High Resolution Variable-Density 3D Cones Coronary MRA

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Target Audience: MR physicists, engineers and clinicians interested in coronary angiography and accelerated imaging.

Purpose: High resolution in coronary MR angiography (CMRA) is necessary for imaging vessels on the order of 2-3 mm in proximal segments. Sub-millimeter scanning has been investigated for Cartesian acquisitions using both parallel and compressed sensing reconstructions[1-2]. This work presents clinical results of high-resolution non-Cartesian imaging using a variable-density (VD) 3D cones trajectory[3] and wavelet-based efficient self-consistent parallel imaging reconstruction (L1-ESPIRiT)[4].

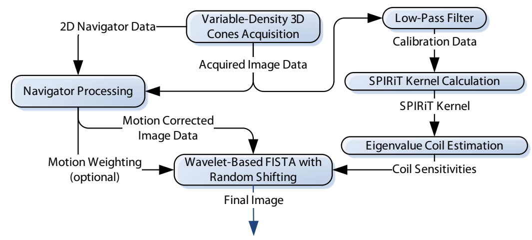

Figure 1: L1-ESPIRiT reconstruction process.

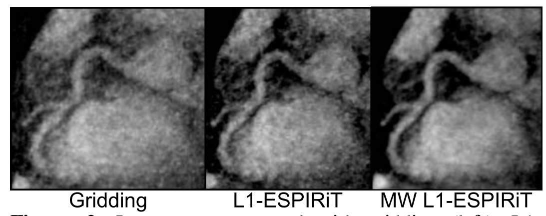

Figure 2: Images reconstructed with gridding (left), L1-ESPIRiT (middle), and motion-weighted L1-ESPIRiT (right).

Methods: To increase the resolution without incurring a scan time penalty, a self-calibrating, 0.8 mm isotropic resolution, VD 3D cones trajectory was designed with the sampling density reduced from 1.0 at the edge of the calibration region to 0.59 at k_r=k_{max}. This resulted in an acceleration factor of 2.9. The reconstruction process, outlined in Fig. 1, was performed using L1-ESPIRiT to reduce the presence of streaking and noise-like aliasing image artifacts. Coil sensitivities were calculated from the calibration data as shown on the right side of the chart. The iterative reconstruction framework provides the option to retrospectively weight data based on displacement from the mode heart position to improve the consistency of reconstructed data[5].

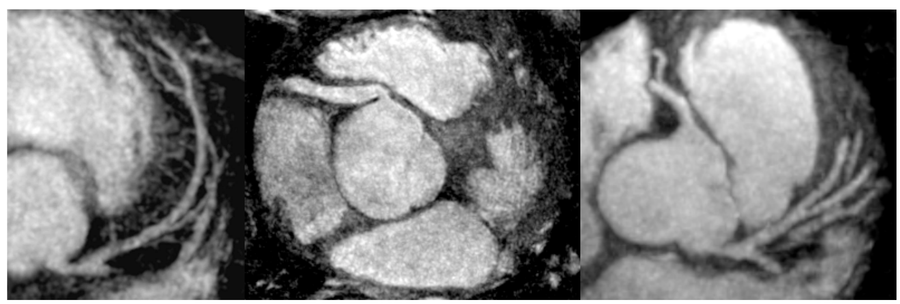

Figure 3: Three patient study images reconstructed with MW L1-ESPIRiT.

High-resolution scans were incorporated into patient exams following a Gd-based contrast injection. An ATR-SSFP sequence[6] was run on a 1.5 T GE Signa Twinspeed scanner using an 8-channel cardiac coil with imaging parameters: 28×28×14 cm^3 field of view, 2.8 ms readout duration, 70° flip angle, TE/TR1/TR2 = 0.61/1.15/4.33 ms, 66 ms acquisition window, and 800 heartbeat scan time. Sagittal and coronal 2D image-based navigators were acquired each heartbeat to provide linear phase 3D translational motion correction and 3D position information for motion weighting. Within the L1-ESPIRiT reconstruction process, the inverse problem was solved using a wavelet-based FISTA algorithm[7].

Results: Figure 2 shows a dataset reconstructed with 3 methods. Compared to gridding reconstruction (left), image quality and vessel sharpness successively improve with L1-ESPIRiT (middle) and motion weighting (right). The degree of improvement from motion weighing varied from subject to subject based on the rigidity of the heart motion. Figure 2 shows reformated images from 3 additional patient studies, reconstructed with motion-weighted L1-ESPIRiT. A clear depiction of the coronary arteries can be seen.

Discussion/Conclusion: Results demonstrate the feasibility of acquiring high spatial and temporal resolution CMRA in clinically feasible scan times using VD 3D Cones.

References: [1] Gharib A, et al. Invest Radiol 2012; 47(6): 339–345. [2] Akçakaya M, et al. MRM 2013. [3] Addy NO, et al., Proc. 20th ISMRM p. 4178, 2012. [4] Uecker M, et al. MRM 2013. [5] Forman C, et al. Proc. 20th ISMRM 2012, p. 1160. [6] Wu HH, et al. MRM 2013; 69:1083-93. [7] Guerquin-Kern, M, et al., IEEE TMI 2011; 30:1649-60.