A motion-corrected reconstruction for highly undersampled perfusion CMR

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Abstract

INTRODUCTION: First-pass perfusion cardiac MR (pCMR) facilitates the non-invasive diagnosis of coronary artery disease by acquiring dynamic images during the rapid passage of a contrast bolus through the heart[1]. A trade-off exists between heart coverage and temporal/spatial resolution. To alleviate this shortcoming, undersampled acquisitions followed by constrained reconstruction methods have been proposed. Also, there is a growing preference for acquiring images during free-breathing, as it offers increased reliability and enhanced patient comfort. In this context, the incorporation of motion correction (MoCo) approaches becomes essential for both free-breathing acquisitions and for correcting residual motion due to imperfect breath-holding. However, MoCo tends to degrade as acceleration increases. This work proposes a pipeline for a motion-corrected reconstruction of highly undersampled pCMR acquisitions. A novel rigid MoCo step, formulated exclusively in k-space, is proposed.

METHODS: Data Three patients underwent a REST pCMR acquisition on a Philips 3T Achieva scanner. Acquisitions parameters were: in-plane resolution = 1.6 × 1.6 mm^2, FOV = 320×320 mm^2, slice thickness = 10 mm, 32 coils, and scan time = 1 min. A radial sampling was used with 10 spokes per frame (acceleration factor ~20x); however, prior to any other step, the k-space was gridded onto a Cartesian grid. Sensitivity maps were estimated using ESPIRIT[2].

Proposed approach: The main steps of the motion-corrected reconstruction pipeline are: 1) Rigid MoCo in k-space with K-CC-MoCo[3]; this method performs a pairwise registration formulated exclusively in k-space with the normalized cross correlation as the registration metric defined between a synthetic reference and the k-spaces of each frame. To focus the minimization on the heart region, a ROVir coil-compression approach[4] is employed. 2) Low Rank + Sparse (L+S) reconstruction[5] of the rigidly motion-corrected k-space. 3) Pair-wise non-rigid image-based MoCo of the reconstructed dynamic images to correct for slight residual motion[6].

RESULTS & DISCUSSION: Figure 1 shows the results for the motion-corrected reconstructions in a representative patient in which bulk motion caused by imperfect breath-holding is observable. The results show that the application of MoCo approaches notably reduces blurring when all the frames of the dynamic images are combined. Also, we should highlight that the rigid MoCo step in k-space becomes crucial for an accurate overall MoCo; specifically, the non-rigid motion-corrected images that were reconstructed without this first step (Fig 1.C) present a poorer correction compared to the images obtained with the three-steps proposed approach (Fig 1.D).

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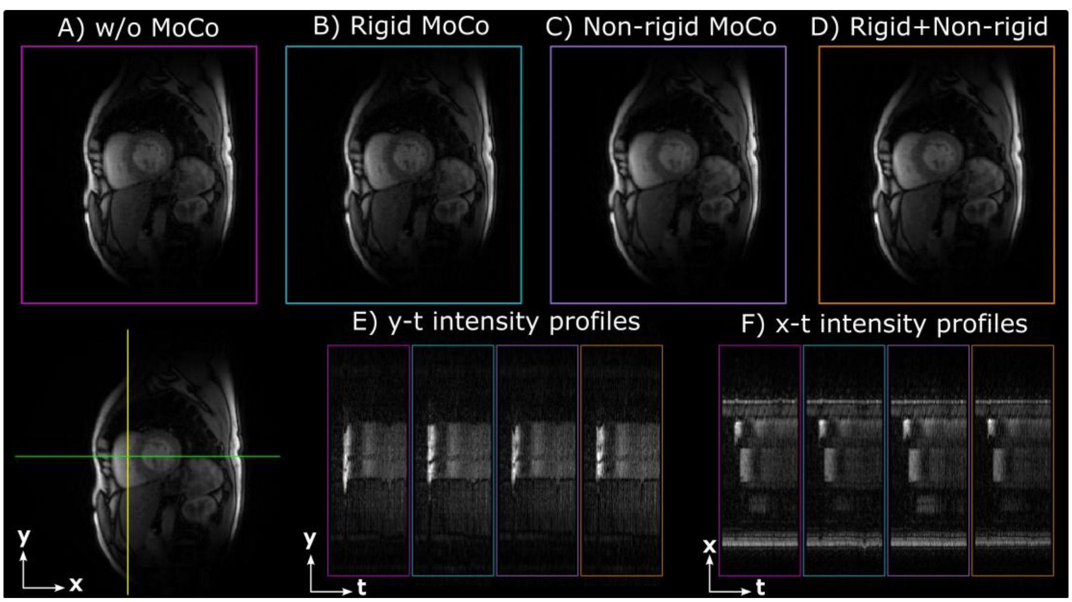

Figure 1 – Sum along frames of the reconstructed dynamic images for the pipelines A) without MoCo, B) with only rigid k-space-based MoCo. C) with only non-rigid image-based MoCo, and D) with both rigid (in k-space) and non-rigid (in image-space) MoCo. Also, intensity profiles for E) y-t direction (yellow line, foot-head) and F) x-t direction (green line, right-left).

References

1. Fair M.J., et al. J Cardiovasc Magn Reson. 2015;17(1),68; **2.** Uecker M., et al. Magn Reson Med 2021;71(3),990-1001; **3.** Moya-Sáez E., et al. ISMRM 2025. **4.** Kim D., et al. Magn Reson Med 2021; 86(1),197-212; **5.** Otazo, R., et al; Magn Reson Med 2015;73(3),1125-1136; **6.** Menchón-Lara R.M., et al. Signal Processing 2023;202,108771.