

Motion compensated reconstruction for thoracoabdominal dynamic contrast-enhanced MRI in free-breathing

M. Filipovic^{1,2}, P-A. Vuissoz^{1,2}, A. Codreanu³, M. Claudon⁴, and J. Felblinger^{1,5}

¹INSERM-U947, Nancy, France, ²Laboratory IADI, Nancy-Université, Nancy, France, ³Centre Hospitalier de Luxembourg, ⁴University Hospital Nancy, ⁵INSERM-CIC801

INTRODUCTION

The analysis of abdominal and thoracic dynamic contrast-enhanced MRI is often impaired by motion-induced artifacts and misregistration, caused by physiological motion. Breath-holding is too short to cover these long acquisitions and suffers from imperfections. A previously published reconstruction algorithm, GRICS [1], corrects for motion-induced artifacts in a single image reconstruction. A novel method has been developed by modifying GRICS with the purpose of performing whole motion compensation in dynamic contrast-enhanced MRI. The main goal is to simplify post-processing and to improve the accuracy of time-intensity curves analysis. The performance is demonstrated on myocardial perfusion MRI, on 6 clinical examples and a simulated data set.

THEORY

Given in entry MRI raw data and physiological respiratory signals, GRICS [1] reconstructs the wanted image corrected for motion artifacts and yields in addition spatial distortion maps. The equations solved by GRICS are modified in order to include dynamic contrast enhancement: the true image ρ_0 is replaced by a linear dynamic contrast change model (1), where $S_i(t)$ are ideally independent functions of time capable of modelling different local intensity changes occurring in any DCE-MRI series. This model was already applied to a series of two images, using a step function [3]. In order to reduce the number of variables, only pixels with significant profile in x-f space were retained, similarly to [2].

$$\rho_0 = \sum_i \beta_i S_i(t) \quad (1)$$

METHODS

Myocardial perfusion data were collected from 6 routine clinical cardiac MRI exams on a 3T scanner (General Electric, Milwaukee, WI). After Gd-DTPA (Dotarem, Guerbet, France) injection (0.05mmol/kg at 4 ml/s rate), the heart was imaged at rest, in free-breathing with cardiac gating, with a saturation recovery interleaved GRE-EPI pulse sequence for about 1min, with spatial resolution 128x128, FOV 175mm, temporal resolution 1 RR, and echo train length 4. Collected data were reconstructed both by the MRI device and with the presented method. In order to evaluate the method in a more thorough manner, simulation data were generated by choosing and adding known motion and known contrast change to an initial clinical image. Motion was simulated using spatial distortion maps obtained from previous clinical data reconstructions. Different sets of time-intensity curves, resembling typical myocardial perfusion curves, were applied on the initial image in several regions of interest. The contrast change model was implemented with 3rd degree B-splines created with control points two times sparser than image series time points. This basis was chosen because of its attractive properties: it maintains the linearity of the equation system, and the curve shapes are suitable for typical time-intensity curves occurring in thoracoabdominal DCE-MRI.

RESULTS

Simulation results present whole motion correction and higher accuracy of time-intensity curves. The mean rms error between ideal curves and those extracted after reconstruction showed to be reduced by 80% with the presented method, compared to standard reconstruction. In 5 clinical myocardial perfusion series out of 6, the method performed good 2D motion compensation and resulted in time-intensity curves with lower local variability. In the 6th example, heavy physiological motion disturbed the optimization process. Time-motion profiles shown on Fig.1 demonstrate the performance of elastic registration: motion is very apparent in the original profiles and clearly corrected for in the new ones. Motion-induced variability in time-intensity curves, present after a standard reconstruction, is suppressed after the presented reconstruction, Fig.2.

DISCUSSION:

The presented method performs elastic registration and motion artifact correction on dynamic contrast-enhanced MRI image series. It outputs in addition a motion model and a contrast change model. The main purpose consists in removing motion-induced errors from time-intensity curves, thus improving curve analysis and post-processing in general. Further work shall deal with improving the robustness of the proposed method. The method has an intrinsic ability to distinguish between contrast change and motion. It is extendable in 3D and calls for more clinical tests.

REFERENCES: 1. Odille *et al.* [2008] MRM. 60:146-157 2. Tsao *et al.* [2001] MRM. 46:652-660 3. Filipovic *et al.* [2009] ISMRM, Abstract #1429

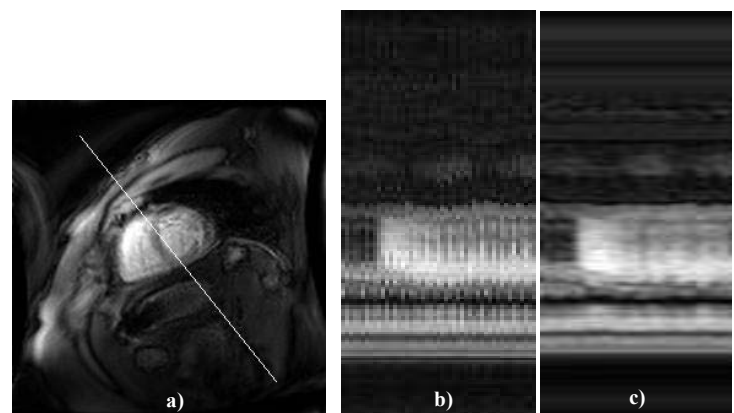


Fig 1: a) The line on the image used to generate motion-time profiles of: b) original data and c) data reconstructed by the presented method

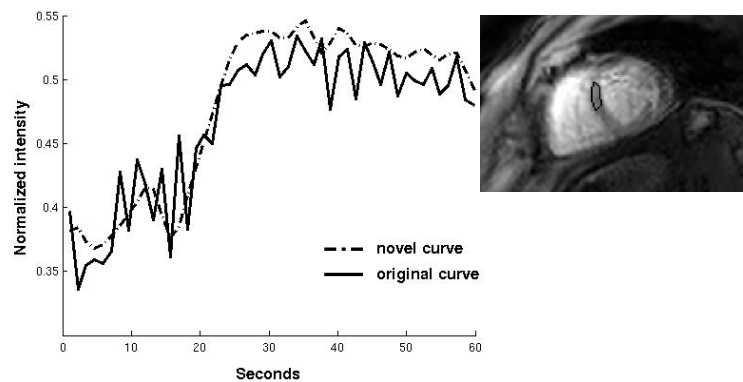


Fig 2: Time-intensity curves in free-breathing (left) extracted from a myocardial segment (right) after standard reconstruction and after reconstruction with the presented method