ACCURATE REGISTRATION OF MYOCARDIUM REGION IN CARDIAC PHASE-RESOLVED BOLD MRI

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Abstract

Unfortunately, most imaging methods used today for ischemia detection are invasive. Cardiac Phase resolved Blood Oxygen Level Dependent (CP-BOLD) MRI is a recently developed approach for examining BOLD changes and wall motion in a single cine acquisition. It does not use ionizing radiation or contrast media and provides physiological information on myocardial oxygenation. With this technique,myocardial BOLD signal intensity can be obtained as a function of cardiac phase. BOLD MRI may be used for detecting myocardial oxygenation changes secondary to coronary artery stenosis (1,2). To identify the disease, CP–BOLD relies on the observation that myocardial signal intensity varies as a function of cardiac phase (3). The method has the potential to rapidly determine the presence of oxygenation anomalies in the myocardium due to coronary artery disease, and provide an unbiased and quantitative imaging biomarker that can enable the assessment of the critical states of stenosis. In order to achieve highly sensitive results, accurate pixelwise registration of the myocardium region in between the cardiac cycle is essential. The pixels need to be specified and tracked throughout a cardiac cycle for determining the location of ischemia.

Background

Previous work had focused on the territories of the myocardium, which are able to identify the regions that are possibly ischemic (4, 5). This methods give the opportunity to identify the cardiovascular disease without any stress conditions. The possibility to identify ischemic territories without exogenous contrast agents or provocative stress before the evolution of myocardial edema is shown.

Challenges

- The image artifacts
- The affine and non-rigid motion of heart
- The absence of data sets for testing
- The evaluation of the registration

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Data

2D cine SSFP-based BOLD images were acquired in 9 dogs under rest, and adenosine stress with and without LCX stenosis (of varying grades, controlled by surgically implanted hydraulic occluder) in a 1.5T scanner. Scan parameters: spatial resolution=1.2x1.2x6mm^3; flip-angle=90^o; and TR/TE=6.2/3.1ms Fig. 1 shows an image sequence on different cardiac phases.

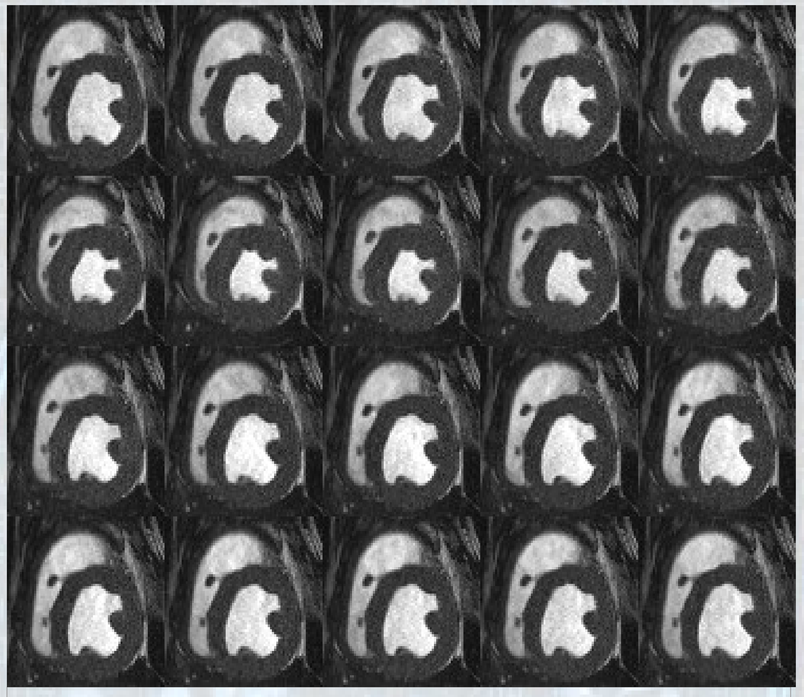

Fig. 1 A whole cardiac cycle BOLD Time Series
End diastolic phase (upper left) to end diastolic phase (lower right)

Methods

Many registration approaches used in the brain challenges are applied to the m**yo**cardial region registration in cardiac BOLD MRI.

- Myocardial Motion Estimation (6)
- Advanced Normalization Method (ANTs) (7)
- ImageJ Registration Tool (bunwarpj) (8)
- Diffeomorphic Demons(9)

References

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Preliminary Results

- The accuracy of registration for the myocardium region is calculated by Jacard and Dice overlaps between annotation of the target image and deformed annotation of the source image (Fig. 2, Fig. 3) .
- The aggressiveness of the algorithms are calculated by minimum Jacobian determinants for each point. Low minimums reflect an aggressive approach (Fig.4) .

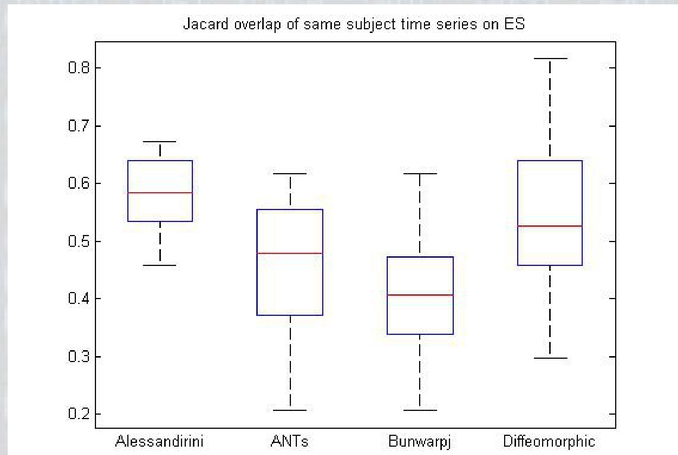

Fig. 2 Comparison of Jacard Scores

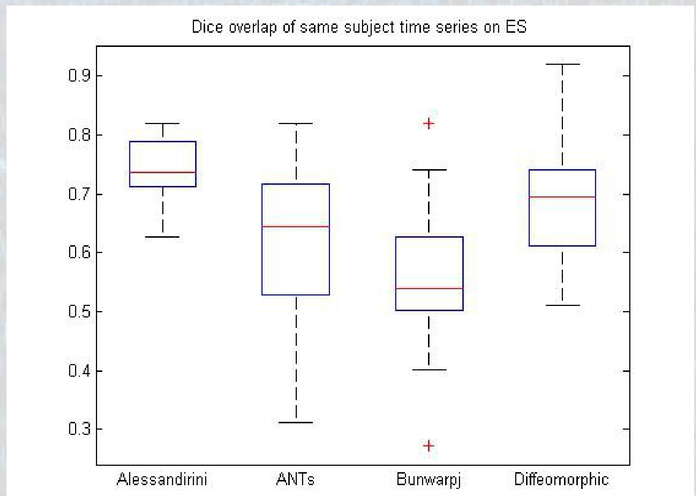

Fig. 3 Comparison of Dice Scores

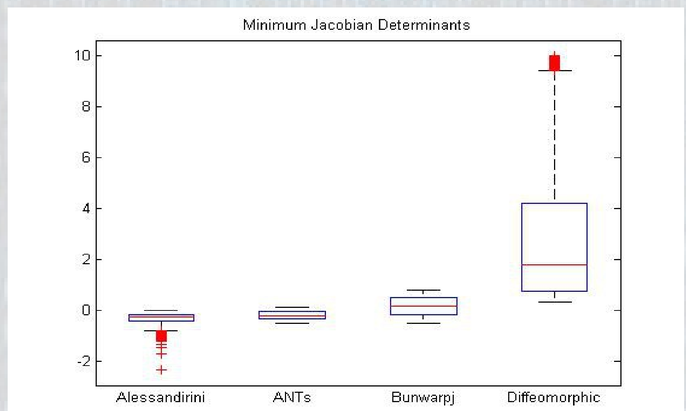

Fig. 4 Comparison of Algorithm Aggressiveness