Journal of Cardiovascular Magnetic Resonance

BioMed Central

Poster presentation

Open Access

Highly efficient respiratory gating in coronary MR employing non-rigid retrospective motion correction

Johannes F Schmidt*, Martin Buehrer, Peter Boesiger and Sebastian Kozerke

Address: Institute of Biomedical Engineering, University and ETH Zürich, Zurich, Switzerland

* Corresponding author

from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P41 doi:10.1186/1532-429X-12-S1-P41

This abstract is available from: http://jcmr-online.com/content/12/S1/P41

Introduction

Three-dimensional whole heart imaging becomes the method of choice in cardiac applications [1] as it avoids extensive planning of imaging slices and allows reconstructing arbitrary slice orientations. The drawback is a relatively long scan time on the order of several minutes which requires motion compensation to suppress motion artifacts. Prospective techniques such as respiratory navigator based gating or triggering including slice tracking is often used. Recently, retrospective approaches were successfully implemented by extending the image encoding matrix with motion operators and solving the system iteratively [2-4]. This allows for increased gating windows or even continuous scanning across the entire breathing cycle but necessitates detailed information of the underlying motion vector field at each acquisition.

Purpose

In this work, a template-based approach for retrospective motion correction was used to correct for respiratory motion artifacts in free-breathing coronary MR scans with gating windows as large as 20 mm.

Methods

Whole heart images were acquired in six healthy subjects on a 1.5 T Philips Achieva System (Philips Healthcare, Best, The Netherlands). A volunteer-specific motion model was retrieved from a low-resolution multi-2D prescan with a voxel size of 4 × 4 × 4 mm³, where each slice was acquired repeatedly in single-shot mode at different respiratory states. The motion vector fields between these respiratory states were then calculated by image registration [5]. Missing respiratory states were linearly interpolated. The actual 3D scan was a standard navigator-gated 3D-BTFE sequence with an increased gating window of 20 mm and a voxel size of 1.33 × 1.33 × 1.33 mm³. An additional 3D scan with a gating window of 5 mm was acquired as reference.

Before reconstruction, the coil array was combined to one virtual coil to reduce the data set [6]. The extended encod-

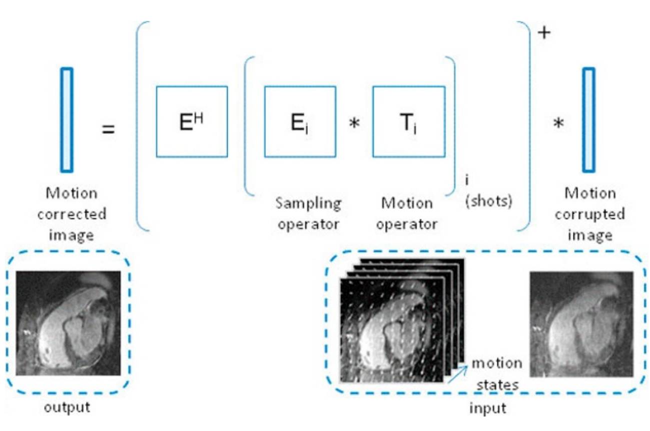

Figure 1
The effect of motion during a multi-shot scan can be written as matrix equation. T_i are motion operators which describe the motion per voxel from the reference to the respiratory state at the given shot. E_i and E^H are standard sampling operators and their Hermitian conjugate, respectively. The '+' indicates the pseudo-inverse.

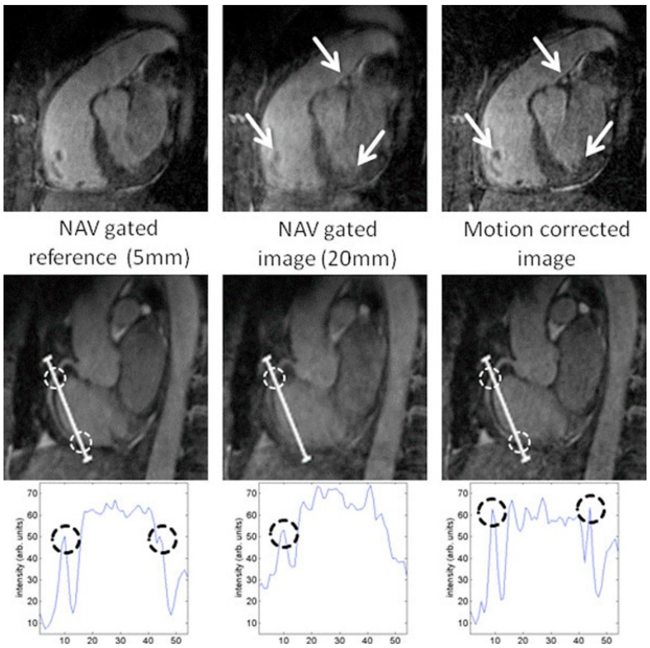

Figure 2
Sagittal slice (upper row) and slice along the right coronary artery (middle row) for the 5 mm gated reference, the 20 mm gated image and the retrospectively corrected image. The lower row shows intensity profiles along the white line.

ing matrix (Fig. 1) was inverted iteratively using six iterations for each reconstruction.

Results

The average gating efficiency increased from 47% ± 18% for the 5 mm gated reference to 93% ± 7% for the 20 mm gated scan. The image quality of the motion corrected image was found to be comparable to the reference scan (Fig. 2). Reconstruction times using Matlab on a standard computer were on the order of 15 min.

Conclusion

It has been shown that respiratory motion artifacts can be retrospectively corrected using a non-rigid motion model derived from a short pre-scan. The gating efficiency could be doubled and thus scan times reduced. Further work is warranted to determine the robustness of the method in the presence of strong respiratory drifts as can occur in cardiac patients.

References

1. Uribe S, *et al.*: *Radiology* 2008, **248(2):**606-614.
2. Batchelor PG, *et al.*: *MRM* 2005, **54(5):**1274-1280.
3. Atkinson D, *et al.*: *MRM* 2006, **56(5):**1135-9.
4. Odille F, *et al.*: *MRM* 2008, **60(1):**146-157.
5. Andronache A, *et al.*: *MIA* 2008, **12(1):**3-15.
6. Buehrer M, *et al.*: *MRM* 2007, **57(6):**1131-1139.