Efficient Image Super-Resolution with Collapsible Linear Blocks

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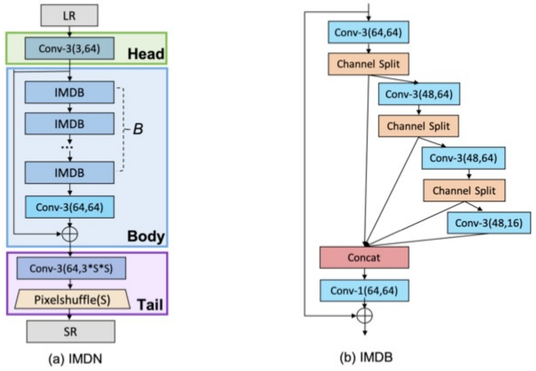
Motivation & Contribution

- Proposed a simple but effective architecture for fast and accurate SISR
- Apply IMDN as baseline, adopt a coarse-grained pruning strategy to get a more shallow network.
- To improve the accuracy while maintaining the same inference latency, we introduce collapsible linear blocks to recover the representative ability of the pruned super-resolution network.
- We evaluate the proposed algorithm on the NTIRE 2022 Efficient Image Super-Resolution Challenge, and achieve the best fidelity results under the condition of limited inference time (≤ 49.42ms) and parameter amount (≤ 0.894M). **Specifically, our solution achieves PSNR scores of 29.05dB and 28.75dB on the DIV2K validation and test sets, respectively.**

Proposed Method

IMDN Overview



Optimization Strategy

- Network Pruning
- Collapsible Linear Block

Method	*B*	Parameters [M]	PSNR [dB]
Target		≤ 0.8939	≥ 29.00
IMDN	8	0.8939	29.13
IMDN	7	0.7905	28.97
IMDN	6	0.6871	28.93
IMDN	5	0.5836	28.91
IMDN	4	0.4802	28.85

Table 1. IMDN pruning results.

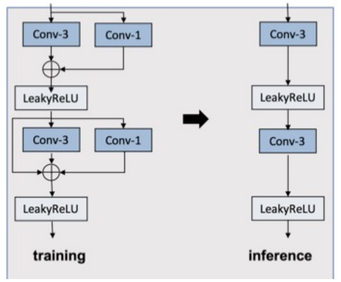


Figure 1. Collapsible Linear Block.

Experiments

Experimental Settings

- Dataset: DIV2K with upsampling 4x

Results of Efficient SISR Challenge *(Table 2)*

Team	Val PSNR [dB]	Test PSNR [dB]	Avg. PSNR [dB]	Val Time [ms]	Test Time [ms]
Target	≥ 29.00	-	-	≤ 49.42	≤ 52.3
Ours	**29.05**	**28.75**	**28.90**	48.86	47.55
imglhl	29.03	28.75	28.89	57.65	56.11
IMGWLH	29.01	28.72	28.87	56.14	56.53
Dragon	29.01.	28.69	28.85	42.40	41.2
VMCL-Taobao	29.01	28.68	28.85	34.70	33.79
XPixel	29.01	28.69	28.85	142.58	138.37
Alpan Team.	29.01	28.75	28.88	40.17	39.08
NEESR	29.01	28.71	28.86	30.37	29.58
rainbow	29.01	28.74	28.88	34.69	33.52
ByteESR	29.00	28.72	28.86	27.46	26.76
IPCV-IITM†	29.10	28.68	28.89	64.00	-
AiriA-CG†	29.00	28.70	28.85	37.00	-

Table 2. Ranking results by Val PSNR in the NTIRE 2022 Efficient SISR Challenge under the condition of Val Time ≤ 49.42ms, and parameter amount ≤ 0.894M).

Ablation Study

- Effect of algorithmic components ***(Table 3)***
- Effect of Network Pruning ***(Table 4)***
- Effect of Two-Stage Training Strategy ***(Table 5)***

Model	Val PSNR [dB]	Parameters [M]	Val Time [ms]
Target	≥ 29.00	≤ 0.8939	≤ 49.42
IMDN Baseline	29.13	0.8939	49.42
+ Network Pruning	28.97	0.7905	48.86
++ Collapsible Linear Blocks	29.00	0.7905	48.86
+++ Two-Stage Training	29.05	0.7905	48.86

Table 3. Effect of our each algorithmic components.

Method	Val PSNR [dB]	Parameters [M]	FLOPs [G]	#Conv	Val Time [ms]
Target	≥ 29.00	≤ 0.8939	58.53	43	≤ 49.42
OFA-based	28.84	**0.3915**	**33.71**	42	**42.72**
Pruning-based	**28.97**	0.7905	51.76	**37**	48.86

Table 4. Performance comparison between our pruning-based and OFA-based methods.

Model	Patch size	Val PSNR [dB]	Training Time / Epoch [s]	GPU Memory [M]
Stage 1	64×64	29.00	63	3358
Stage 2	160×160	**29.05**	342	1,4747
Stage 2	256×256	29.02	796	2,8991

Table 5. Performance comparisons using different patch sizes for two-stage training.

Visualization