



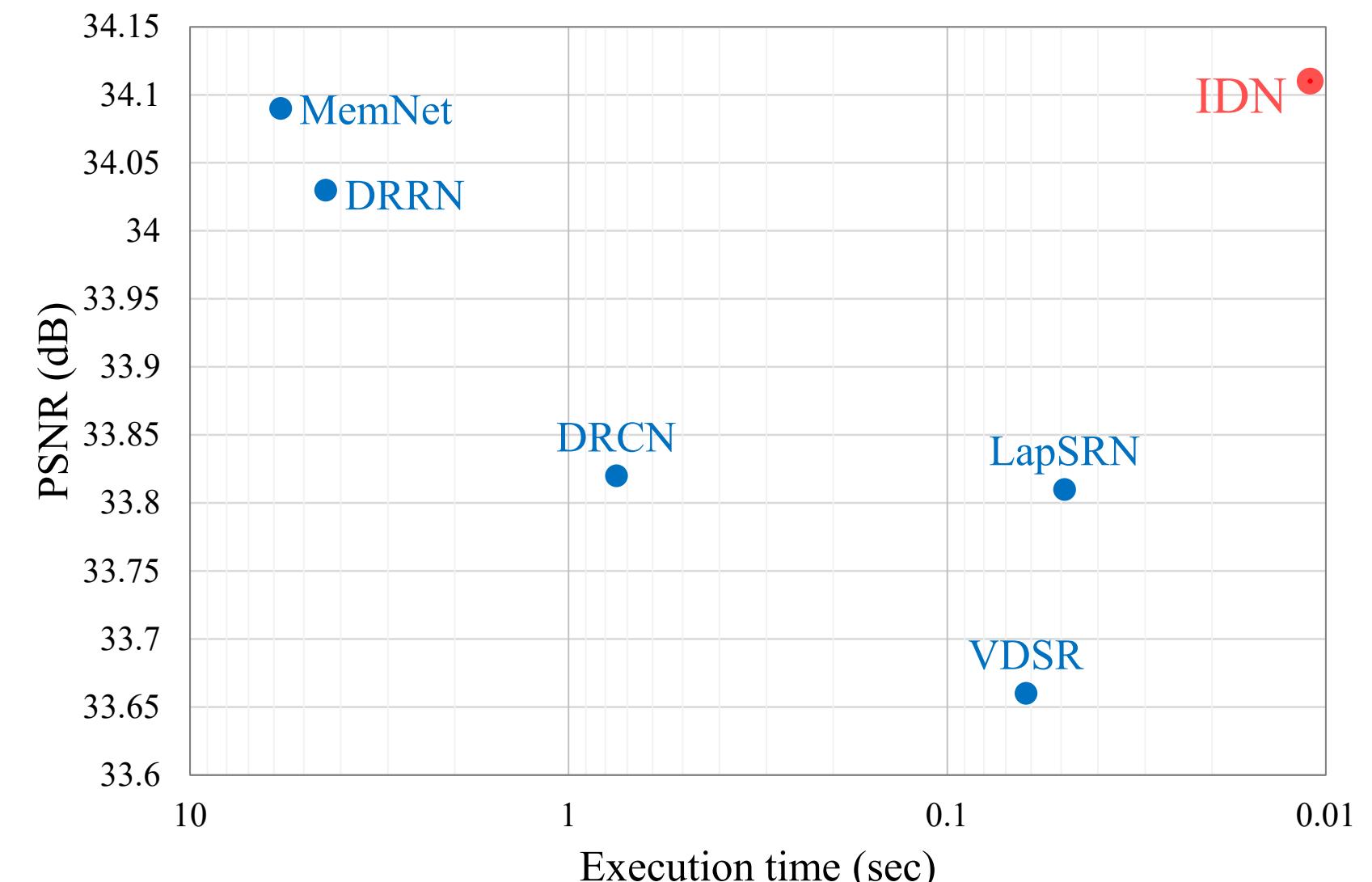
ABSTRACT



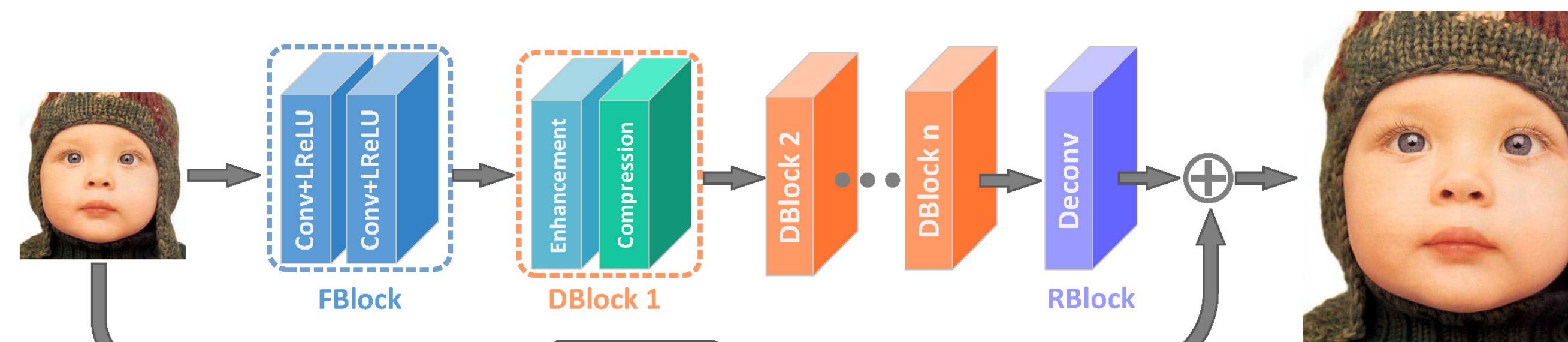
- Deep convolutional neural networks have been successfully applied to single image super-resolution task.
 - As the depth and width of the networks increase, the requirement of heavy computation is not applicable to real-world applications.
 - An accurate and lightweight deep model is devised for image super-resolution.
 - The proposed method constructs a distillation block to extract useful information for the sequential stage.
 - To speed up inference, the proposed approach utilize the bottleneck-like structure and group convolution.
 - To improve the SR performance, two sizes of training patches are used to training the model and fine-tuning this network with L2 loss.
 - Experimental results show that the proposed method has good performance on single image super-resolution task, especially in terms of time performance.

EXAMPLE OF EXECUTION TIME

The average PSNR and inference time for upscaling 3 × on Set5



FRAMEWORK



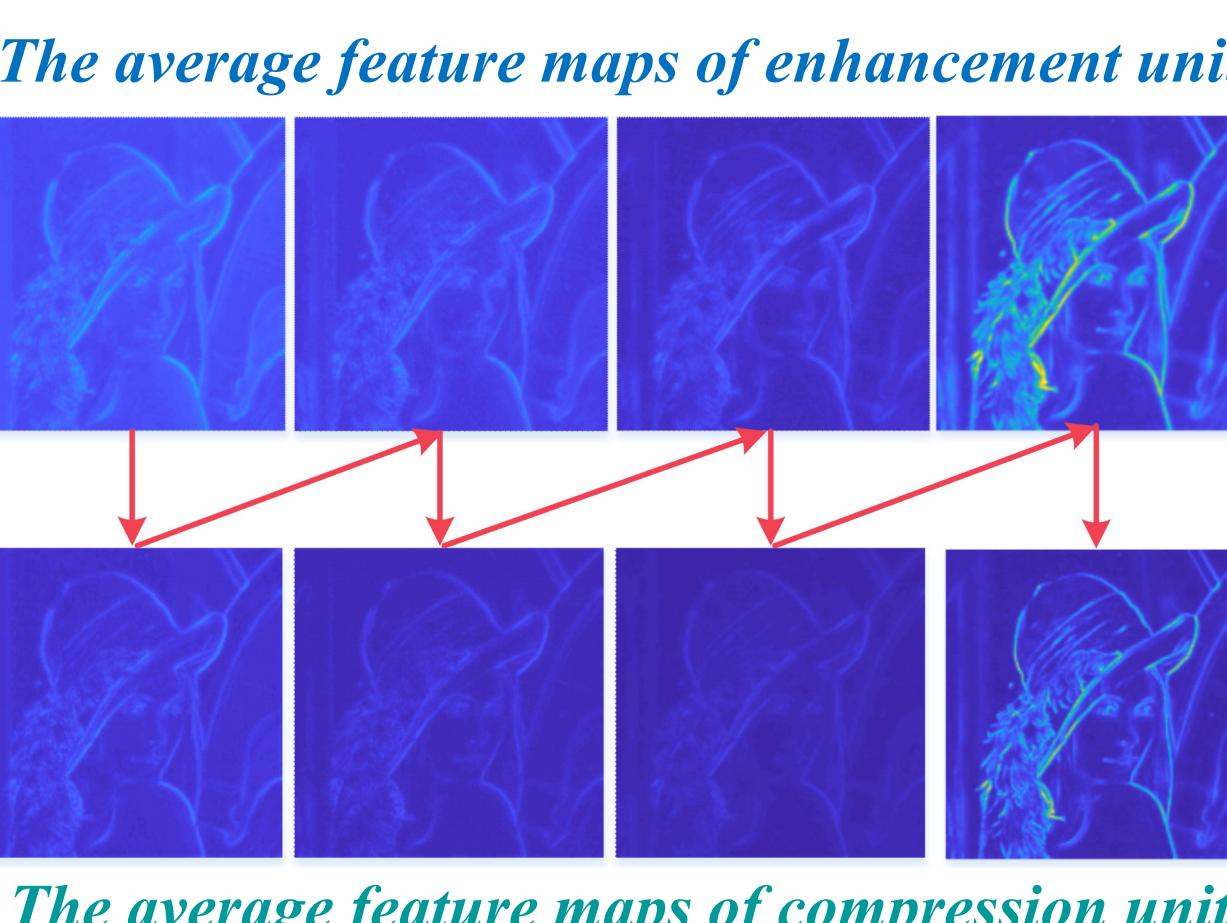
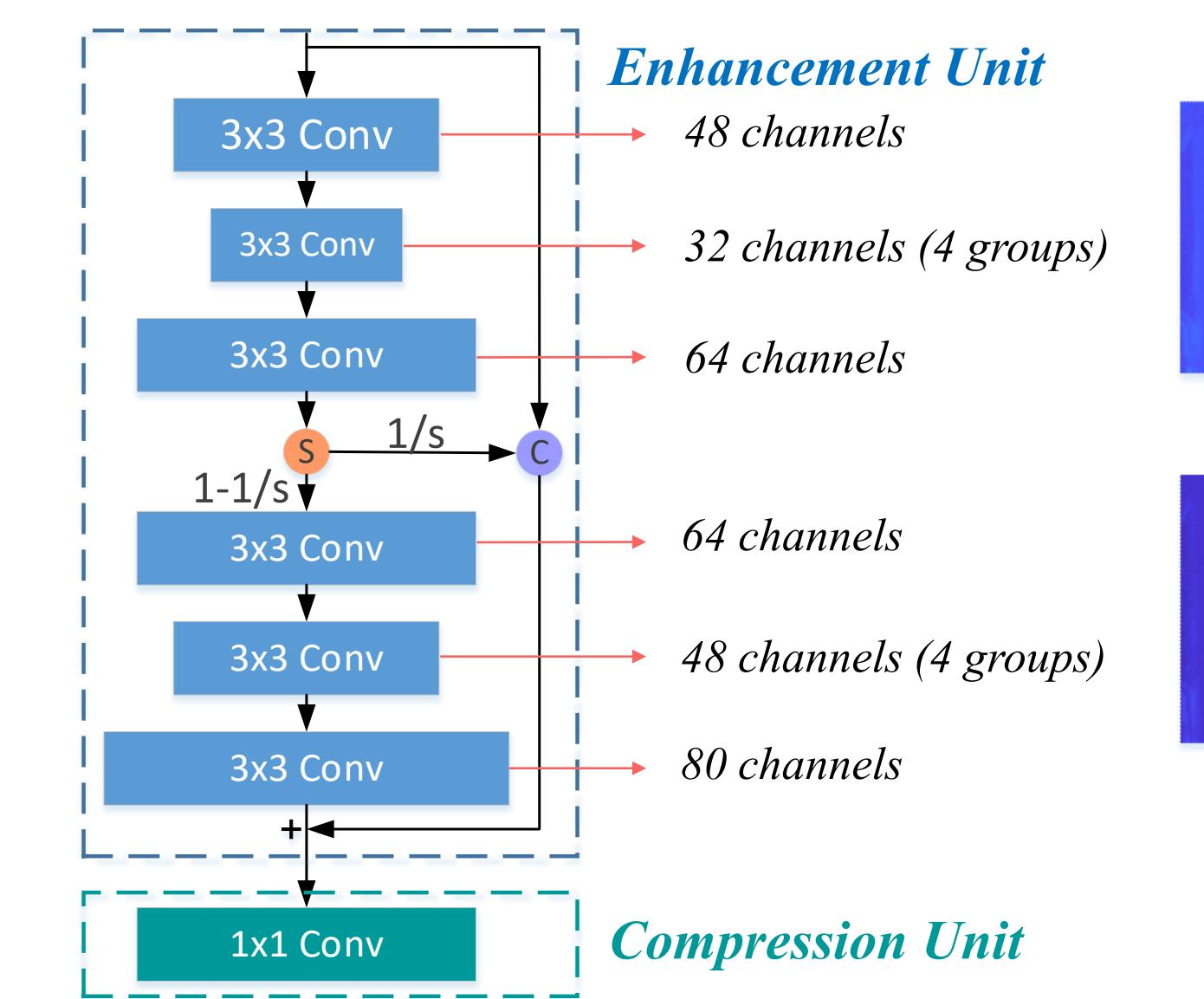
$$\mathcal{L}_{MAE} = \frac{1}{N} \sum_{i=1}^N \|I_i - \hat{I}_i\|_1$$


Training

$$\mathcal{L}_{MSE} = \frac{1}{N} \sum_{i=1}^N \|I_i - \hat{I}_i\|$$

Fine-tuning

DETAILS OF DISTILLATION BLOCK



$$T_{mean}(A) = \frac{1}{c} \sum_{i=1}^c A$$

TRAINING DETAILS

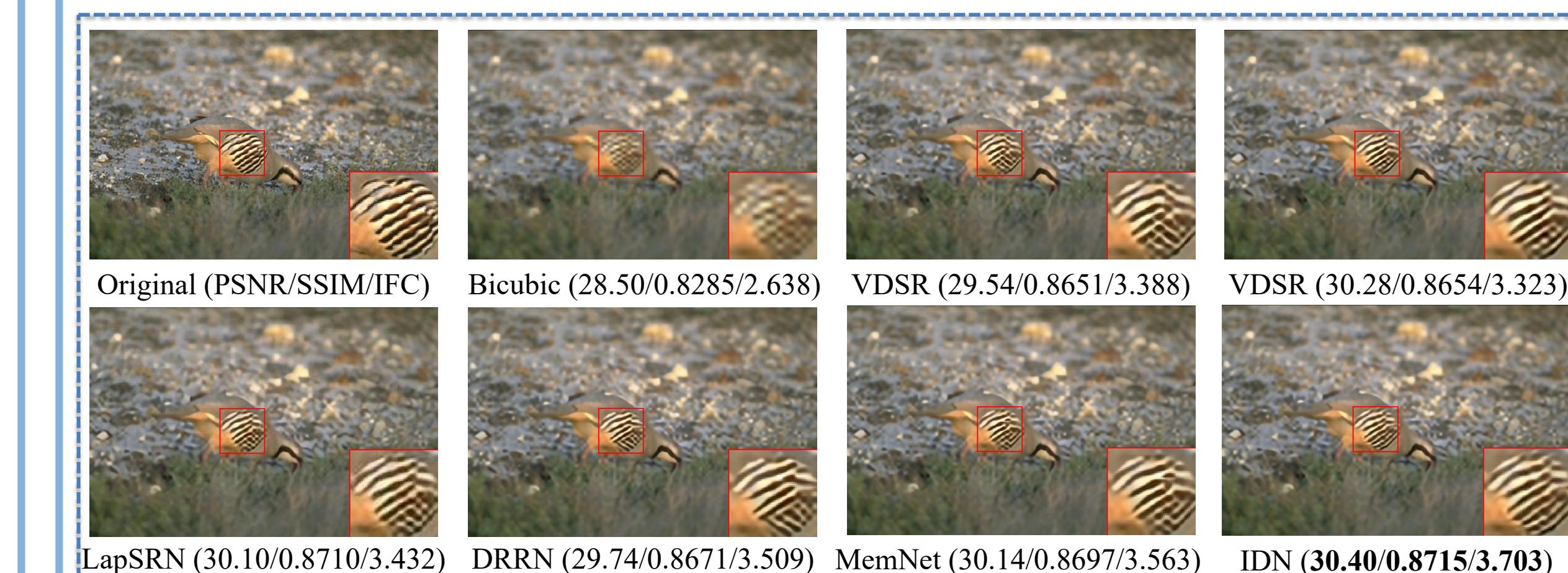
Item	Detail
Input channels	1 (Y)
Training images	291
Mini-batch size	64
Learning rate	10^{-4} , halved at every 5×10^5 iterations
Data augmentation	Rotate, Flip and Downscale ($\times 40$)
Optimizer	ADAM ($\beta_1 = 0.9$)
Dataset	91 images + BSD200

Patch size

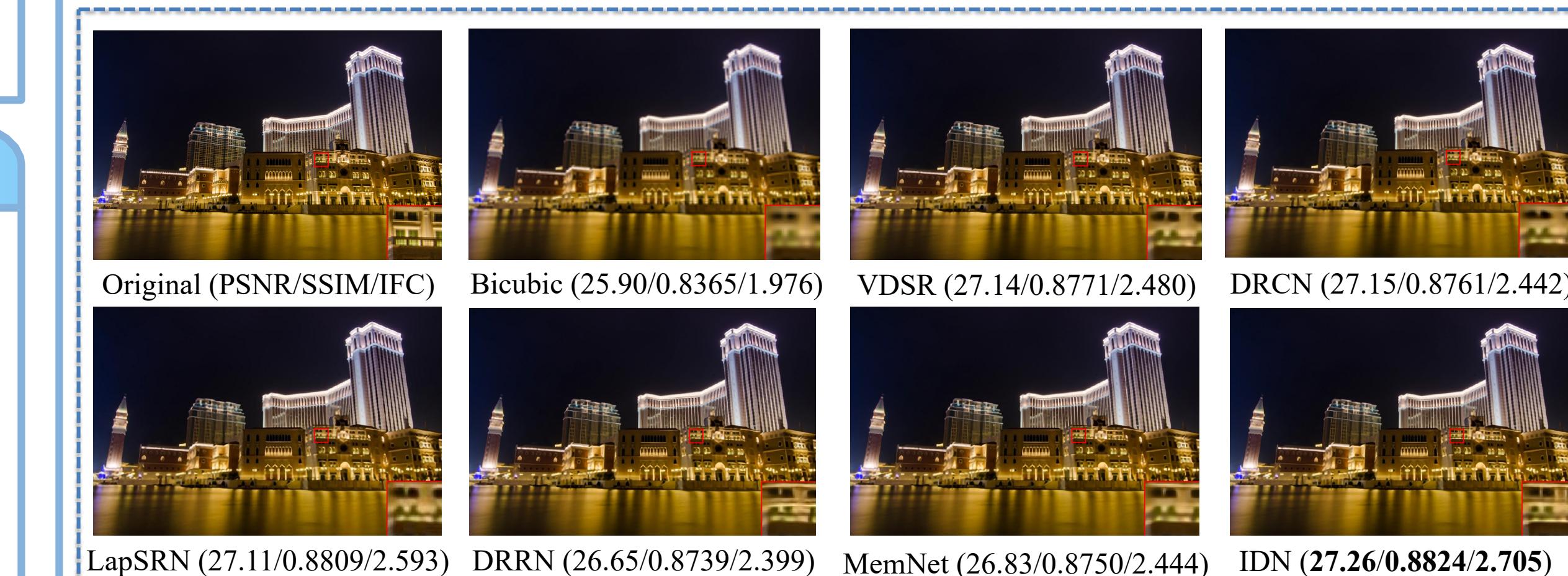
AVERAGE PSNR/SSIM/IFC RESULTS

Dataset	Scale	Bicubic	VDSR	DRCN	LapSRN	DRRN	MemNet	IDN(Ours)
Set5	× 2	33.66/0.9299/6.083	37.53/0.9587/8.580	37.63/0.9588/8.783	37.52/0.9591/ 9.010	37.74/0.9591/8.670	37.78/0.9597/8.850	37.83/0.9600/9.252
	× 3	30.39/0.8682/3.580	33.66/0.9213/5.203	33.82/0.9226/5.336	33.81/0.9220/5.194	34.03/0.9244/5.394	34.09/0.9248/5.503	34.11/0.9253/5.620
	× 4	28.42/0.8104/2.329	31.35/0.8838/3.542	31.53/0.8854/3.543	31.54/0.8852/3.559	31.68/0.8888/3.700	31.74/0.8893/3.787	31.82/0.8903/3.826
Set14	× 2	30.24/0.8688/6.105	33.03/0.9124/8.159	33.04/0.9118/8.370	32.99/0.9124/ 8.501	33.23/0.9136/8.280	33.28/0.9142/8.469	33.30/0.9148/8.839
	× 3	27.55/0.7742/3.473	29.77/0.8314/4.691	29.76/0.8311/4.782	29.79/0.8325/4.662	29.96/0.8349/4.870	30.00/0.8350/4.958	29.99/ 0.8354/5.062
	× 4	26.00/0.7027/2.237	28.01/0.7674/3.106	28.02/0.7670/3.098	28.09/0.7700/3.145	28.21/0.7721/3.249	28.26/0.7723/3.309	28.25/ 0.7730/3.354
BSD100	× 2	29.56/0.8431/5.619	31.90/0.8960/7.494	31.85/0.8942/7.577	31.80/0.8952/ 7.715	32.05/0.8973/7.513	32.08/0.8978/7.665	32.08/0.8985/7.931
	× 3	27.21/0.7385/3.138	28.82/0.7976/4.151	28.80/0.7963/4.184	28.82/0.7980/4.057	28.95/0.8004/4.235	28.96/0.8001/4.300	28.95/ 0.8013/4.398
	× 4	25.96/0.6675/1.978	27.29/0.7251/2.679	27.23/0.7233/2.633	27.32/0.7275/2.677	27.38/ 0.7284/2.746	27.40/0.7281/2.778	27.41/0.7297/2.837
Urban100	× 2	26.88/0.8403/6.245	30.76/0.9140/8.629	30.75/0.9133/8.959	30.41/0.9103/8.907	31.23/0.9188/8.889	31.31/0.9195/9.122	31.27/0.9196/9.594
	× 3	24.46/0.7349/3.620	27.14/0.8279/5.159	27.15/0.8276/5.314	27.07/0.8275/5.156	27.53/0.8378/5.440	27.56/0.8376/5.560	27.42/0.8359/ 5.676
	× 4	23.14/0.6577/2.361	25.18/0.7524/3.462	25.14/0.7510/3.465	25.21/0.7562/3.530	25.44/0.7638/3.669	25.50/0.7630/3.786	25.41/ 0.7632/3.789

VISUAL RESULTS



Visual comparison for $4 \times$ SR on “8023” from BSD100.



Visual comparison for $4 \times$ SR on “img085” from Urban100

TIME RESULTS

Method	Scale	Set5	Set14	BSD100	Urban100
VDSR	$\times 2$	0.054	0.113	0.071	0.451
RCN		0.735	1.579	0.983	5.010
pSRN		0.032	0.035	0.018	0.082
RRN		4.343	8.540	4.430	26.699
emNet		5.715	12.031	5.875	35.871
IDN		0.016	0.025	0.015	0.062
VDSR	$\times 3$	0.062	0.122	0.071	0.514
RCN		0.748	1.569	0.996	5.054
pSRN		0.049	0.061	0.037	0.122
RRN		4.380	8.298	4.430	26.693
emNet		5.761	11.543	5.897	35.803
IDN		0.011	0.014	0.009	0.034
VDSR	$\times 4$	0.054	0.112	0.071	0.448
RCN		0.735	1.526	0.984	5.048
pSRN		0.040	0.040	0.023	0.100
RRN		4.450	8.540	4.373	26.702
emNet		5.728	11.956	5.887	37.404
IDN		0.009	0.010	0.007	0.022

FOR PAPER, CODE

