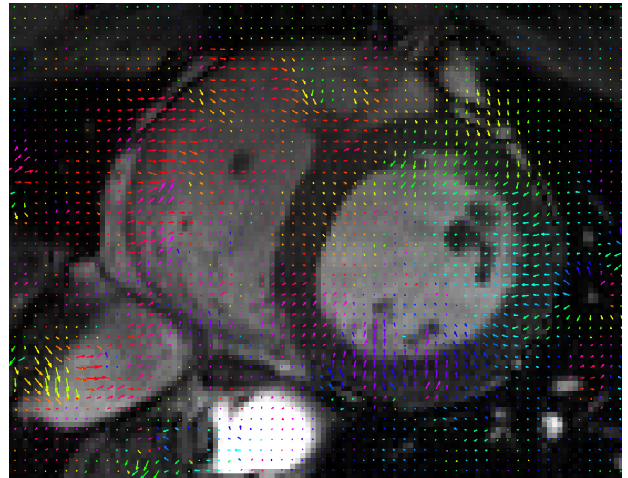
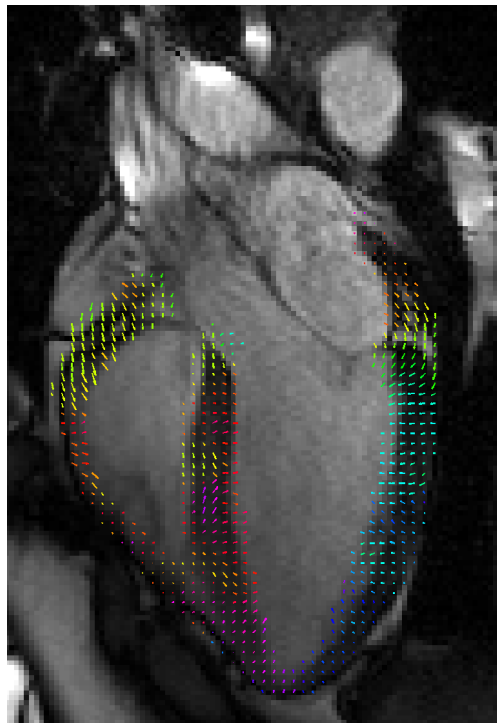


MYOCARDIAL MOTION ESTIMATION FROM CARDIAC CINE-MRI WITH A PHASE-BASED OPTICAL FLOW METHOD

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Introduction: The aim of this study was to estimate myocardial motion directly from a conventional SSFP (steady-state free precession) cine-MRI sequence. This sequence provides precise morphological information coupled with an adequate temporal resolution and excellent contrast between structures. We propose to use information naturally present in SSFP Cine-MRI for myocardial motion estimation. Generally, the evaluation of myocardial motion from cine-MRI sequences requires a visual evaluation of the regional contractile function and depends on the experience of the reader. Here, we propose to automatically and accurately detect myocardial wall motion abnormalities from cardiac cine-MRI. The technique used to assess motion information is an optical flow approach based on phase information. Optical flow (OF) is the representation of the apparent two-dimensional movement of an object in a scene. This technique allows the detection of local movement estimated at each pixel in the image with sub-pixel precision.

Materials and Methods: Myocardial motion is estimated locally using a phase-based OF technique: for a given pixel, the instantaneous velocity vector gives the magnitude and orientation of motion. The phase-based OF technique operates in the frequency space using orientation-sensitive filters also known as complex Gabor filters. First, the phase-based OF technique was tested on synthetic images to evaluate the robustness with regards to Rician noise and to brightness variations. To improve visualization of the flow field, color coding according to the velocity orientation was used. It provides a comprehensive and adapted display of motion field within the image plane. Finally, the developed OF method were applied to cardiac SSFP sequences along short and long-axis orientations.



Results: The study of the estimated phase-based OF on the synthetic sequence has shown that this technique is quite robust with respect to Rician noise. Moreover, it is relatively insensitive to brightness changes that occur with the through-plane motion of the myocardium. Therefore, in the context of cardiac cine-MRI, the visual interpretation of the quality of the computed motion field was done by an experimented observer and concords with heart behavior (contraction and relaxation). Finally, a segmental decomposition of the myocardium allowed us to study the mean velocity along the cardiac cycle and gave similar values to those obtained by echocardiography.

Discussion: This first experiment of a two-dimensional phase-based OF method applied to cardiac cine-MRI sequences gives promising results. In conjunction to cardiac cine-MRI, phase-based OF technique may help in detecting local wall motion abnormalities. Indeed, velocity is estimated at each pixel within the image sequence with an accurate quantification of tissue motion. From local motion information, regional motion parameters can be determined, giving mean velocities per ROI along the cardiac cycle.

Furthermore, phase-based OF techniques may enable applications such as quantifying heart mechanical dyssynchrony. The mechanical dyssynchrony could be available from an OF evaluation at each myocardial segment.