Automatic Selection of Cardiac Acquisition Window Using an Image-Based Global Cross-Correlation of Multi Heart Phase Cine Scans

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Synopsis:
For coronary MR angiography, a careful selection of the cardiac acquisition window is essential for the minimization of blurring due to cardiac motion. For the present study, an image-based cross-correlation approach was implemented to extract the position of the cardiac rest period from multi heart phase cine scans. Initial experiments on healthy volunteers indicate the feasibility of this approach. The cardiac rest periods could be identified easily and automatically by comparing the correlation between consecutive images. Hence, this approach may be used to plan the cardiac acquisition window in a patient-specific way without the need for user interaction.

Introduction:
For reducing motion artefacts, data acquisition in Coronary MR angiography is usually limited to the diastolic rest period of the heart. The corresponding ECG trigger delay may roughly be estimated from empirical formulas [1]. Multi heart phase cine pre-scans provide much more accurate information on the patient-specific cardiac motion, but require visual inspection of the images to derive the optimal acquisition window. Recently, a calibration scan based on navigator echoes was introduced [2]. This approach allows an automatic detection of the rest period, but requires a careful geometrical planning of the navigator position and, hence, additional user interaction. In addition, the information provided by the one-dimensional navigator is rather limited compared to multi heart phase images.

For the present study the advantages of the latter two approaches were combined by implementing an automatic image-based cross-correlation analysis for multi heart phase cine scans.

Method:
An image-based correlation algorithm was implemented on a clinical 1.5 T scanner (Gyroscan ACS-NT15, Philips Medical Systems). After completion of a multi heart phase cine scan, the global cross-correlation within each pair of consecutive cine images is determined by the host software of the scanner and stored on disk for later evaluation. This frame-to-frame correlation scheme was chosen, because it directly measures the differences between successive images and represents a robust measure for the relative changes. To define a correlation kernel, the algorithm uses the position of the shim volume, which covers the vicinity of the heart, as an image mask.

Experiments were performed on 7 healthy volunteers. 2D ECG-gated, breath-hold cine segmented balanced (True-Fisp) gradient-echo sequences were performed (FOV: 320mm x 224mm, 192 x 100 scan matrix, 5mm slice thickness, 30 heart phases, TE = 2.8ms, α=60°, 10 s scan time). A transversal scan orientation was chosen containing the intersection with the RCA (Fig. 1, right), since the motion amplitude of the RCA is larger than that of the left system [3]. A single circular surface coil was used for signal reception. The positions of the maxima of the correlation curves derived by the cross-correlation were compared to the rest periods of the RCA, which were derived manually by visual inspection of the images.

Results:
For all volunteers, the different cardiac phases were identified easily by the minima and maxima of the correlation curves, which correspond to phases of low and high cardiac motion, respectively. Fig. 1 shows the correlation graph for three selected volunteers. A shortening of the diastolic rest period with increasing heart rate was found. The correlation maximum in the systolic rest period was slightly reduced compared to the maximum in mid-diastole. This shows that the residual motion is more prominent in the systolic rest period than in the diastolic period. The manually derived rest periods (visual inspection) of the RCA coincide very well with the maxima of the correlation curves for all volunteers. Thus, a simple algorithm (e.g. selecting the two highest neighboring data points) would be sufficient to determine the cardiac rest period.

Discussion:
The initial results obtained in this study, which are in accordance with the literature [4], indicate that the correlation between images of consecutive heart phases is a good measure for cardiac motion. The optimal acquisition window could be identified easily (and automatically) by selecting the maximum of the correlation curve. To further improve the approach, the spatial position and orientation of the cine scan could be optimised. To track the motion of the coronary vessel directly, the correlation kernel could be limited to the vicinity of the vessel (e.g. intersection of RCA with transversal imaging plane). This would require one additional user interaction. The presented approach can be extended to identify other phases of the cardiac motion or to allow its quantification. Using a registration approach [5], the motion can be measured quantitatively to perform motion correction prospectively or as a postprocessing step.

References: