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What is K-Space? And Why We Need MRI Reconstruction?

MRI is sampled in k-space and transformed to image domain. Sampling in k-space is time-consuming, it's common to undersample MRI data and apply reconstruction algorithm.



Undersampled k-space and corresponding MRI image

Reconstruction





Complete k-space and corresponding MRI image

K-Space Transformer with Implicit Neural Representation

Previous work: CNN-based k-space reconstruction

K-Space Transformer: use spatial coordinates to query the sparsely sampled points —> learn implicit representation of k-space data



Consider both k-space decoding and image domain refinement to provide complementary bias

Design hierarchical decoder for better computational efficiency:

$$\Phi_{DEC}(\ \cdot\) = \Phi_{HRD} \circ \Phi_{LRD}$$



K-Space Transformer

K-Space Transformer for Undersampled MRI Reconstruction

Experiments

Evaluation on 2 public single-coil MRI dataset (OASIS brain and fastMRI knee); Simulate gaussian and uniform sampling pattern, and 3 different acceleration ratio; Compare with PSNR and SSIM

	OASIS				fastMRI						
Method	5 ×		2.5 ×		5	Х	2.5 ×				
	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM			
K-UNet	24.53	0.7808	26.50	0.8483	24.68	0.6058	26.99	0.7223			
Deep ADMM	26.03	0.7202	29.95	0.8165	24.43	0.6172	29.84	0.7838			
SwinMR	27.17	0.9041	29.83	0.9435	26.01	0.6684	29.10	0.7842			
UNet	27.53	0.8895	29.05	0.8988	26.72	0.6835	29.81	0.7983			
D5C5	27.66	0.8895	32.48	0.9615	26.87	0.6793	30.64	0.8126			
OUCR	29.52	0.9310	33.75	0.9709	27.71	0.7009	30.95	0.8168			
Ours	31.50	0.9528	36.32	0.9848	27.80	0.7078	31.04	0.8189			

K-Space Transformer perform the best on 15 out of 18 results

Much better than k-space **U-Net**

Table 1: Quantitative comparison on uniform 1D sampling settings.

	OASIS						fastMRI			
Method	10 ×		5 ×		$2.5 \times$		5 ×		$2.5 \times$	
	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM
K-UNet	25.34	0.766	28.76	0.8427	33.96	0.9288	27.15	0.6696	28.90	0.7710
Deep ADMM	26.17	0.7312	30.41	0.8122	33.94	0.8513	29.31	0.7515	30.97	0.8162
SwinMR	27.48	0.8893	30.36	0.9341	33.75	0.9659	28.41	0.7080	30.30	0.7949
UNet	27.63	0.8437	31.27	0.9024	35.02	0.9388	28.33	0.7120	31.35	0.8283
D5C5	30.51	0.9241	35.91	0.9743	42.72	0.9927	29.78	0.7507	32.00	0.8399
OUCR	31.61	0.9442	36.78	0.9797	42.80	0.9933	29.95	0.7522	32.04	0.8382
Ours	32.58	0.9529	37.47	0.9823	43.68	0.9946	29.88	0.7534	31.97	0.8389

Table 2: Quantitative comparison on Gaussian 2D sampling settings.



Qualitative comparisons

K-Space Transformer recovers more anatomical details

More experiments on the paper and supplementary materials







