Debiasing incorporated into reconstruction of low-rank modelled dynamic MRI data

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Introduction
- Perfusion is diagnostic method in medicine
- Reconstruction treated often as optimization problem (compressed sensing, CS)
- It gives biased estimates

Perfusion DCE-MRI reconstruction

\[ \min_L \| Y - E(L) \|_F^2 + \lambda \| L \|_2, \]  

(1)

- \( Y \) is the matricized k-t-space data
- \( E \) is the respective subsampled Fourier transform
- Computed using proximal gradient algorithm
- After each iteration, SVD of \( L^{(k)} \) is known:
  \[ L^{(k)} = U^{(k)} \cdot \operatorname{diag}(\sigma_1^{(k)}, \sigma_2^{(k)}, \ldots, \sigma_k^{(k)}) \cdot V^{(k)*} \]

Debiasing

\[ \min_{\sigma_1, \sigma_2, \ldots, \sigma_k > 0} \| Y - E(U^{(k)} \cdot \operatorname{diag}(\sigma_1, \sigma_2, \ldots, \sigma_k) \cdot V^{(k)*}) \|_F^2 \]  

(2)

- Solved by repeating several times: gradient step w.r.t. \( \sigma \) and projecting result to real, non-negative values
- First evaluated on a Shepp-Logan modified to simulate perfusion [1] using Matlab
- Phantom of 100 × 100 px × 100 time points in size
- Perturbed by additive Gaussian noise with standard deviation 0.05
- Used 100 radials per frame with random slopes of spokes
- Using (1) with postdebiasing (2) led to worse reconstruction than joint debiasing algorithm

References

Real data

Free-breathing abdominal DCE-MRI data [3]
- The acquisition used golden-angle scheme with a 12-element receiver coil array
- 21 golden-angle radial trajectories per frame were used
- With joint debiasing, perfusion curves enjoy higher initial peak and the second peak is more readable

With joint debiasing

Without debiasing