SUPPLEMENTARY MATERIAL

MPRNet: Multi-Path Residual Network for Lightweight Image Super Resolution

Armin Mehri
*Computer Vision Center,
Edifici O, Campus UAB,
08193, Bellaterra,
Barcelona, Spain
amehri@cvc.uab.es

Parichehr B.Ardakani
*Computer Vision Center,
Edifici O, Campus UAB,
08193, Bellaterra,
Barcelona, Spain
pbehjati@cvc.uab.es

Angel D. Sappa
+ESPOL Polytechnic University,
Guayaquil, Ecuador
*Computer Vision Center,
08193, Bellaterra, Barcelona, Spain
sappa@ieee.org

Summary

The following items are contained in the supplementary material:

1) Memory Complexity Analysis
2) Inference Time and Memory Consumption
3) Width Multiplier
4) Additional Qualitative Results

1. Memory Complexity Analysis

In this section, we compare the proposed MPRNet with the most recent lightweight and expensive networks: LapSRN, VDSR, DRCN, SelNet, DRRN, MemNet, SRFBN, CARN, MSRN, OISR, CBPN, MAFFSRN, and LatticeNet in term of number of MAC operations (Multi-Adds) and reconstruction results (PSNR) to show the efficiency of the purposed MPRNet. In Fig. 1, reconstruction results (PSNR) and MAC (G), which shows the number of multiply-accumulate operations, are illustrated. As we can see, our MPRNet can achieve better results with a large gap among all the recent networks with less needed MAC operations; and even perform better than MSRN, which has more than 160 layers by only 13% of the total number of MSRN multiply-accumulate operations ($1365.4G$).

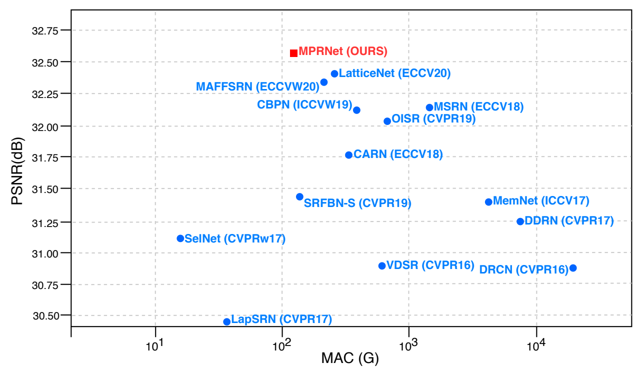

Figure 1: PSNR $vs.$ MAC on Urban100 for scale factor $\times 2$.

2. Inference Time and Memory Consumption

Table 1 illustrates the superiority of the proposed MPRNet in terms of Inference Time (s) and Memory Consumption (MB) when it compares with the recent light- and heavy-weight state of the art approaches on Urban100 for scale factor $\times 4$, namely MemNet, SRFBN, CARN, RCAN, RDN, EDSR. We consider the pyTorch version of MemNet instead of Caffe version due to large memory consumption in Caffe. The inference time and memory consumption of each approach is evaluated using their official code on the same environment. The MPRNet has the fastest inference time while using less memory compared to other approaches, which reflect the efficiency of the proposed method.

Table 1: Average Inference Time (s) and Memory Consumption (MB) comparisons with other SOTA models on Urban100 for scale factor $\times 4$.

Model	Params.	Time	Memory	PSNR
MemNet	$667K$	0.543	$3,170$	25.54
SRFBN-S	$483K$	0.0069	$2,960$	25.71
CARN	$1592K$	0.0047	$3,015$	26.07
RCAN	$16000K$	0.5927	$2,731$	26.82
RDN	$22000K$	0.0294	$3,835$	26.61
EDSR	$43000K$	0.0841	$8,263$	26.64
MPRNet [Ours]	**$538K$**	**0.0095**	**$2,154$**	**26.31**

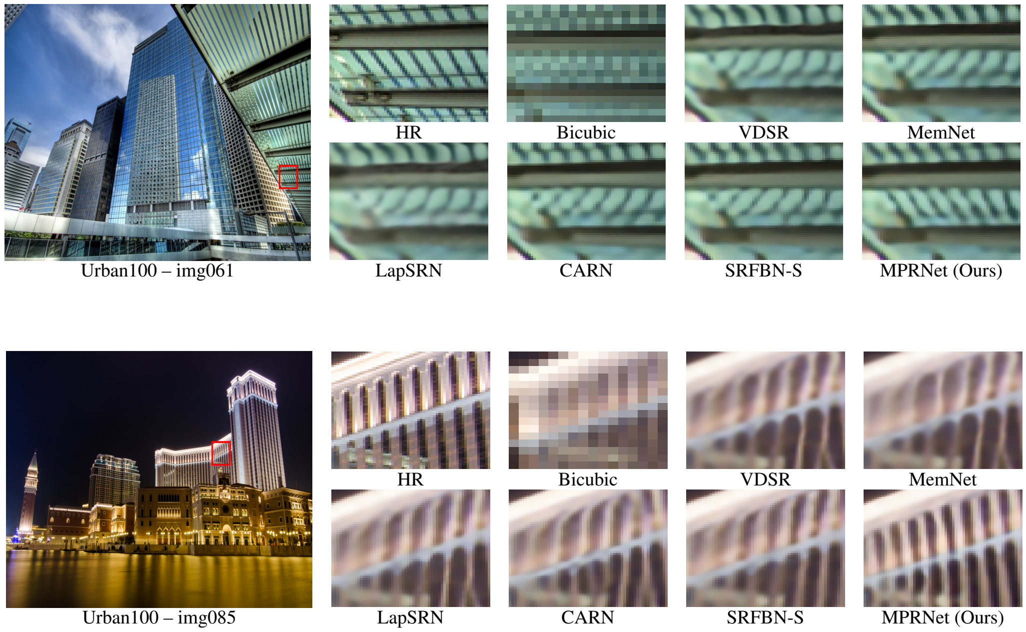

Figure 2: Qualitative results on **BI** degradation model with a scale factor $\times 4$ on $Urban100$ dataset.

3. Depth Multiplier

In Table 2, the effect of depth multiplier on model size and reconstruction results are illustrated. Similar to MobileNetV2, we employed depth multiplier ($alpha$) to make our MPRNet even more light cost with small reduction in performance. Depth multiplier is a float number between 0 and 1 that controls the depth of input layer. $\alpha = 1$ is the baseline model. By decreasing α, model size and computational cost are reduced. As can be seen, the proposed MPRNet with $372.7K$ ($\alpha = 0.25$), can achieve a good performance among the lightweight SOTA methods.

Table 2: Impact of Depth Multiplier on MPRNet

Depth Multiplier	1.0	0.75	0.5	0.25
# Parameters	$538.2K$	$470.4K$	$416.2K$	$372.7K$
Set114 ($\times 4$)	32.38	32.23	32.01	31.84
Urban100 ($\times 4$)	26.31	26.16	25.99	25.83

As we can see, by analyzing the number of parameters and MAC operations vs PSNR, inference time, memory consumption, and reconstruction result, the proposed MPRNet can prove that it is well-balanced in terms of speed, accuracy and computation cost.

4. Additional Qualitative Results

In this section, additional results are provided showing the superiority of the SR images obtained with the proposed model. Qualitative results with all degradation models (i.e., **BI**, **BD**, and **DN**) are presented below.

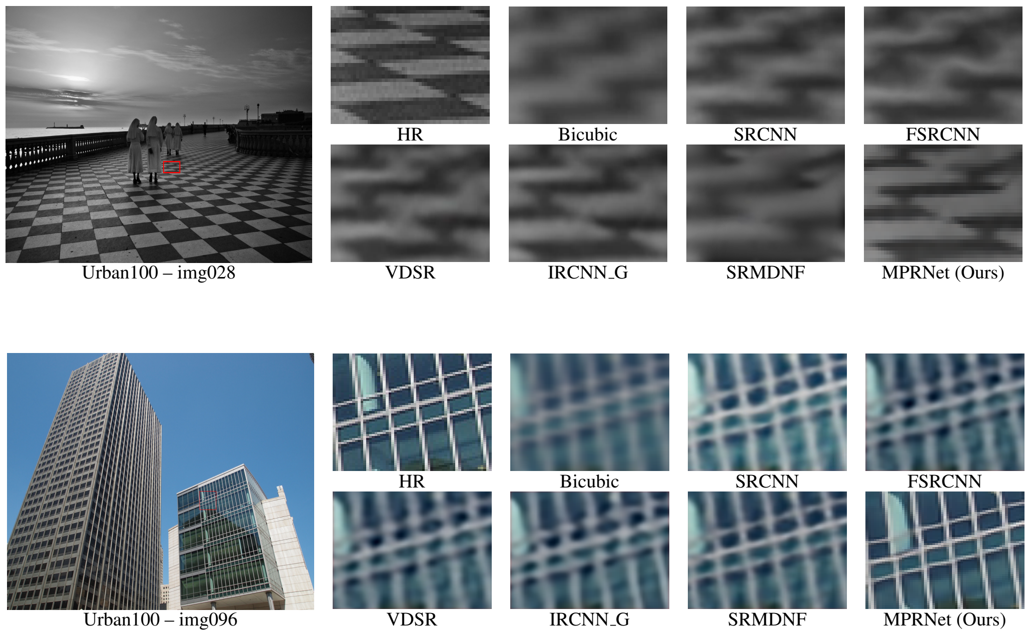

Figure 3: Qualitative results on **BN** degradation model with a scale factor $\times 3$.

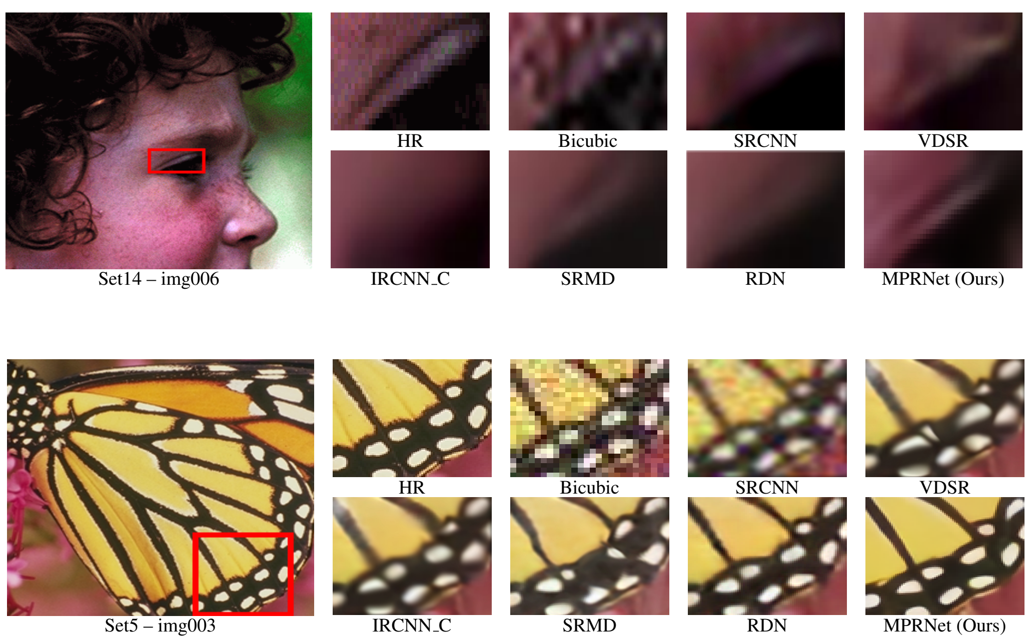

Figure 4: Qualitative results on **DN** degradation model with a scale factor $\times 3$.