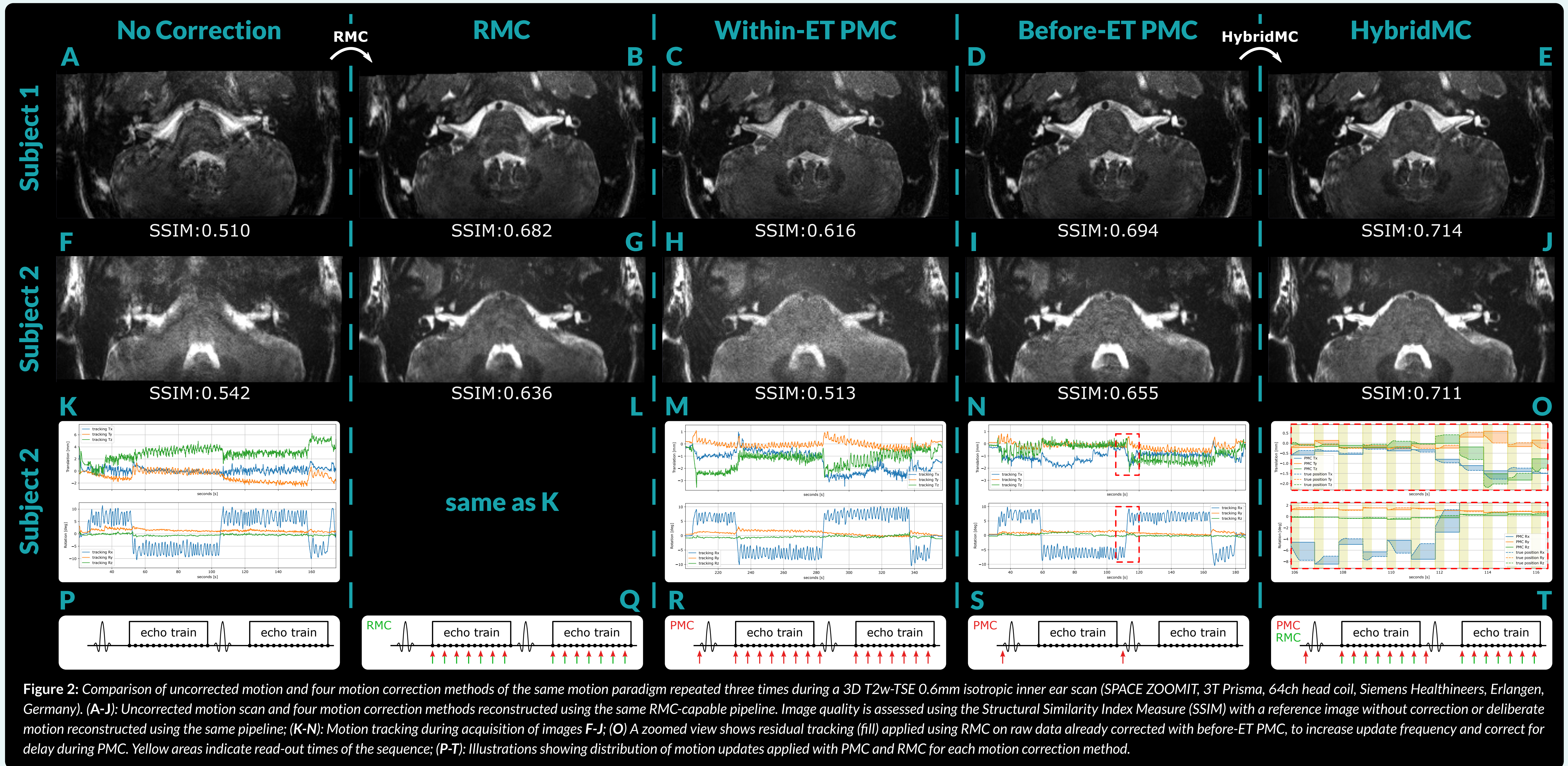


HYBRID MOTION CORRECTION: WITHIN-ECHO-TRAIN MOTION CORRECTION FOR 3D T2W-TSE INNER EAR MRI

Malte Laustsen¹, Stefan Glimberg¹, Jakob Slipsager¹, Robert Frost², Melanie Ganz³, André van der Kouwe², and Thomas Gaass¹
¹TracInnovations, Ballerup, Denmark, ²Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, United States, ³Copenhagen University Hospital, Rigshospitalet, Copenhagen, Denmark



INTRODUCTION

High temporal frequency within-echo-train (within-ET) Prospective Motion Correction (PMC) outperforms before-echo-train (before-ET) PMC for 3D MPRAGE [1]. However, within-ET updates were ineffective in 3D T2w-TSE limiting update frequency to before-ET [1]. Hybrid motion correction (HybridMC) – combining before-ET PMC and within-ET Retrospective Motion Correction (RMC) – can alleviate these shortcomings and correct for motion during echo-trains in 3D T2w-TSE.

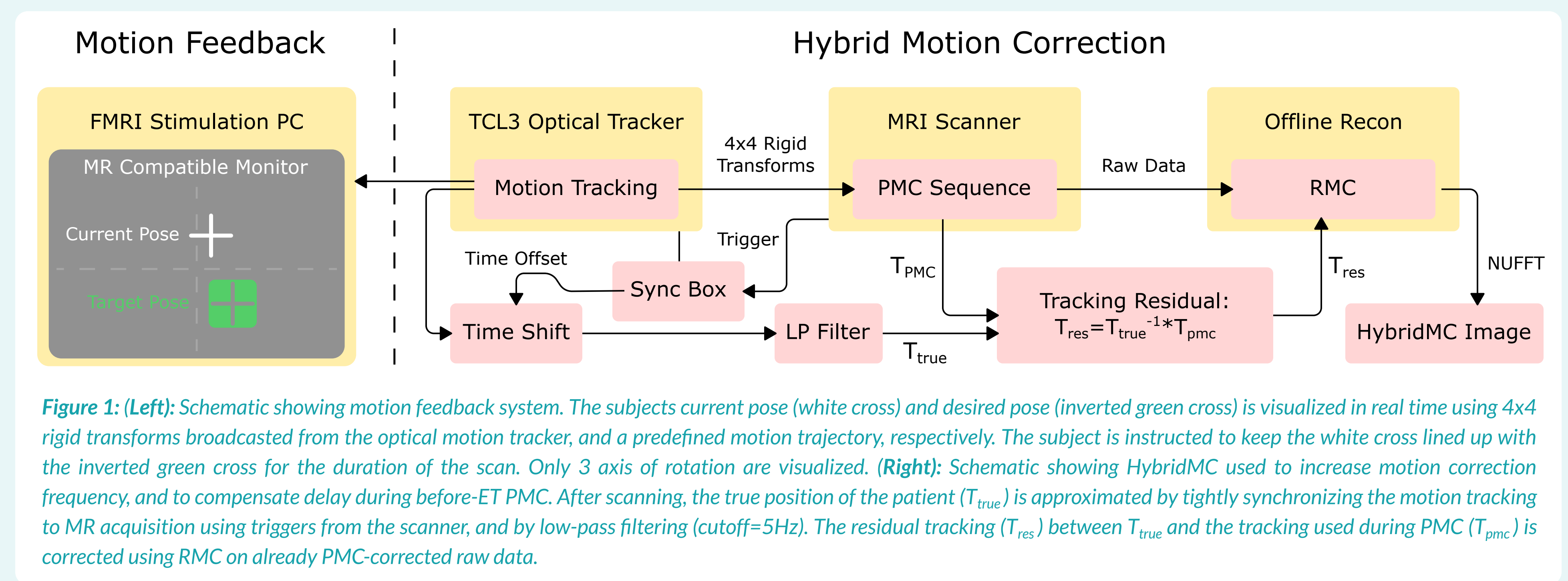
METHODS

The study used:

- a PMC-enabled 3D T2w-TSE sequence [1] with "blipped" RF-excitation enabling tight FOV around the inner ear.
- a markerless optical motion tracking system (Tracoline TCL 3.2, TracInnovations) supplying 30 head pose estimates per second.
- an RMC-capable reconstruction pipeline utilizing the Fourier Shift Theorem and a non-uniform Fourier transform. [2]

Four correction methods were compared: before-ET PMC, within-ET PMC, within-ET RMC, and HybridMC. Motion correction frequency was 30Hz (once every 5.5 lines on average) except for before-ET PMC with a motion correction frequency of 1Hz.

HybridMC: the residual between the motion corrected by before-ET PMC and tracked motion during the ET, filtered with a non-causal lowpass filter, is applied using RMC on the raw data already corrected with PMC. In addition to increasing motion correction frequency, HybridMC also compensates latency-induced errors by applying the residual between PMC updates and motion tracking precisely synchronized to the scanner. [3] (See Figure 1: Right)



Two healthy volunteers performed a motion paradigm with/without PMC, guided by a motion feedback system displayed on an MR-compatible screen (NordicNeuroLab, Bergen, Norway) (see Figure 1: Left). Motion consisted of four slow head nods (8 & 12 deg. rotation for subj. 1 & 2 respectively) with addition of heavy breathing motion in a pseudorandom pattern (1.5 & 2 deg. rotation for subj. 1 & 2 respectively, with 20-60 breaths per minute).

RESULTS

- Bulk motion is sufficiently corrected using before-ET PMC while within-ET motion remains uncompensated.
- Enabling within-ET PMC leads to a loss of contrast and SNR.
- Combining before-ET PMC and RMC using HybridMC sufficiently compensate within-ET motion, achieving superior image quality and SSIM (see Figure 2).

DISCUSSION

- The study indicates that within-ET updates are worse than before-ET PMC for 3D T2w-TSE, causing loss of signal and SNR, limiting PMC to correct inter-ET motion only.
- A combination of PMC and RMC can be used to overcome these limitation enabling intra-ET correction in 3D T2w-TSE.
- Future research should explore the efficacy of HybridMC across different types of motion, and other TSE sequence variants.

REFERENCES

- [1] Frost R, et al. 2019 [doi: 10.1002/mrm.27705].
 [2] Slipsager JM, et al. 2022 [doi: 10.1002/mrm.28991].
 [3] Laustsen M, et al. 2024, Proc 33rd ISMRM, p. 2660
Funding: grant NIH S10OD025253