A Lightweight Lateral Inhibition Network for Single MR Image Super-Resolution



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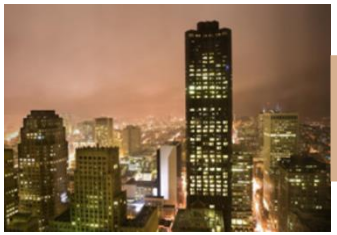
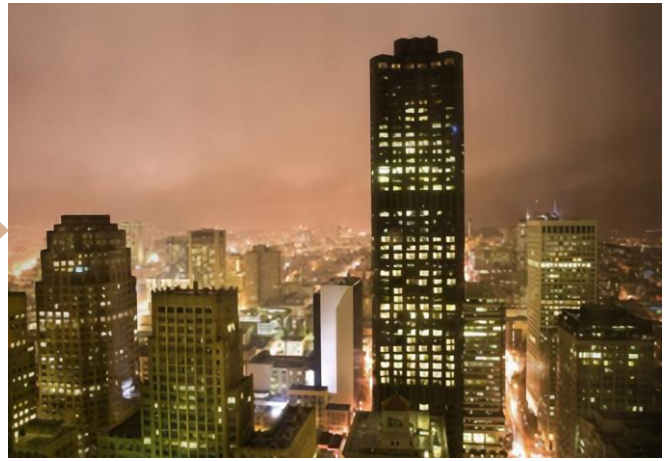
Single Image Super-Resolution (SISR)

- **Target: recovering a HR image from a single LR image**

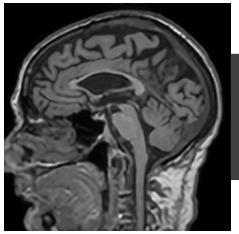


Low-resolution (LR) image

Super-Resolution

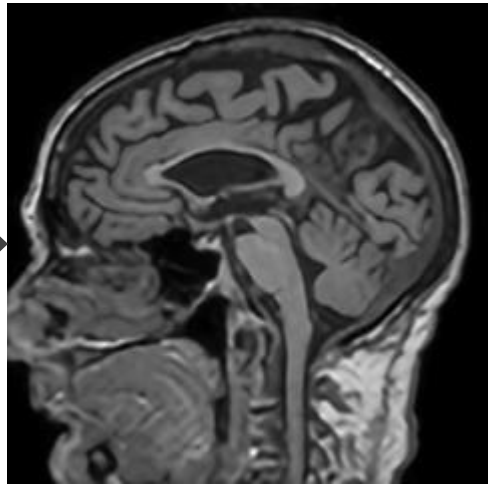


High-resolution (HR) image



LR image

Super-Resolution

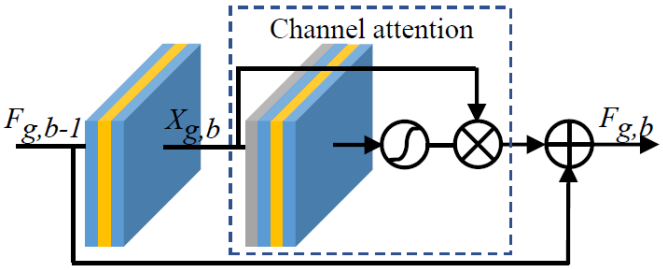


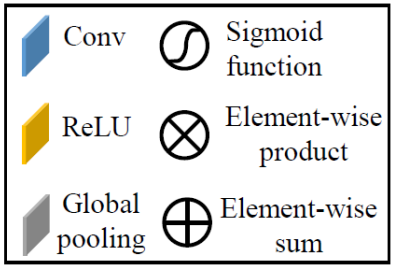
HR image

Motivation

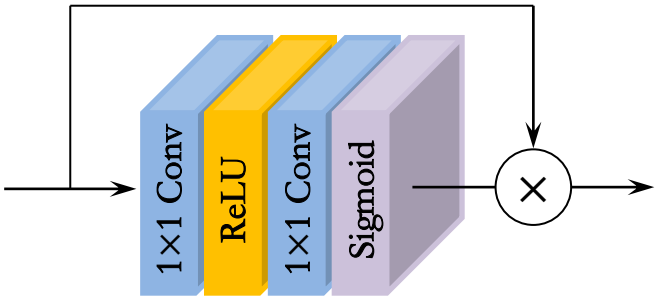
■ CNN Structure Design Inspired by Physiological Mechanisms

➢ Channel Attention and Spatial Attention





Channel Attention

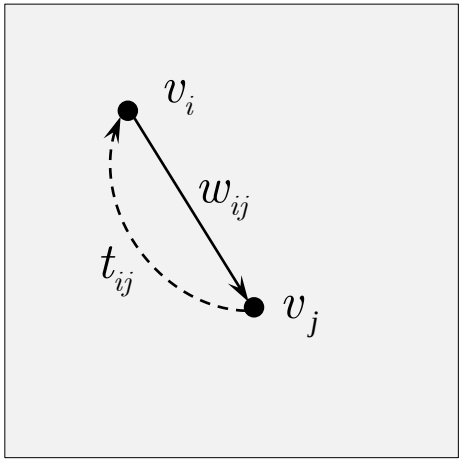


Spatial Attention

- **Promoting the effective allocation of network resources**
- **Improving the model representational capacity**

➢ Visual Inhibition

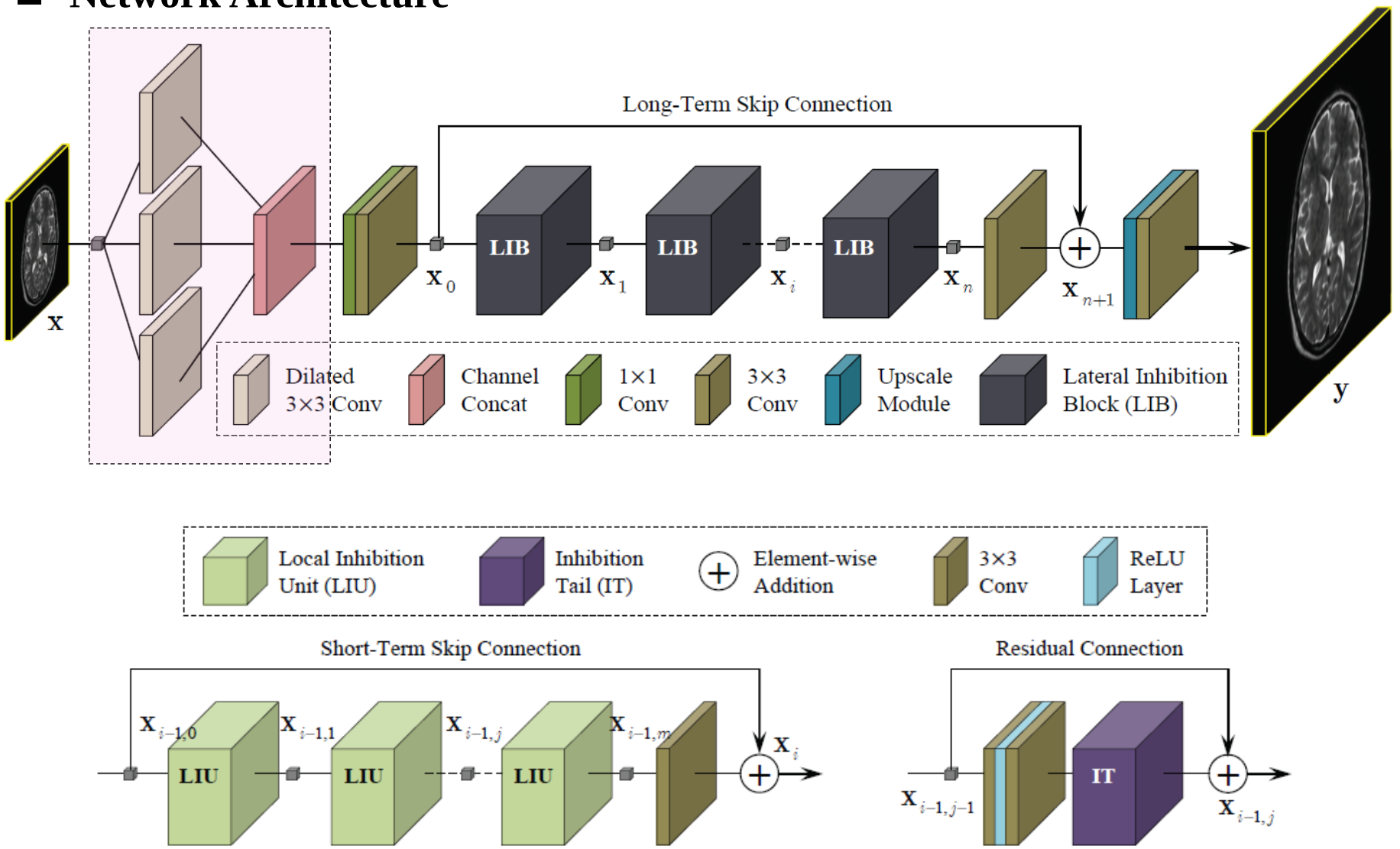
$$v_i^{'} = v_i - \sum_{j \neq i} w_{ij} \cdot \max\left(0, v_j - t_{ij}\right)$$



- **Explicitly imposing inhibitory regulation on features**
- **Alleviating the representational burden of the model**

Lateral Inhibition Network (LIN)

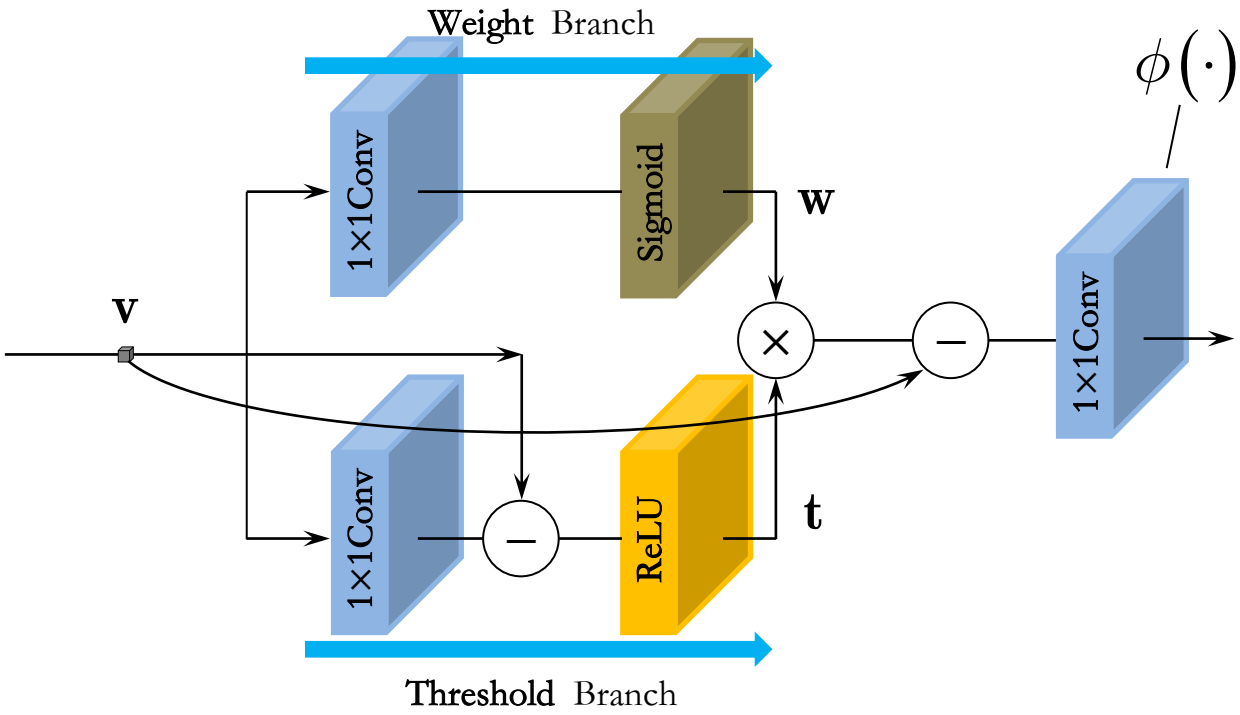
- **Network Architecture**



Lateral Inhibition Network (LIN)

- **Network Architecture**

$$v_i' = v_i - \sum_{j \neq i} w_{ij} \cdot \max\left(0, v_j - t_{ij}\right) \quad \Rightarrow \quad v_i' = \phi\left\{ v_i - \sum_{j \neq i} w_{ij} \cdot \max\left(0, v_j - t_{ij}\right) \right\}$$



Implementation Details

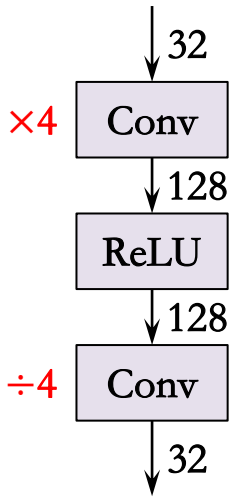
Network Structure

LIB Number	LIU Number	Batch Size	Patch Size	Kernel Size	Feature Maps	Activation Function	Wide Activation
4	4	16	24×24	3×3	32(×4)	ReLU	Yes

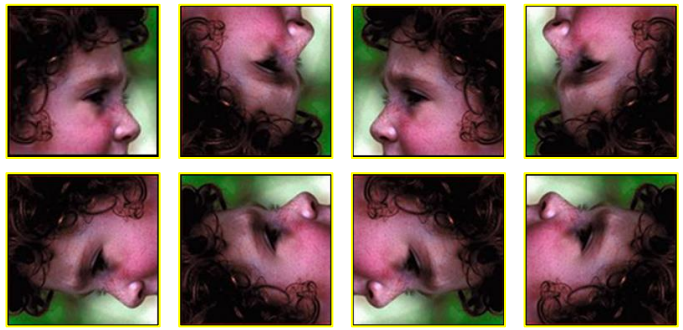
ModelTraining

Initializer	Optimizer	Total Iterations	Learning Rate	GPU	Data Augmentation
Xavier Initialization	Adam Optimizer Beta1 = 0.9 Beta2 = 0.999 Epsilon = 10^{-8}	10^6 Training steps	2×10^{-4} Halved at every 200000 iters	NVIDIA GeForce GTX 1080 Ti	Horizontal and vertical flips, and 90° rotations

- Wide activation



- Data augmentation

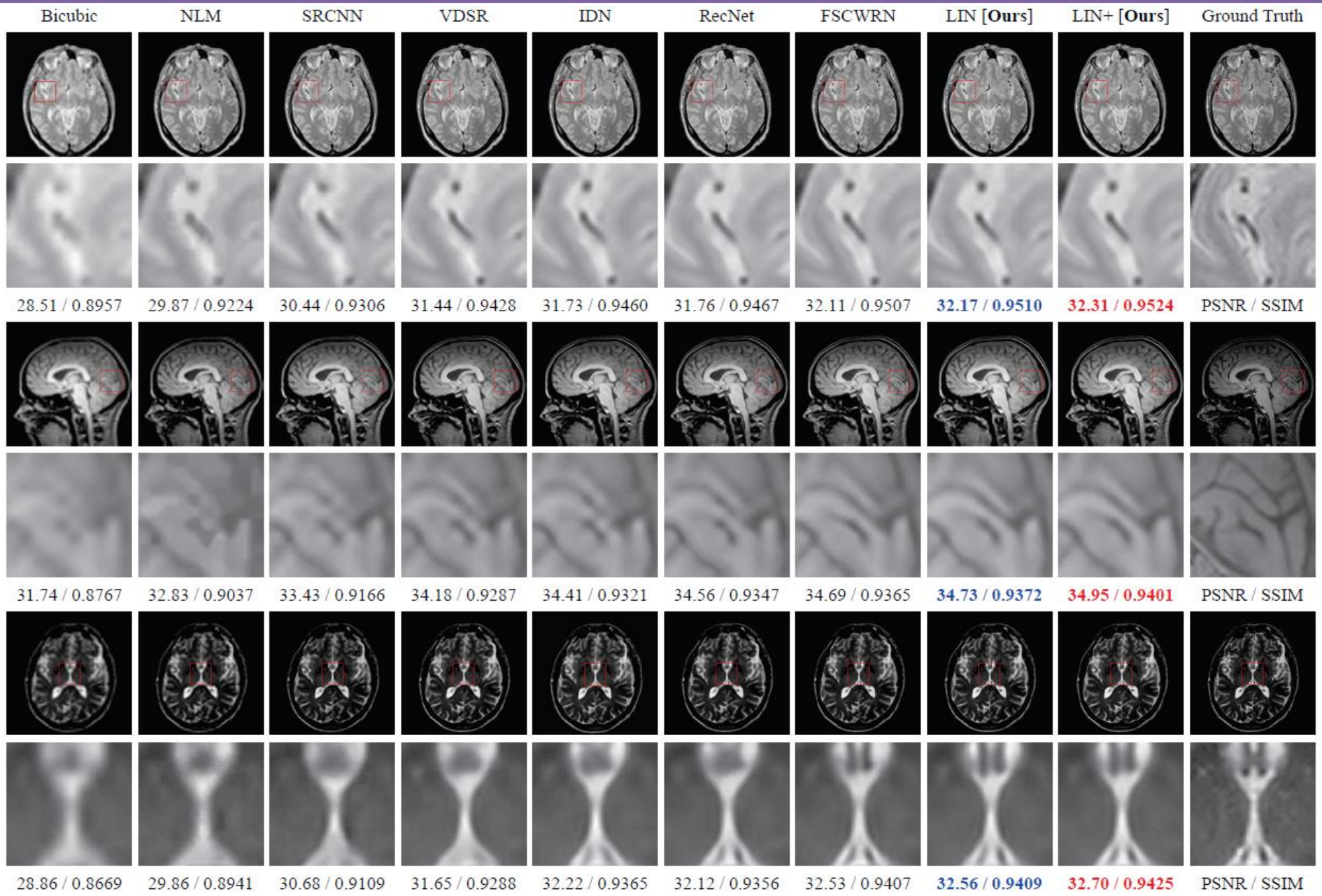


Results

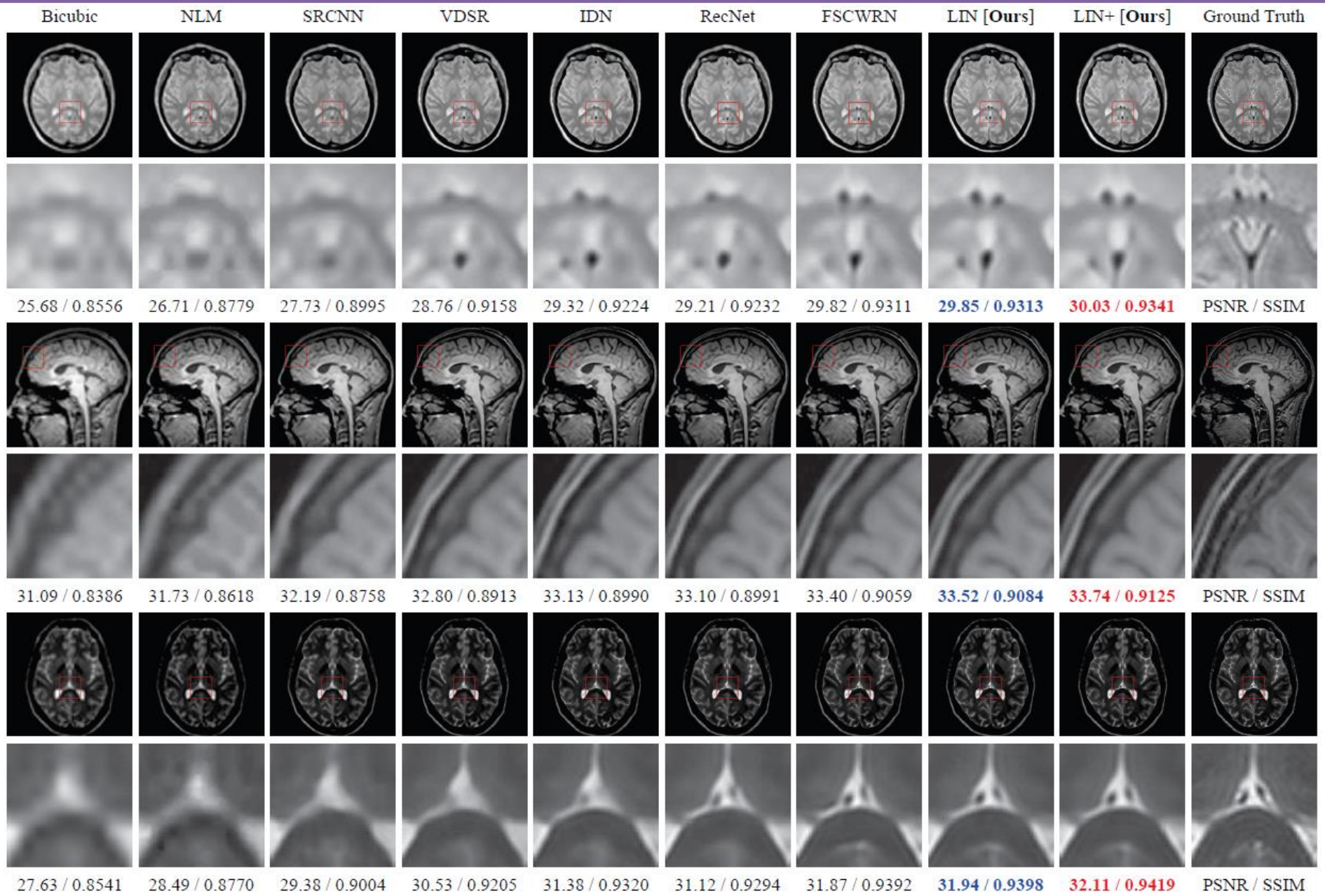
Quantitative evaluation

Methods	Scales	Params	Bicubic Downsampling (BD)			*k*-space Truncation (TD)		
			PD	T1	T2	PD	T1	T2
Bicubic	×2	/	35.04/0.9664	33.80/0.9525	33.44/0.9589	34.65/0.9625	33.38/0.9460	33.06/0.9541
NLM		/	37.26/0.9773	35.80/0.9685	35.58/0.9722	36.18/0.9707	34.71/0.9581	34.56/0.9641
SRCNN		24.5K	38.96/0.9836	37.12/0.9761	37.32/0.9796	38.23/0.9802	36.52/0.9705	37.04/0.9773
VDSR		0.67M	39.97/0.9861	37.67/0.9783	38.65/0.9836	39.89/0.9850	37.58/0.9760	38.74/0.9823
IDN		0.73M	40.27/0.9869	37.79/0.9787	39.09/0.9846	40.43/0.9862	37.79/0.9765	39.48/0.9842
RecNet		1.33M	40.43/0.9873	37.86/0.9792	39.13/0.9848	40.10/0.9857	37.54/0.9764	39.03/0.9832
FSCWRN		3.50M	40.72/0.9880	37.98/0.9797	39.44/0.9855	40.91/0.9876	38.04/0.9786	39.82/0.9851
LIN		1.33M	40.86/0.9884	38.04/0.9798	39.50/0.9856	41.11/0.9880	38.21/0.9793	40.02/0.9855
LIN+		1.33M	41.03/0.9886	38.19/0.9803	39.62/0.9860	41.31/0.9886	38.40/0.9801	40.18/0.9859
Bicubic	×4	/	29.13/0.8799	28.28/0.8312	27.86/0.8611	28.82/0.8713	27.96/0.8182	27.60/0.8511
NLM		/	30.27/0.9044	29.31/0.8655	28.85/0.8875	29.27/0.8906	28.68/0.8439	28.37/0.8718
SRCNN		24.5K	31.10/0.9181	29.90/0.8796	29.69/0.9052	30.52/0.9078	29.31/0.8616	29.32/0.8960
VDSR		0.67M	32.09/0.9311	30.57/0.8932	30.79/0.9240	31.69/0.9244	30.14/0.8818	30.51/0.9162
IDN		0.96M	32.47/0.9354	30.74/0.8966	31.37/0.9312	32.33/0.9318	30.40/0.8889	31.31/0.9270
RecNet		1.33M	32.58/0.9378	30.86/0.9005	31.30/0.9310	32.16/0.9310	30.46/0.8900	31.03/0.9243
FSCWRN		3.50M	32.91/0.9415	30.96/0.9022	31.71/0.9359	32.78/0.9387	30.79/0.8973	31.71/0.9334
LIN		1.36M	32.94/0.9417	31.01/0.9033	31.72/0.9361	32.82/0.9391	30.88/0.8990	31.77/0.9339
LIN+		1.36M	33.12/0.9432	31.28/0.9073	31.88/0.9376	33.03/0.9415	31.20/0.9041	31.96/0.9362

Results


Bicubic
NLM
SRCNN
VDSR
IDN
RecNet
FSCWRN
LIN [Ours]
LIN+ [Ours]
Ground Truth
28.51 / 0.8957
29.87 / 0.9224
30.44 / 0.9306
31.44 / 0.9428
31.73 / 0.9460
31.76 / 0.9467
32.11 / 0.9507
32.17 / 0.9510
32.31 / 0.9524
PSNR / SSIM
31.74 / 0.8767
32.83 / 0.9037
33.43 / 0.9166
34.18 / 0.9287
34.41 / 0.9321
34.56 / 0.9347
34.69 / 0.9365
34.73 / 0.9372
34.95 / 0.9401
PSNR / SSIM
28.86 / 0.8669
29.86 / 0.8941
30.68 / 0.9109
31.65 / 0.9288
32.22 / 0.9365
32.12 / 0.9356
32.53 / 0.9407
32.56 / 0.9409
32.70 / 0.9425
PSNR / SSIM

Results


Bicubic
NLM
SRCNN
VDSR
IDN
RecNet
FSCWRN
LIN [Ours]
LIN+ [Ours]
Ground Truth
25.68 / 0.8556
26.71 / 0.8779
27.73 / 0.8995
28.76 / 0.9158
29.32 / 0.9224
29.21 / 0.9232
29.82 / 0.9311
29.85 / 0.9313
30.03 / 0.9341
PSNR / SSIM
31.09 / 0.8386
31.73 / 0.8618
32.19 / 0.8758
32.80 / 0.8913
33.13 / 0.8990
33.10 / 0.8991
33.40 / 0.9059
33.52 / 0.9084
33.74 / 0.9125
PSNR / SSIM
27.63 / 0.8541
28.49 / 0.8770
29.38 / 0.9004
30.53 / 0.9205
31.38 / 0.9320
31.12 / 0.9294
31.87 / 0.9392
31.94 / 0.9398
32.11 / 0.9419
PSNR / SSIM

Thank you!