Enhanced Reconstruction of Compressive Sensing MRI via Cross-Domain Stochastically Fully-Connected Random Field Model

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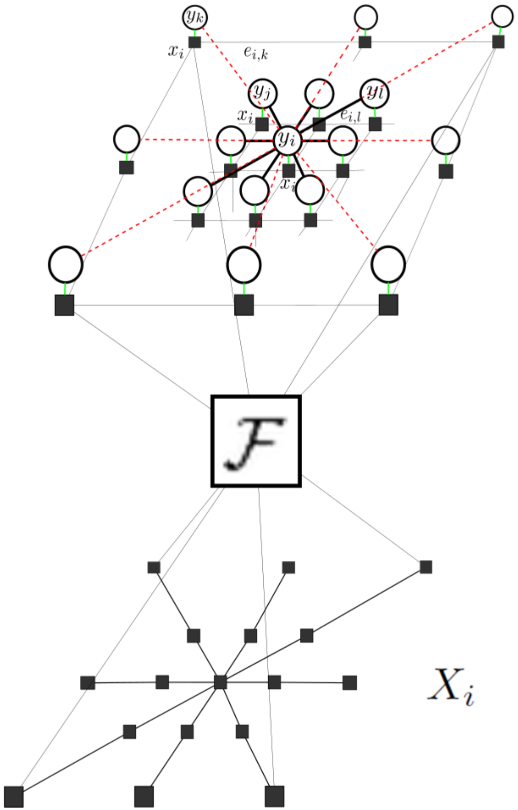
Motivation/Objectives

- Low MRI acquisition times increase patient comfort and image quality
- Decrease MRI acquisition times through compressive sensing
- High quality reconstruction for diagnosis and screening of different types of cancer



Methodology:

- Conditional Random Field Inference:

$$P(Y|X) = \frac{1}{Z(X)} \exp(-\psi(Y|X))$$

where $Z(X)$ is a the normalization function and $\psi(.)$ is described below

- Cross domain unary(ψ_u)and pairwise(ψ_p)energies:

$$\psi(Y|X) = \mathcal{F}\{\sum_{i=1}^{n} \psi_u(y_i, X)\} + \sum_{\varphi \in C} \psi_p(y_\varphi, X)$$

Where $y_i \in Y$ is a single state in the set $Y = {y_i}_{i=1}^n$, $y_\varphi \in Y$ is the subset of clique structure in the set of C . $X = {x_j}_{j=1}^n$ is the set of *k-space* observations.

The Cross-Domain Stochastically fully connected Conditional Random Field (CD-SFCRF) enforces original *k-space* (Frequency Domain) observations combined with spatial domain neighborhood consistencies to perform inference of states given compressive sensed *k-space* observations

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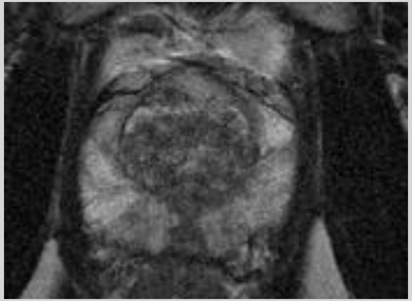
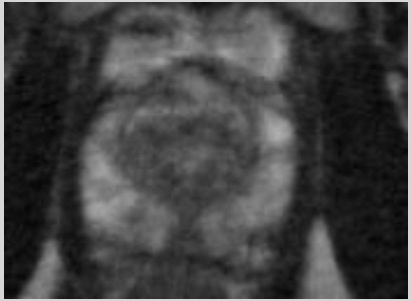
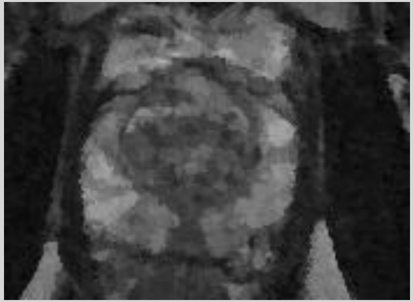
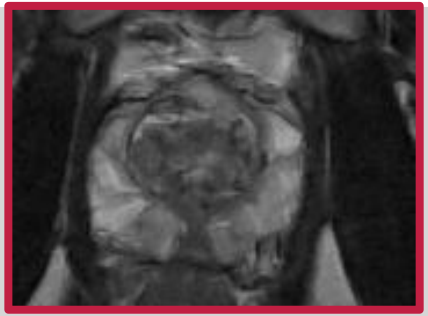
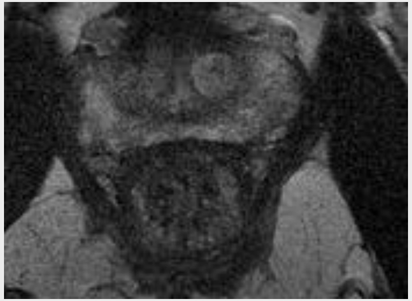
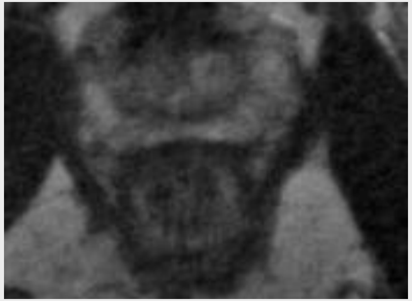
Existing Methods

- Total Variation (K. Block, *et al*. (2007)
  - Assumes piecewise smooth de-noising/reconstruction approach
- L2 Minimization (M. Lustig, et al. (2007))
  - Direct transformation from *k-space* into spatial domain

Results (32% *k-space sampling*)

Original Image	L2 Minimization (Compressive Sensed)	Total Variation Reconstruction (TV)	CD-SFCRF Reconstruction
			
			

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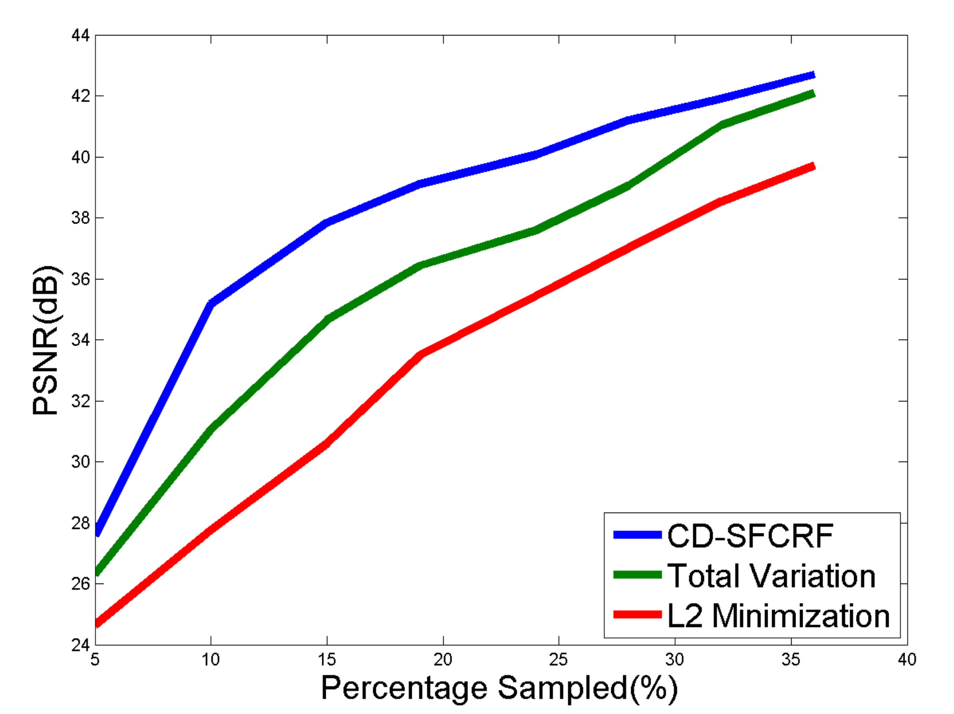
Results with phantom data



Peak-to-Peak Signal to Noise (PSNR)

Sampling Rate(%)	L2 Min (dB)	TV (dB)	CD-SFCRF (dB)
5	24.63	26.22	**27.90**
10	27.75	30.81	**34.63**
15	30.60	34.26	**37.69**
19	33.49	36.10	**39.05**
24	35.43	37.40	**40.03**
28	37.01	39.22	**41.05**
32	38.53	40.56	**41.80**
36	39.71	42.18	**42.68**

Conclusions

- Better results for the proposed method show better tissue and structure details reconstructed while eliminating noise
- PSNR analysis shows significant improvements at very low sampling rates
- The proposed method fully utilizes available data for high quality reconstruction
- Potential to decrease acquisition time significantly with little compromise in image reconstruction quality

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