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Bayesian network-based Tikhonov MRI reconstruction

Uncertainty quantification is essential for assessing the reliability of MRI reconstructions. The Network-based Tikhonov reconstruction method was demonstrated to produce excellent results in accelerated multicoils settings. However, in challenging low-field settings, where noise is high and scanners are single coil, this scheme requires a careful evaluation of its reconstruction uncertainty.

In this work, we study the Bayesian network-based Tikhonov reconstruction scheme and derive an upper bound on the posterior expected reconstruction error. Starting from the posterior mean-squared error, we separate the error into a variance term, given by the posterior covariance trace, and a bias term measuring the discrepancy between the posterior mean and the true image. By introducing a fixed network-based image prior and a worst-case prior mismatch, we obtain a tractable bound that depends on the posterior variance, the deviation of the reconstruction from the prior, and a bounded prior-to-truth error. We further derive pixelwise bounds, providing uncertainty map estimates.

We will present further experiments showing that for these challenging reconstruction conditions, the CNN-based Tikhonov regularization, yielding a linear reconstruction scheme, is too simple and relies too heavily on the prior, motivating the need to use more sophisticated reconstruction schemes like plug-and-play methods.

This analysis offers a simple theoretical framework and an analytical error bound for interpreting reconstruction quality in low-field MRI. It highlights the trade-off between data consistency and prior dependence for the reconstruction and its uncertainty.

Special/ Invited session

Classification

Both methodology and application

Keywords

Uncertainty quantification, MRI reconstructions, imaging

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