Self-Supervised Deep Learning Reconstruction for Highly Accelerated Diffusion Imaging

Ismail Arda Vurankaya[1], Yohan Jun[2,3], Jaejin Cho[2,3], Berkin Bilgic[2,3,4]

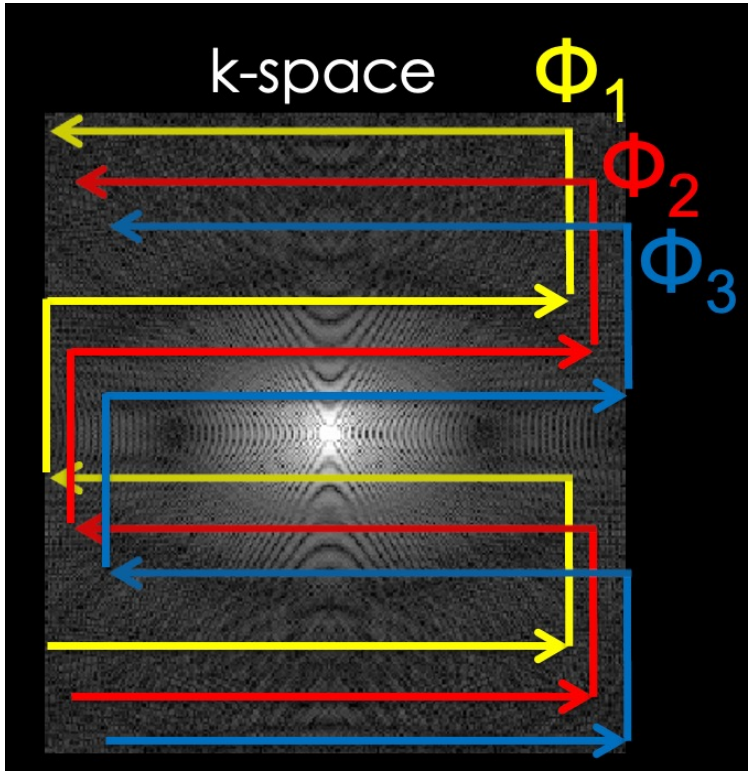
[1] *Bogazici University, Istanbul, Turkey*

[2] *Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA, United States*

[3] *Department of Radiology, Harvard Medical School, Boston, MA, United States*

[4] *Harvard/MIT Health Sciences and Technology, Cambridge, MA, United States*

Motivation



Multishot EPI

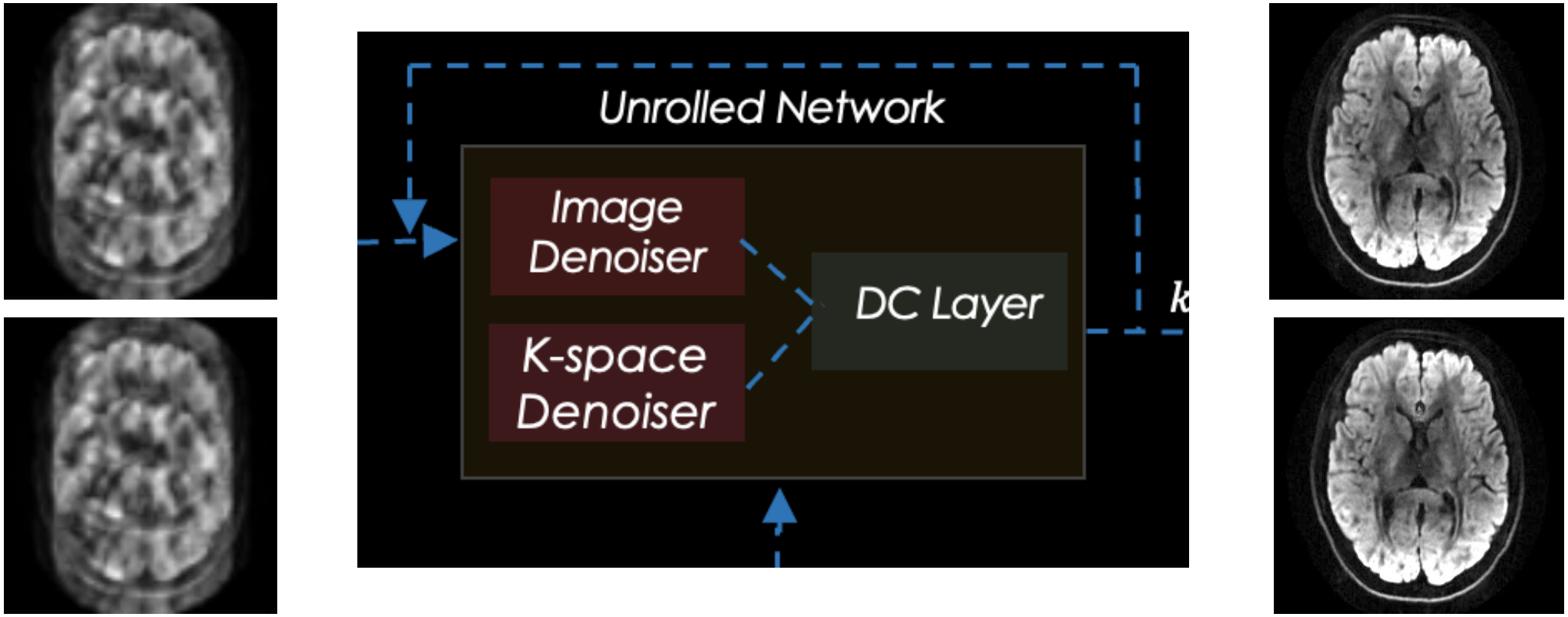
- Multi-shot EPI allows us mitigating T_2 and T_2^* blurring and minimizing B_0-related distortion
- Combining the multiple shots can be challenging due to shot-to-shot phase variation.
- Advanced image reconstruction method is needed at high acceleration factor.

Approach

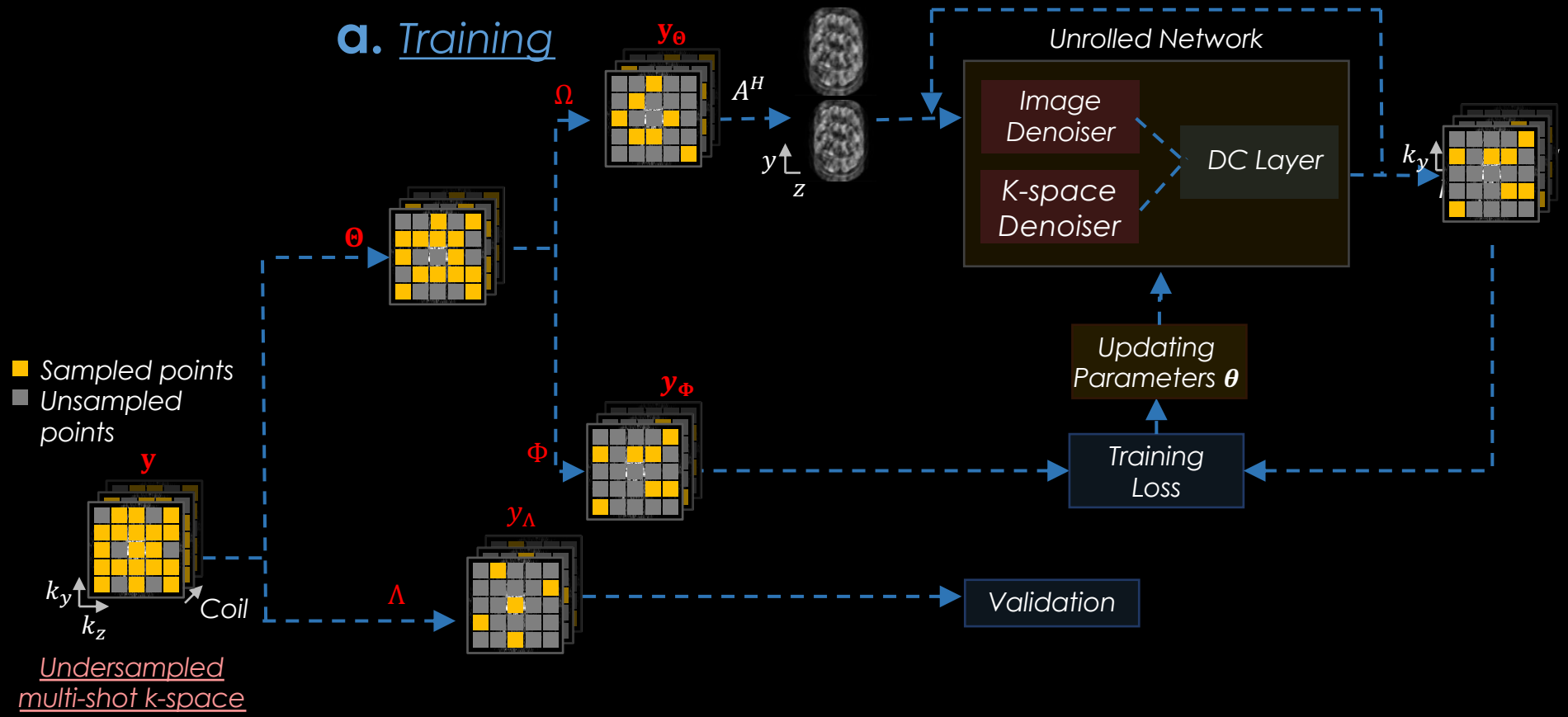
- The recent zero-shot self-supervised learning (ZS-SSL) technique reconstructs images using scan-specific neural networks trained without additional training datasets.

- We employ ZS-SSL approach for joint reconstruction of accelerated multi-shot diffusion MRI.

Approach



Unrolled network
employed in our work


a. Training
y_Θ
A^H
Unrolled Network
Image Denoiser
K-space Denoiser
DC Layer
k_y
Ω
Θ
y
z
Sampled points
Unsampled points
y_Φ
Φ
Updating Parameters $\boldsymbol{\theta}$
Training Loss
y
y_Λ
k_y
k_z
Coil
Λ
Validation
Undersampled multi-shot k-space

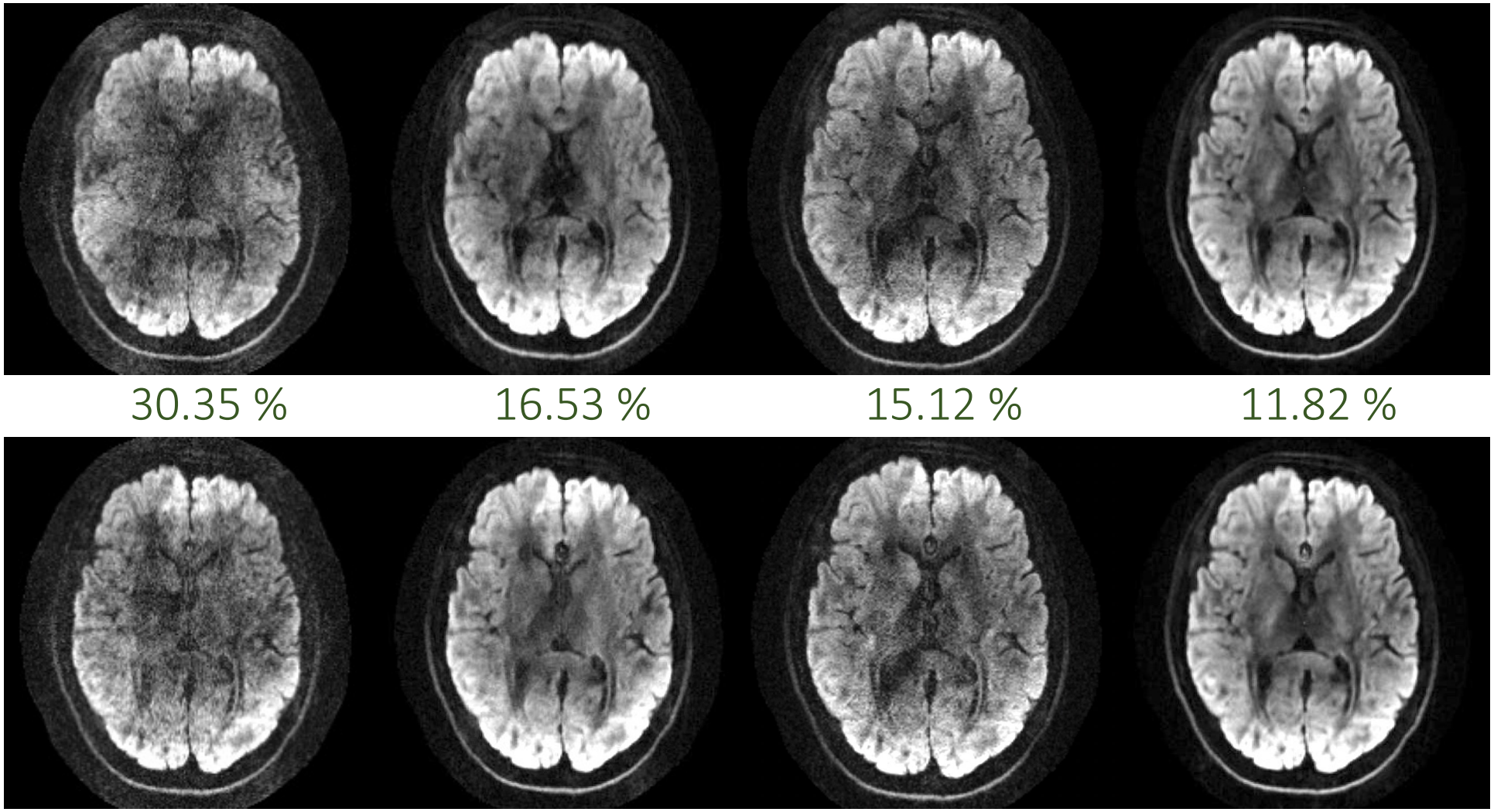
Approach

- We train one network across all diffusion directions instead of training multiple networks individually.
- We use magnitude constraint (MC) of two shot assuming the two shots have similar signal intensity.

$$\left(\frac{||u-v||_1}{||v||_1} + \frac{||u-v||_2}{||v||_2}\right) + \gamma\,||s_1| - |s_2||$$

k-space loss Magnitude constraint

@ R = 5, b = 1k, 32 directions, 1x1x4mm^3



Summary

- We introduced a ZS-SSL method for multishot diffusion MRI reconstruction.
- Our method can yield better reconstruction than state-of-the-art LORAKS reconstruction.
- Proposed model can be trained for all directions at once, with an additional benefit of reduced training time. (2.5-fold)
- The magnitude constraint improves reconstruction performance.