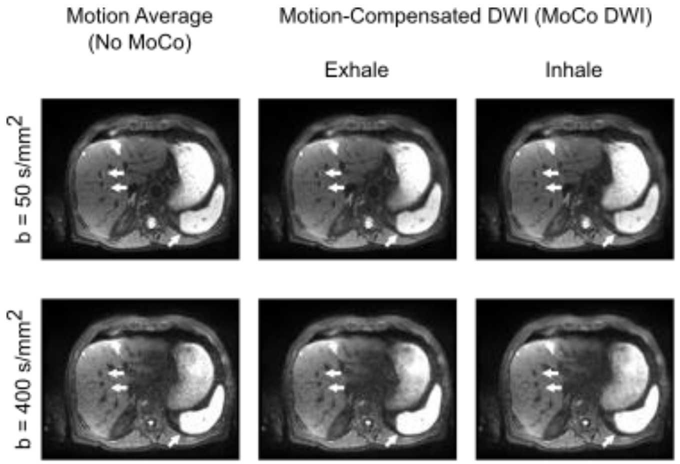

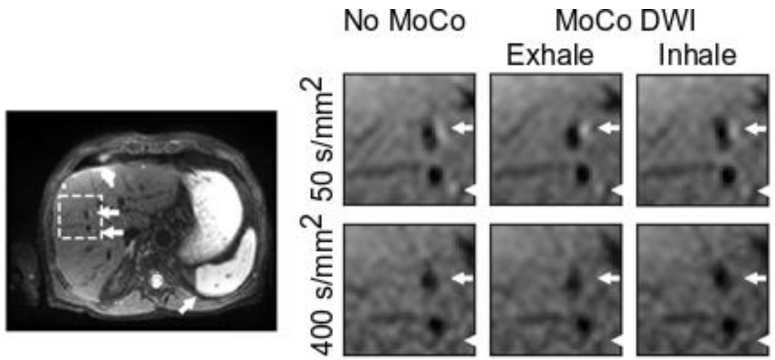

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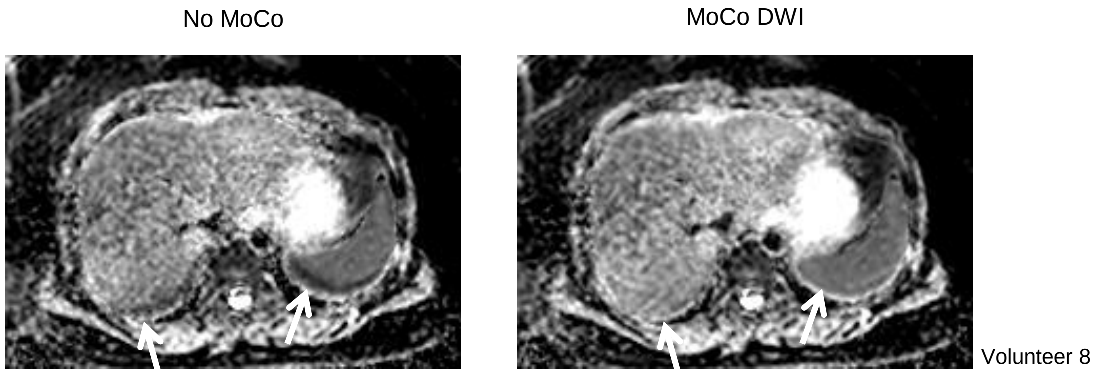

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