Journal of Cardiovascular Magnetic Resonance

BioMed Central

Meeting abstract

Open Access

212 Material point tracking with enforced incompressibility using MRI

Scott Lipnick*, Abbas Moghaddam and J Paul Finn

Address: University of California, Los Angeles, Los angeles, CA, USA
* Corresponding author

from 11th Annual SCMR Scientific Sessions
Los Angeles, CA, USA. 1–3 February 2008

Published: 22 October 2008

Journal of Cardiovascular Magnetic Resonance 2008, **10**(Suppl 1):A73 doi:10.1186/1532-429X-10-S1-A73

This abstract is available from: http://jcmr-online.com/content/10/S1/A73

Introduction

Phase-contrast (PC) MRI and displacement encoding with stimulated echoes (DENSE) MRI can be used to image heart muscle contraction, from which unique insight into a variety of cardiac diseases can be acquired. Abnormal function can be a result of impaired blood flow and/or tissue necrosis as in coronary artery disease or other primary diseases of the heart muscle. Accurate displacement information is necessary for calculation of strain, which is considered a key indicator of myocardial function. We propose a method for material point tracking using PC-MRI and DENSE-MRI. In order to ensure accurate tissue tracking it is important that material point displacement is physiologically constrained. Muscle tissue maintains constant density at all times, which through conservation of mass this leads to the divergence of the velocity field equaling zero. The proposed method enforces the physiological constraint of incompressibility through a multi-resolution Gauss-Seidel successive over-relaxation technique. After enforcing incompressibility material points follow physiological tracks. This study describes the implementation of the tissue tracking method and subsequent clinical trials.

Purpose

A limitation in tissue tracking and subsequent strain calculations are that material point trajectories do not satisfy the condition of incompressibility. The goal of our research is to implement a tissue tracking algorithm that enforces physiological constraints of myocardial displacement, which can reduce the noise in both PC-MRI and DENSE-MRI data. The algorithm enforces incompressibility through minimizing the divergence of the instant velocity which is acquired from the data field; instantaneous velocity in PC-MRI, and displacement in DENSE-MRI. Further, we evaluate the feasibility of the proposed method using simulations.

Methods

In PC-MRI instantaneous velocity is directly encoded in the phase of the magnetization, as opposed to DENSE-MRI where displacement is directly encoded. If we assume that the phase step is small enough that there is minimal change in the velocity we can conclude the displacement is proportional to the instantaneous velocity.

The tissue tracking method can be summarized through three steps:

1) Removal of high frequency spatial modulations in the velocity through Fourier analysis.

2) Enforcing tissue incompressibility through minimizing the divergence of the velocity field. To acquire the numerical solution we use an iterative multi-resolution method with the Gauss-Seidel successive over-relaxation method.

3) Interpolation of velocity field into Lagrangian coordinates in which material points are tracked through the cardiac cycle.

The influence of limiting factors such as noise, spatial and temporal resolution was tested using simulations of myocardial motion. PC-MRI and DENSE-MRI is acquired

using the Siemens Avanto 1.5 T MRI located at the University of California, at Los Angeles (UCLA). The resulting data will be used evaluated with respect to strain calculation.

Results

Feasibility of the method has been shown for simulations of cardiac motion that incorporate noise and magnetic field in-homogineities, such as eddy currents and susceptibility effects. After enforcing incompressibility the average divergence of the velocity field was decreased 97%, while the mean difference between the initial versus corrected displacement field data was less than 25%. RMS error of the altered displacement compared to the true displacement was significantly reduced following data processing using the proposed tissue tracking algorithm. Patient data is currently being acquired and analyzed.

Conclusion

The proposed method restricts data from PC-MRI and DENSE-MRI to physiological motion. Accurate tissue tracking is ensured through minimization of the divergence of the velocity field. Simulations have shown the feasibility of the method. Strain calculations from resulting data will not suffer from compression errors in the tissue trajectories.