Clinical Implementation of Fast Markerless Motion Correction in K-Space of Structural 3D MR-Images of the Brain

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OBJECTIVES

- Retrospective motion correction (MoCo) has previously been demonstrated using navigators to estimate motion [1].

- Retrospective MoCo using markerless tracking [2] to demonstrate the potential of this combination for clinical use.

- Higher temporal resolution of the motion estimates.

- Correction of standard image sequences without modifications.

METHODS

- Two MPRAGE scans of one subject with different motion patterns were preformed on a Siemens mMR Biograph.

- Head motions were estimated with the markerless motion tracker TCL3 [3] with a temporal resolution of 30 Hz.

- Retrospective correction was implemented in Matlab using RetroMoCoBox [4].

- Rigid-body correction was applied by additional phase-ramps to account for translation and using a non-uniform FFT implementation [5,6] to account for rotations.

Fig 1. Study setup of the mMR Biograph scanner and the TCL3 markerless motion tracker.

REFFERENCES

1. D. Gallichan, J. P. Marques, and R. Gruetter, "Retrospective correction of involuntary microscopic head movement using highly accelerated fat image navigators (3D FatNavs) at 7T," Magn. Reson. Med., vol. 75, no. 3, pp. 1030–1039, 2016..

2. J. Slipsager et al., "Markerless motion tracking and correction for PET, MRI, and simultaneous PET/MRI." PloS one 14.4 (2019): e0215524.

3. R. Frost et al., "Markerless high-frequency prospective motion correction for neuroanatomical MRI," Magn. Reson. Med., no. July 2018, pp. 1–19, 2019

4. RetroMoCoBox Toolbox, github.com/dgallichan/retroMoCoBox

5. MIRT Toolbox, web.eecs.umich.edu/~fessler/code/

6. gpuNUFFT Toolbox, github.com/andyschwarzl/gpuNUFFT

RESULTS

- Improved image quality in both slow continues and fast stepwise motion after MoCo were applied.

- MoCo reconstruction in 2 minutes using GPU accelerated implementation.
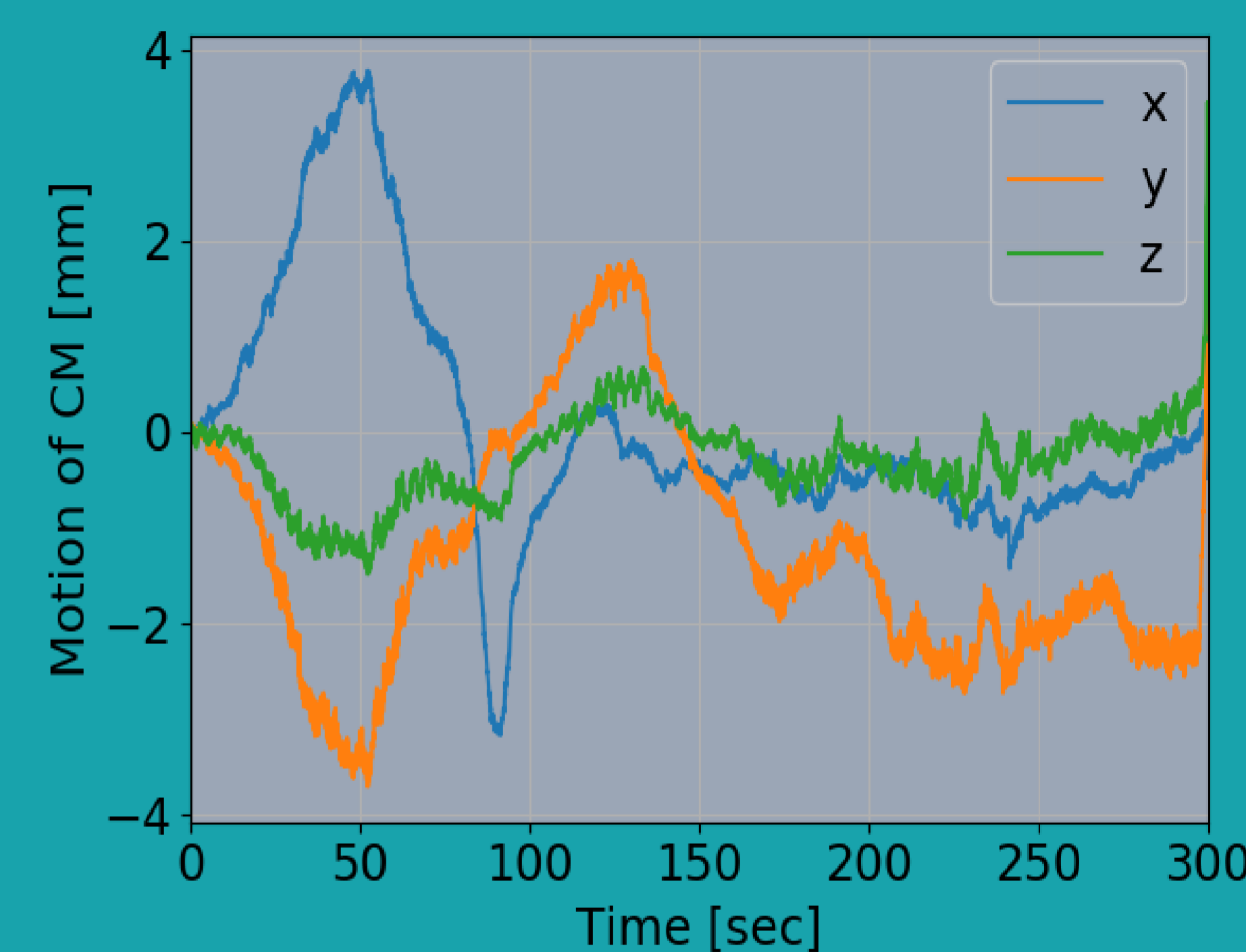

Fig. 2. The left figure shows the reference point cloud of the subject's head. The right figure shows the estimated head motion during the scan with slow continues head rotation. The motion is represented as the displacement of the center of mass (CM) relative to the reference point cloud.

MPRAGE Sequence Settings

- 16-channel Head-Coil

- TR = 1900 ms, TE = 2.44 ms, Flip angle = 9 degrees

- FOV = 192 x 256 x 256 mm

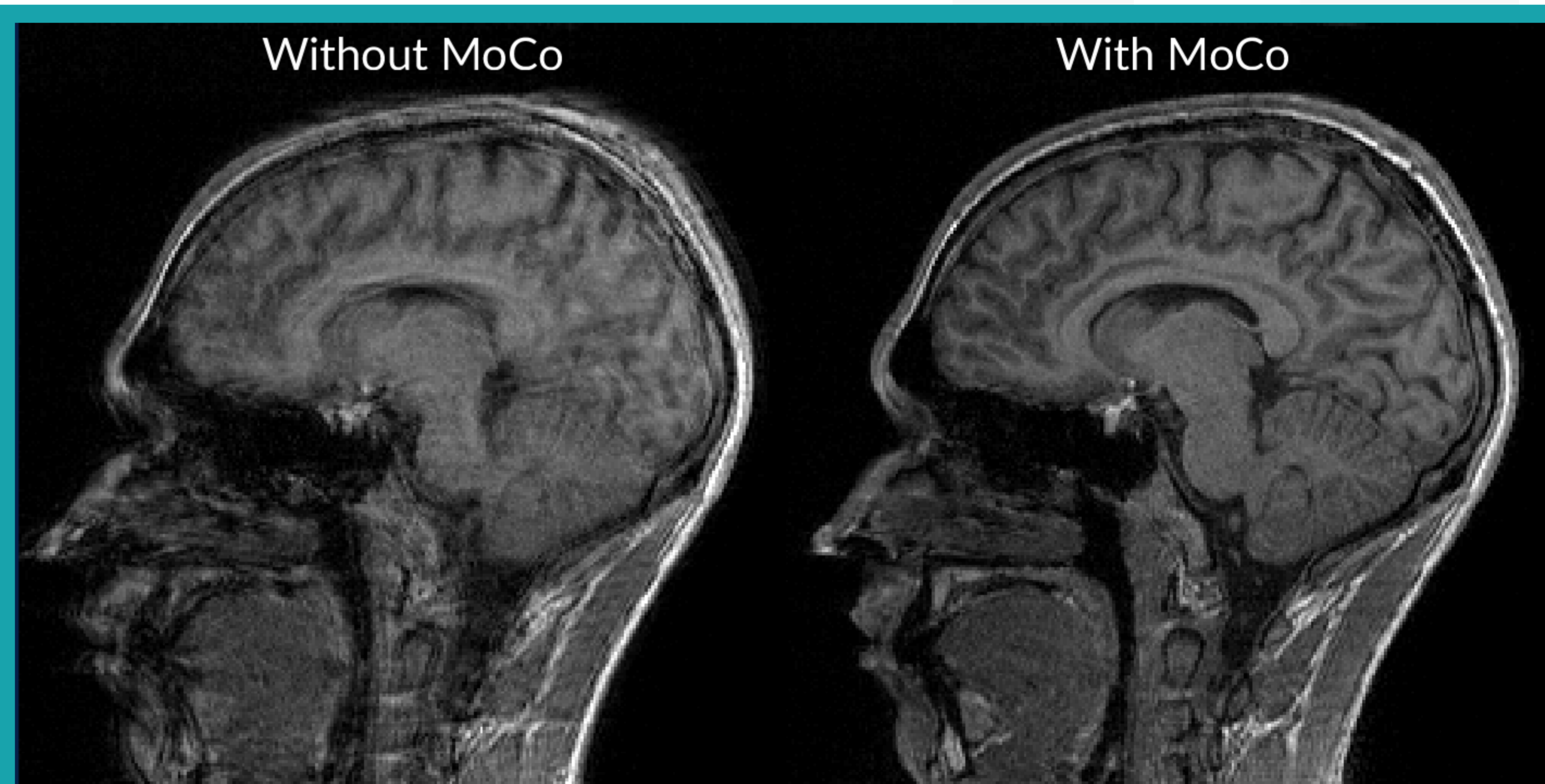- Voxel Size = 1.00 x 1.00 x 1.00 mm

- Grappa acceleration factor = 2

Fig. 3. MPRAGE scan with the associated motion shown in Fig. 2. The contrast of white and gray matter is improved after motion correction.

CONCLUSION

- Fast retrospective MoCo in the k-space domain using an external markerless motion tracker significantly improved the quality of the structural 3D MR-images.

- The MoCo procedure was implemented on a clinical scanner without changing any existing pulse sequences or acquisition protocols

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