Decouple Learning for Parameterized Image Operators

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Codes and model: https://github.com/fqnchina/DecoupleLearning

Challenges

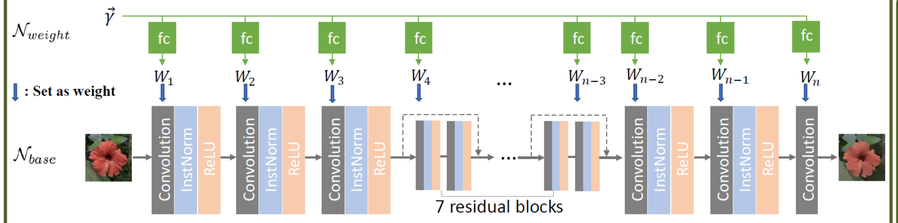
➢ One network for one task

➢ one network for one sub-task

Problems

➢ Can we have one trained network that solves all the different image processing tasks jointly?

Proposed decouple learning framework:



- Network weight is **detached** from the network structure.
- Network weight is learned from a **meta-network** composed of **only one fully connected layer** for one corresponding convolution layer.
- The input to the meta-network is **one parameter** that corresponds to each specific task or sub-task.
- The base network and meta network are **jointly learned** with one supervised loss.

$$\mathcal{L} = \|\mathcal{N}_{base}(\mathcal{N}_{weight}(\vec{\gamma}), \mathcal{I}, E) - f(\vec{\gamma}, \mathcal{I})\|^2$$

How powerful is the decouple learning framework?

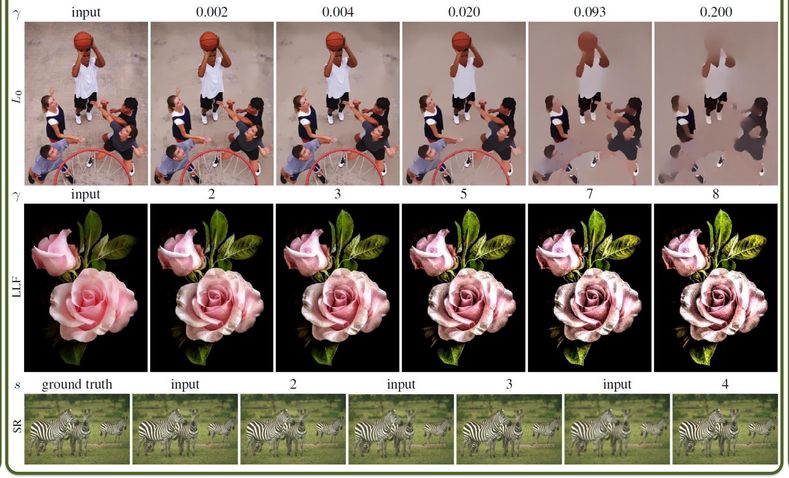
➢ one network for all the sub-tasks

	L_0				WLS				RTV				RGF				WMF				LLF			
metric	γ	single	nume.	diff	γ	single	nume.	diff	γ	single	nume.	diff	γ	single	nume.	diff	γ	single	nume.	diff	γ	single	nume.	diff
PSNR	0.002	40.69	39.46	1.23	0.100	44.00	42.12	1.88	0.002	41.11	40.66	0.45	1.00	41.77	37.03	4.74	1.00	39.06	36.79	2.27	2	38.00	37.83	0.17
	0.004	38.96	38.72	0.24	0.215	43.14	42.64	0.50	0.004	40.91	41.10	0.19	3.25	38.36	38.27	0.09	3.25	39.78	38.76	1.02	3	34.64	35.71	1.07
	0.020	36.07	35.71	0.36	1.000	41.93	41.63	0.30	0.010	40.50	41.07	0.57	5.50	38.11	38.35	0.24	5.50	39.94	38.53	1.41	5	32.34	32.29	0.05
	0.093	33.08	31.92	1.16	4.641	39.42	39.64	0.22	0.022	41.07	40.77	0.30	7.75	37.65	37.99	0.34	7.75	40.06	39.20	0.86	7	30.11	29.91	0.20
	0.200	31.75	30.43	1.32	10.00	39.13	38.51	0.62	0.050	40.73	39.18	1.55	10.0	37.52	37.08	0.44	10.0	39.49	38.72	0.77	8	29.53	28.95	0.58
	ave.	36.11	35.25	**0.86**	ave.	41.52	40.91	**0.61**	ave.	40.86	40.55	**0.31**	ave.	38.68	37.74	**0.93**	ave.	39.66	38.40	**1.26**	ave.	32.93	32.94	**0.01**
SSIM	0.002	0.989	0.988	0.001	0.100	0.994	0.993	0.001	0.002	0.987	0.988	0.001	1.00	0.994	0.981	0.013	1.00	0.985	0.972	0.013	2	0.992	0.992	0
	0.004	0.986	0.987	0.001	0.215	0.993	0.993	0	0.004	0.989	0.990	0.001	3.25	0.986	0.986	0	3.25	0.985	0.979	0.006	3	0.988	0.990	0.02
	0.020	0.982	0.981	0.001	1.000	0.992	0.991	0.001	0.010	0.990	0.991	0.001	5.50	0.985	0.986	0.001	5.50	0.986	0.981	0.005	5	0.983	0.984	0.01
	0.093	0.977	0.973	0.004	4.641	0.987	0.989	0.002	0.022	0.992	0.992	0	7.75	0.984	0.985	0.001	7.75	0.986	0.985	0.001	7	0.977	0.977	0
	0.200	0.973	0.968	0.005	10.00	0.986	0.987	0.001	0.050	0.992	0.990	0.002	10.0	0.984	0.982	0.002	10.0	0.986	0.984	0.002	8	0.976	0.974	0.02
	ave.	0.981	0.979	**0.002**	ave.	0.990	0.990	**0**	ave.	0.990	0.990	**0**	ave.	0.986	0.984	**0.002**	ave.	0.985	0.980	**0.005**	ave.	0.983	0.983	**0**

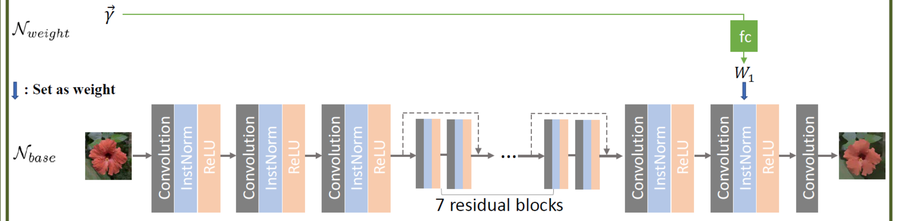
➢ one network for all the tasks

#ope.	L_0	WLS	RTV	RGF	WMF	LLF	SR	denoise	deblock	derain	ave.
1	35.25	40.91	40.55	37.74	38.40	32.94	29.13	28.70	30.21	29.86	**34.36**
6/4	33.27	37.39	37.00	35.41	36.06	30.08	28.89	28.67	30.10	30.32	**32.72**
10	32.67	36.59	36.03	34.64	35.08	29.77	29.69	30.45	28.53	28.36	**32.18**
1	0.979	0.991	0.990	0.984	0.980	0.984	0.804	0.804	0.847	0.893	**0.925**
6/4	0.969	0.980	0.979	0.974	0.967	0.976	0.797	0.800	0.842	0.893	**0.918**
10	0.965	0.978	0.975	0.969	0.962	0.971	0.837	0.895	0.789	0.789	**0.913**

Visual results



Real-time extension

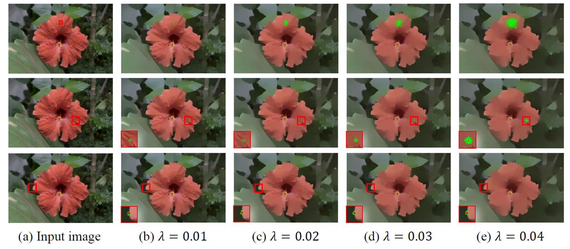


➢ Comparison with state-of-the-art approaches

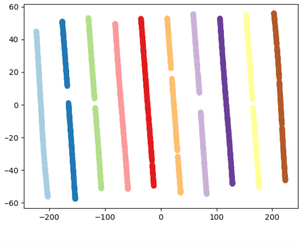
metric	method	L_0	WLS	RTV	RGF	WMF	LLF	LLF remap	WLS enhance	Stylization	Abstraction	Average
PSNR	BGU	31.76	27.03	26.15	22.71	21.27	26.97	33.05	26.93	14.31	16.11	**24.62**
	DBL	28.67	30.63	28.52	27.11	26.88	25.13	29.34	28.29	25.08	19.61	**26.92**
	Ours	31.81	36.59	34.28	33.29	34.00	29.74	32.41	34.40	26.66	25.61	**31.87**
SSIM	BGU	0.912	0.915	0.848	0.776	0.765	0.936	0.978	0.931	0.673	0.427	**0.816**
	DBL	0.852	0.890	0.826	0.805	0.786	0.899	0.945	0.944	0.887	0.502	**0.833**
	Ours	0.946	0.971	0.948	0.945	0.940	0.967	0.969	0.986	0.927	0.835	**0.943**

Deeper understanding of decouple learning framework

➢ How large the real receptive field is?



➢ Weight visualization



metric	method	L_0	WLS	RTV	RGF	WMF	LLF	LLF remap	WLS enhance	Stylization	Abstraction	Average
PSNR	norm(1)	31.06	34.86	33.75	32.87	33.49	29.22	32.21	32.59	27.26	24.81	**31.21**
	norm(7)	30.86	34.75	33.54	32.97	33.39	29.24	31.99	32.79	27.07	24.81	**31.14**
	norm(14)	30.64	34.31	33.06	32.42	33.21	29.15	31.80	32.53	27.05	24.83	**30.90**
	norm(19)	28.53	31.22	29.46	29.72	30.69	27.03	30.36	29.78	25.57	24.38	**28.67**
	norm(all)	31.71	35.51	34.31	33.10	33.96	29.56	32.45	33.11	27.32	25.21	**31.62**
	conv(all)	31.64	35.02	33.67	32.81	33.97	29.59	32.52	32.69	28.12	26.35	**31.63**
SSIM	norm(1)	0.949	0.971	0.959	0.954	0.948	0.966	0.981	0.982	0.923	0.819	**0.945**
	norm(7)	0.945	0.969	0.958	0.955	0.948	0.967	0.980	0.982	0.917	0.812	**0.943**
	norm(14)	0.935	0.963	0.942	0.947	0.945	0.966	0.979	0.980	0.917	0.816	**0.939**
	norm(19)	0.871	0.890	0.809	0.881	0.876	0.947	0.970	0.965	0.889	0.796	**0.889**
	norm(all)	0.954	0.972	0.960	0.956	0.953	0.970	0.982	0.984	0.924	0.823	**0.947**
	conv(all)	0.954	0.969	0.952	0.953	0.954	0.969	0.982	0.982	0.925	0.833	**0.947**