SINGLE-IMAGE RAIN REMOVAL VIA MULTI-SCALE CASCADING IMAGE GENERATION

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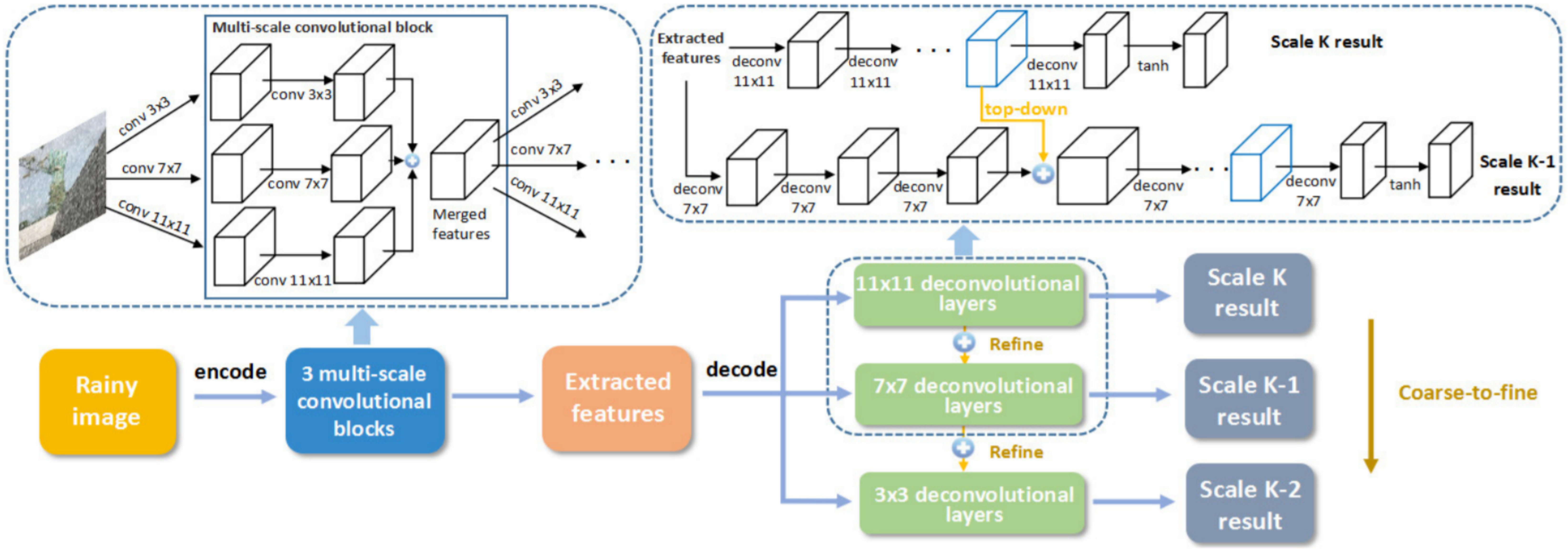
Introduction

- Achieving rain removal is beneficial for many **practical visual systems** like unmanned vehicles, autonomous robots and outdoor surveillance systems.
- The existing methods often lead to over-blurred de-rained images. In fact, **the orientation, density and scale of the rain streaks** are varied not only across different images but also across different regions within each image, which means that different perceptive fields and scale analysis are required to jointly detect and process rain features.

Rainy image Our de-rained result

Multi-scale cascading image generation (MSCG) framework



- **Encoder-decoder framework**: encoder is used to extract multiple scale features of a rainy image and the decoder is used to generate the de-rained image from extracted features by a coarse-to-fine approach.
- **Cascading feature flow** across scales will supplement more spatial and contextual information to enhance the de-raining performance. the ground truth is used to optimize the de-rained images at each scale and thus such a **multi-task learning strategy** would refine the back propagation across all the scales.
- **Hybrid loss function**: $\mathcal{L} = \lambda_E \mathcal{L}_E + \lambda_P \mathcal{L}_P + \lambda_A \mathcal{L}_A$ data fidelity loss $\mathcal{L}_E$, perceptual content loss $\mathcal{L}_P$ and adversarial loss $\mathcal{L}_A$
- Ablation study on the right proves that **feature integration** across scales and **the top-down image generation strategy** in the multi-scale cascading structure is important in de-raining task.

Data	Rain100		Rain40	
	Single scale	Multi-scale	Single scale	Multi-scale
PSNR	26.1869	**27.4514**	27.1517	**28.4799**
SSIM	0.8502	**0.8676**	0.8365	**0.8502**
UQI	0.6793	**0.6992**	0.6710	**0.6922**

Experiments

Rain100	LP	CNN	RES	JORDER	IDCGAN	DID-MDN	Ours
PSNR	23.6218	23.3917	22.8457	20.4823	24.4715	26.5243	**27.4514**
SSIM	0.7481	0.7719	0.7500	0.6247	0.8133	0.8262	**0.8676**
UQI	0.5562	0.5931	0.5767	0.4994	0.6449	0.6723	**0.6992**
Rain40	**LP**	**CNN**	**RES**	**JORDER**	**IDCGAN**	**DID-MDN**	**Ours**
PSNR	27.3579	24.8458	27.6553	23.4191	23.9327	26.4789	**28.4799**
SSIM	0.7613	0.7692	0.8018	0.7279	0.7932	0.8252	**0.8502**
UQI	0.5785	0.6253	0.6449	0.5590	0.6327	0.6701	**0.6922**

- Our method achieves the **best visual perception** due to full use of multi-scale properties of rain streaks while most of other methods introduce blurriness or distortions to the background and remain more rain regions.