Gated Multiple Feedback Network for Image Super-Resolution

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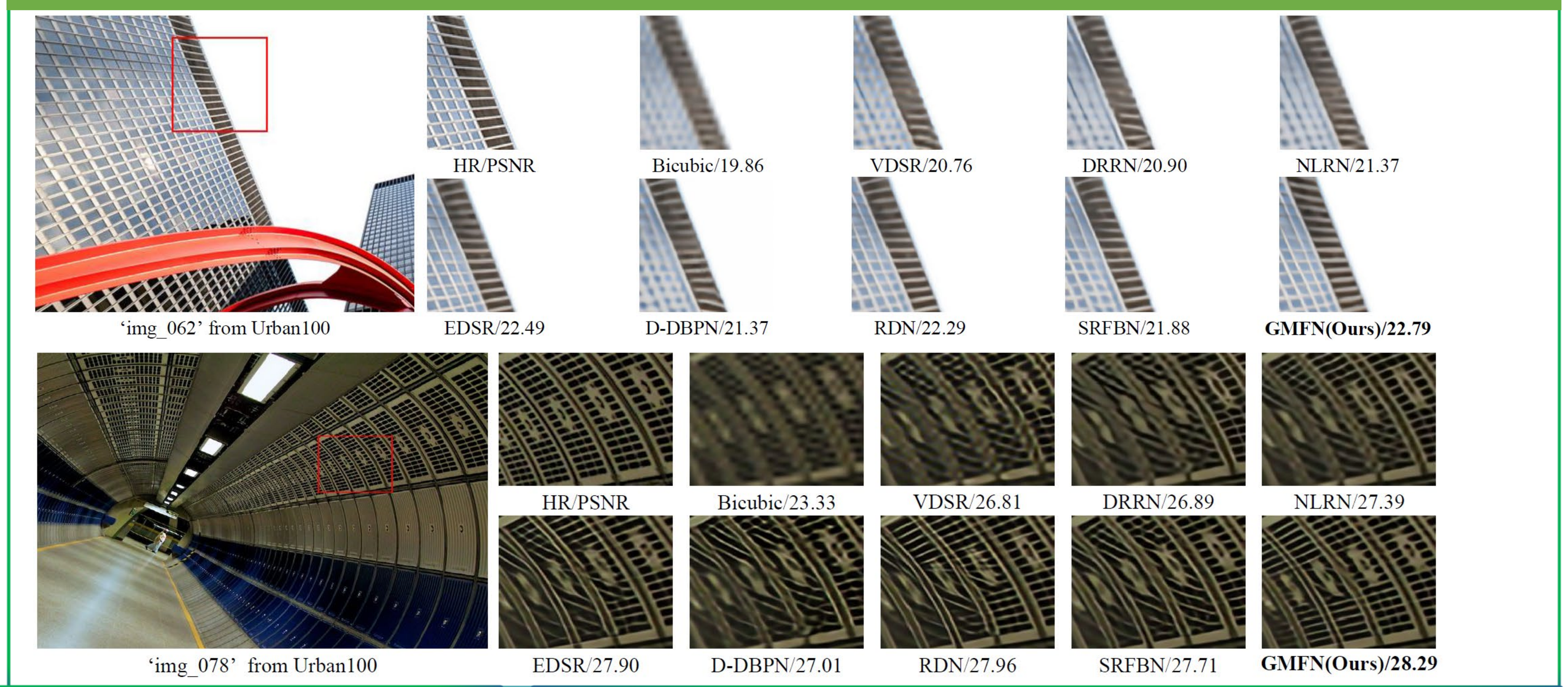
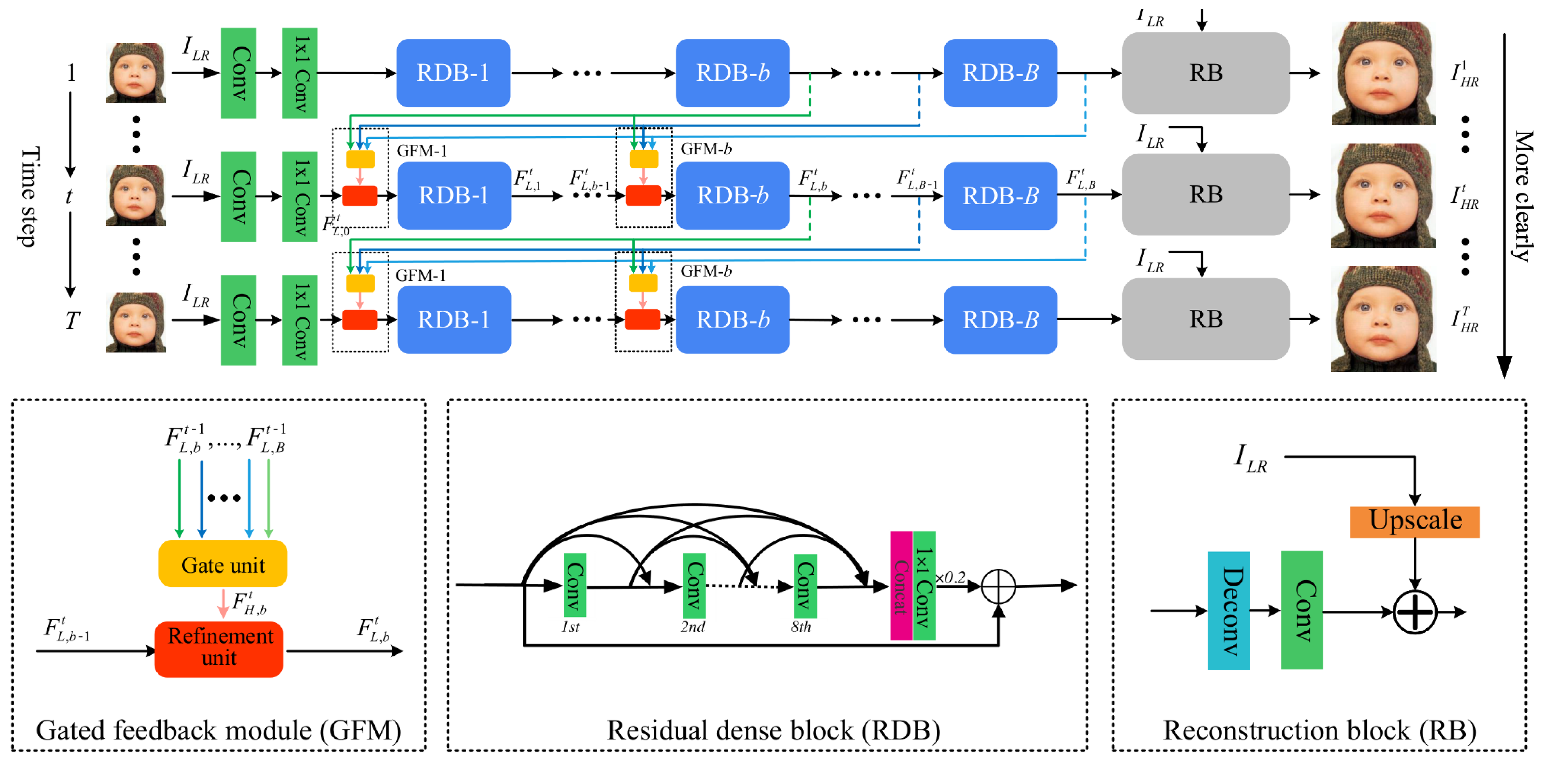
Motivation and Main idea

1. Deep layers have larger receptive fields than shallow layers, thus they can capture more contextual high-level information.
2. Existing super-resolution (SR) networks fail to make full use of such high-level information in deep layers.
3. We first employ multiple feedback connections to reroute multiple hierarchical high-level features to shallow layers.
4. We design a simple yet efficient gated feedback module (GFM) to adaptively select meaningful Information from the rerouted high-level features.

Visual results



Framework



1. Initial low-level features $F^t_{L,0}$: $F^t_{L,0} = H_{LFEB}(I_{LR})$,

2. Hierarchical low-level feature $F^t_{L,b}$ at b-th RDB:

$$F^t_{L,b} = \begin{cases} H_{RDB,b}\left(H_{RU,b}\left(\left[F^t_{H,b}, F^t_{L,b-1}\right]\right)\right), & \text{if } b \in \mathbf{S}_M \text{ and } t > 1, \\ H_{RDB,b}\left(F^t_{L,b-1}\right), & \text{otherwise,} \end{cases}$$

3. Enhance $F^t_{L,b}$ with the rerouted high-level feature:

$$F^t_{H,b} = \begin{cases} H_{GU,b}\left(\left[F^{t-1}_{L,N}, ..., F^{t-1}_{L,B}\right]\right), & \text{if } b < N, \\ H_{GU,b}\left(\left[F^{t-1}_{L,b}, ..., F^{t-1}_{L,B}\right]\right), & \text{otherwise,} \end{cases}$$

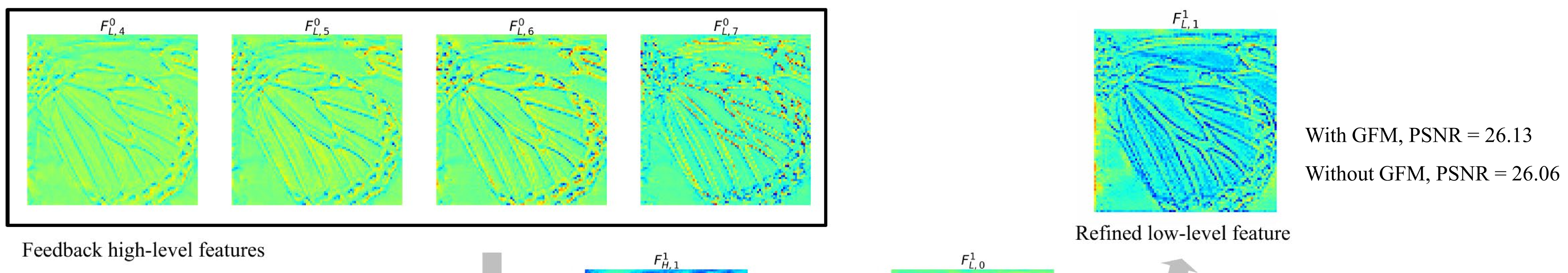
4. The final high-level feature $F^t_{L,B}$: $F^t_{L,B} = H_{GFM-RDB}\left(F^t_{L,0}\right)$,

5. Reconstruction the SR image I^t_{SR} at the t-th time step: $I^t_{SR} = H_{RB}\left(F^t_{L,B}, I_{LR}\right) = H_{UF}\left(F^t_{L,B}\right) + H_{\uparrow}\left(I_{LR}\right)$,

6. Loss function:

$$\mathcal{L}(\Theta) = \frac{1}{T}\sum_{t=1}^{T}\left\|I^t_{HR} - I^t_{SR}\right\|_1$$

Study of gated feedback module (GFM)



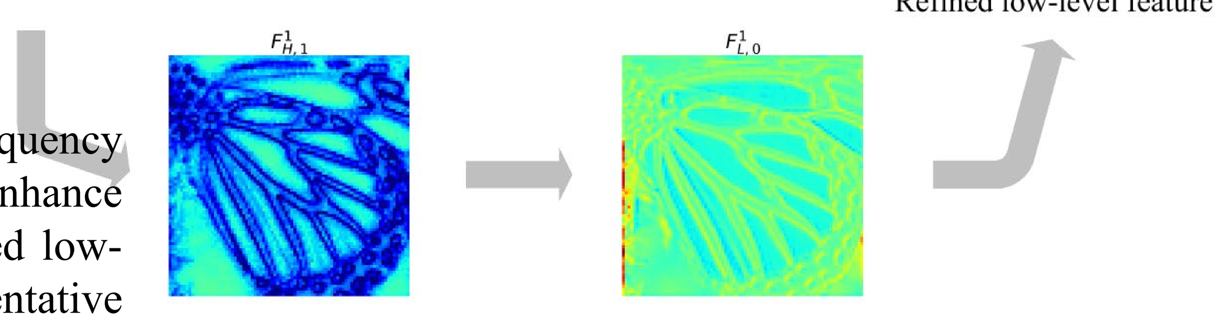
Feedback high-level features

Refined low-level feature

With GFM, PSNR = 26.13

Without GFM, PSNR = 26.06

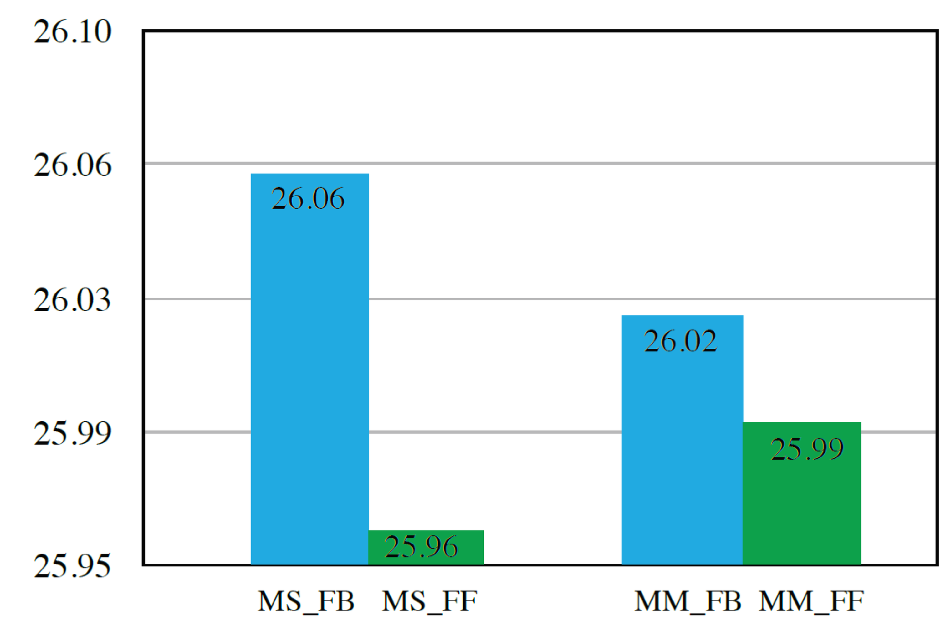
GFM adaptively selects the high frequency components of high-level features to enhance the input low-level feature. The refined low-level feature becomes more representative compared with the raw counterpart.



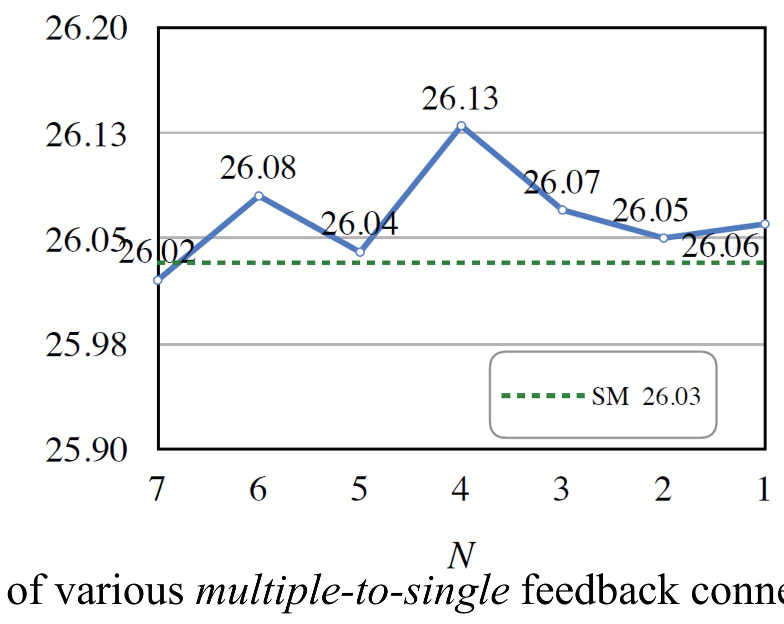
Selected and enhanced high-level feature

Input low-level feature

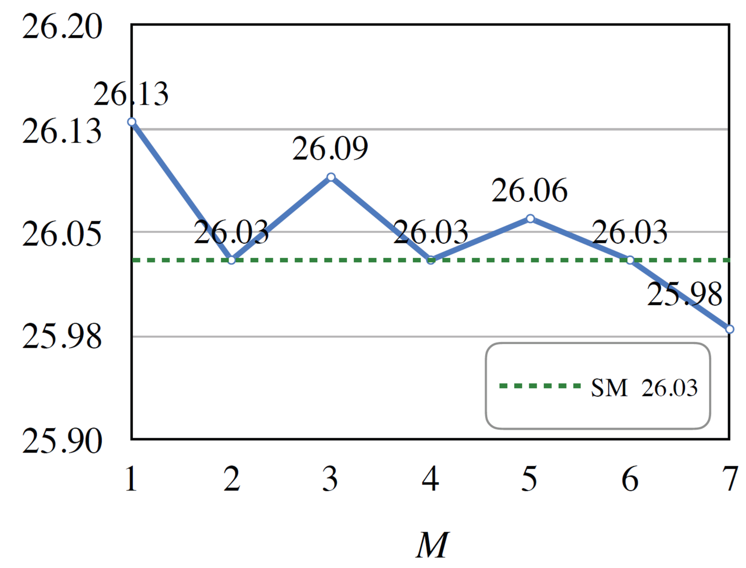
Study of multiple feedback connections



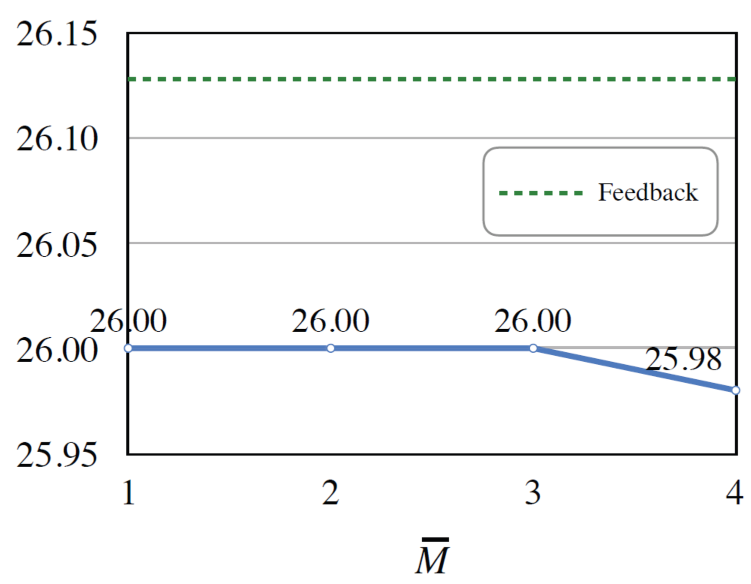
(a). Feedback networks (FB) vs. feedforward networks (FF)



(b). Study of various *multiple-to-single* feedback connections.



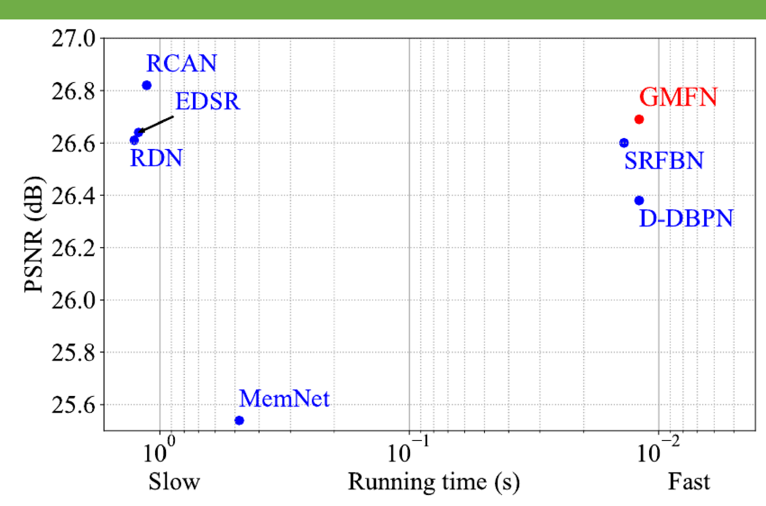
(c). Study of various *multiple-to-multiple* feedback connections.



(d). Study of various *single-to-multiple* anti-feedback connections.

Quantitative comparison with SOTA

Dataset	Scale	Bicubic	SRCNN	VDSR	DRRN	NLRN	EDSR	D-DBPN	RDN	SRFBN	GMFN (Ours)
Set5	×2	33.66/0.9299	36.66/0.9542	37.53/0.9590	37.74/0.9591	38.08/0.9610	38.11/0.9602	38.09/0.9600	**38.24/0.9614**	38.11/0.9609	38.21/0.9612
	×3	30.39/0.8682	32.75/0.9090	33.67/0.9210	34.03/0.9244	34.30/0.9271	34.65/0.9280	-/-	34.71/**0.9296**	34.70/0.9292	**34.73**/0.9295
	×4	28.42/0.8104	30.48/0.8628	31.35/0.8830	31.68/0.8888	31.94/0.8920	32.46/0.8968	32.47/0.8980	32.47/0.8990	32.47/0.8983	**32.55/0.8991**
Set14	×2	30.24/0.8688	32.45/0.9067	33.05/0.9130	33.23/0.9136	33.57/0.9167	33.92/0.9195	33.85/0.9190	34.01/**0.9212**	33.82/0.9196	**34.05**/0.9211
	×3	27.55/0.7742	29.30/0.8215	29.78/0.8320	29.96/0.8349	30.25/0.8386	30.52/0.8462	-/-	30.57/0.8468	30.51/0.8461	**30.58/0.8473**
	×4	26.00/0.7027	27.50/0.7513	28.02/0.7680	28.21/0.7721	28.44/0.7759	28.80/0.7876	28.82/0.7860	28.81/0.7871	28.81/0.7868	**28.84/0.7888**
B100	×2	29.56/0.8431	31.36/0.8879	31.90/0.8960	32.05/0.8973	32.18/0.8991	32.32/0.9013	32.27/0.9000	**32.34/0.9017**	32.29/0.9010	**32.34/0.9017**
	×3	27.21/0.7385	28.41/0.7863	28.83/0.7990	28.95/0.8004	29.05/0.8024	29.25/**0.8093**	-/-	29.26/**0.8093**	29.24/0.8084	**29.27/0.8093**
	×4	25.96/0.6675	26.90/0.7101	27.29/0.7260	27.38/0.7284	27.48/0.7304	27.71/0.7420	27.72/0.7400	27.72/0.7419	27.72/0.7409	**27.74/0.7421**
Urban100	×2	26.88/0.8403	29.50/0.8946	30.77/0.9140	31.23/0.9188	31.77/0.9243	32.93/0.9351	32.55/0.9324	32.89/0.9353	32.62/0.9328	**32.96/0.9361**
	×3	24.46/0.7349	26.24/0.7989	27.14/0.8290	27.53/0.8378	27.90/0.8443	28.80/0.8653	-/-	28.80/0.8653	28.73/0.8641	**28.87/0.8667**
	×4	23.14/0.6577	24.52/0.7221	25.18/0.7540	25.44/0.7638	25.78/0.7713	26.64/0.8033	26.38/0.7946	26.61/0.8028	26.60/0.8015	**26.69/0.8048**
Manga109	×2	30.30/0.9339	35.60/0.9663	37.22/0.9750	37.60/0.9736	38.55/0.9768	39.10/0.9773	38.89/0.9775	**39.18/0.9780**	39.08/0.9779	39.13/0.9778
	×3	26.95/0.8556	30.48/0.9117	32.01/0.9340	32.42/0.9359	33.24/0.9414	34.17/0.9476	-/-	34.13/0.9484	34.18/0.9481	**34.24/0.9487**
	×4	24.89/0.7866	27.58/0.8555	28.83/0.8870	29.18/0.8914	29.82/0.8982	31.02/0.9148	30.91/0.9137	31.00/0.9151	31.15/0.9160	**31.24/0.9174**



Accuracy and numbers of parameters trade-off

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