Accelerated Contrast-Enhanced Whole Heart Coronary MRI Using Low-dimensional-Structure Self-learning and Thresholding (LOST), an Improved Compressed Sensing Reconstruction

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INTRODUCTION: Despite considerable advances during the past decade, coronary MRI still faces major challenges including lengthy acquisition, and sub-optimal SNR and CNR. Slow or bolus infusion of gadobenate-dimeglumine ($[Gd\text{-}BOPTA]^{2-}$), a high relaxivity extra-cellular contrast agent, has been shown to improve SNR and CNR of coronary MRI [1,2]. To fully take advantage of this contrast media and to reduce imaging artifacts due to contrast clearance, the scan time needs to be shortened. Feasibility of compressed sensing (CS) for coronary MRI has been shown in a retrospective study [3]. In this abstract, we investigated a prospectively accelerated whole heart contrast-enhanced coronary MRI after a bolus infusion of Gd-BOPTA using *l*ow-dimensional-structure *s*elf-learning and *t*hresholding (LOST), an improved CS reconstruction.

MATERIALS AND METHODS: IMAGE ACQUISITION: Images were acquired on a 1.5T Philips Achieva magnet with 5-channel cardiac coil. 0.2mmol/kgGd-BOPTA was injected intravenously using a bolus (2ml/s) infusion, immediately followed by a Look-Locker sequence to visually determine the optimal inversion time. Contrast-enhanced whole-heart coronary was then acquired using a prospectively under-sampled free-breathing SSFP coronary MRI (TR/TE/α=4.3/2.2/90°, FOV=300×300×120mm^3, resolution=1.4×1.4×1.3mm^3, 117 slices, ×4 accelerated) with a non-selective inversion pulse. For prospectively accelerated acquisition, 30×5 central k_y-k_z lines were kept, and the edges were randomly under-sampled. To mitigate flow artifacts and eddy currents by minimizing gradient switching, a modified radial k_y-k_z phase reordering scheme was used. Acquisition time was ~ 2:51 minutes, assuming 100% navigator efficiency and heart rate of 70 beats/min.

IMAGE RECONSTRUCTION: Initially, LOST groups 2D image patches of similar signal content into "similarity clusters" (SCs) using a low-resolution image generated from the fully-acquired central k-space. When the 2D blocks in a SC are stacked into a 3D structure, and a 3D FFT is applied, the data are sparse: 2D FFT applied to each block promotes sparsity within the block, and FFT along third dimension of SC greatly enhances sparsity since the 2D blocks have similar content [4]. This adaptively-learned sparsity property is then used to de-alias the image. The reconstruction algorithm for each coil is implemented as: 1) SCs are learnt by block matching [4] from low-resolution images generated from central k-space using a Hanning window, 2) An iterative method (**Fig. 1**) is applied, where LOST de-aliases $\mathbf{v}_j^{(t)}$ by hard thresholding the SCs in FFT domain. Final estimates are generated by root-sum-squares. Proposed method for off-line reconstruction was implemented in Matlab, with thresholding in C++.

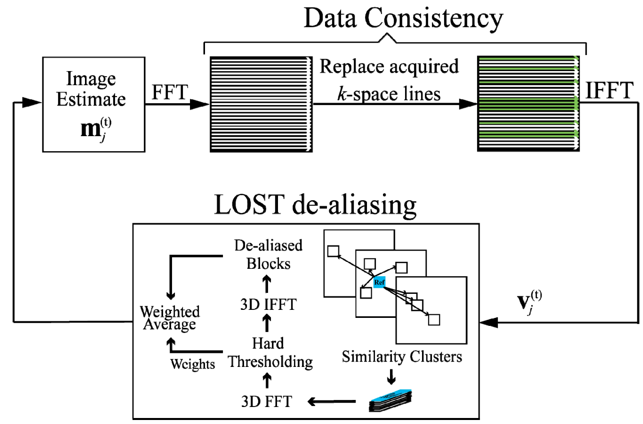

Fig. 1: *Iterative reconstruction algorithm:LOST adaptively learns similarity clusters, uses their Fourier sparsity to remove aliasing.*

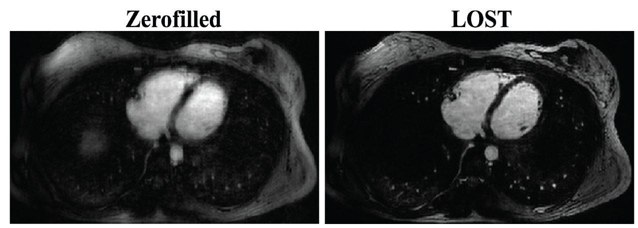

Fig. 2: *An example axial slice from a prospectively under-sampled contrast-enhanced whole heart coronary MRI with x4 acceleration in k_y-k_z, using zerofilling and LOST.*

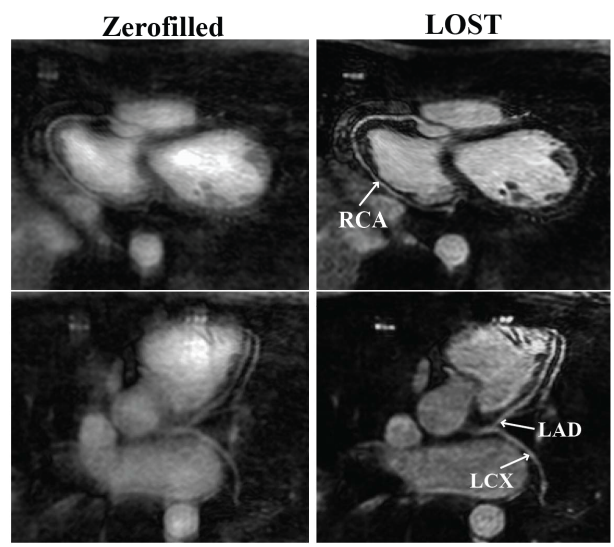

Fig. 3: *Reformatted axial image from the same dataset, using zerofilling and LOST.*

RESULTS: Fig. 2 depicts an example axial slice from the contrast-enhanced whole heart dataset. **Fig. 3** depicts reformatted images of the right and left coronaries from the same dataset, reconstructed with LOST and zero-filling. The proposed LOST reconstruction yields excellent results, with sharp visibility of the coronaries, at a high acceleration rate (×4).

CONCLUSIONS: An accelerated contrast enhanced coronary MRI method using LOST reconstruction, results in a shorter acquisition time and takes full advantage of the contrast media.

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