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Robust Test-Time Adaptation for Single Image Denoising Using Deep Gaussian Prior

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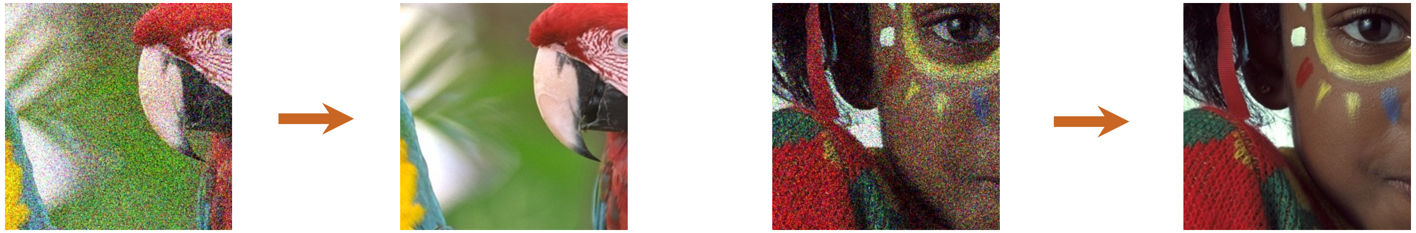
Introduction

Definition

- Single Image denoising aims to recover a clean image from a single noisy observation.



Noisy Denoised Noisy Denoised

Challenges

- **Time consuming.** Existing single image denoising approaches are time consuming.
- **Lack prior knowledge.** Existing single image denoising approaches rely on a single image and lack prior knowledge to guide denoising.

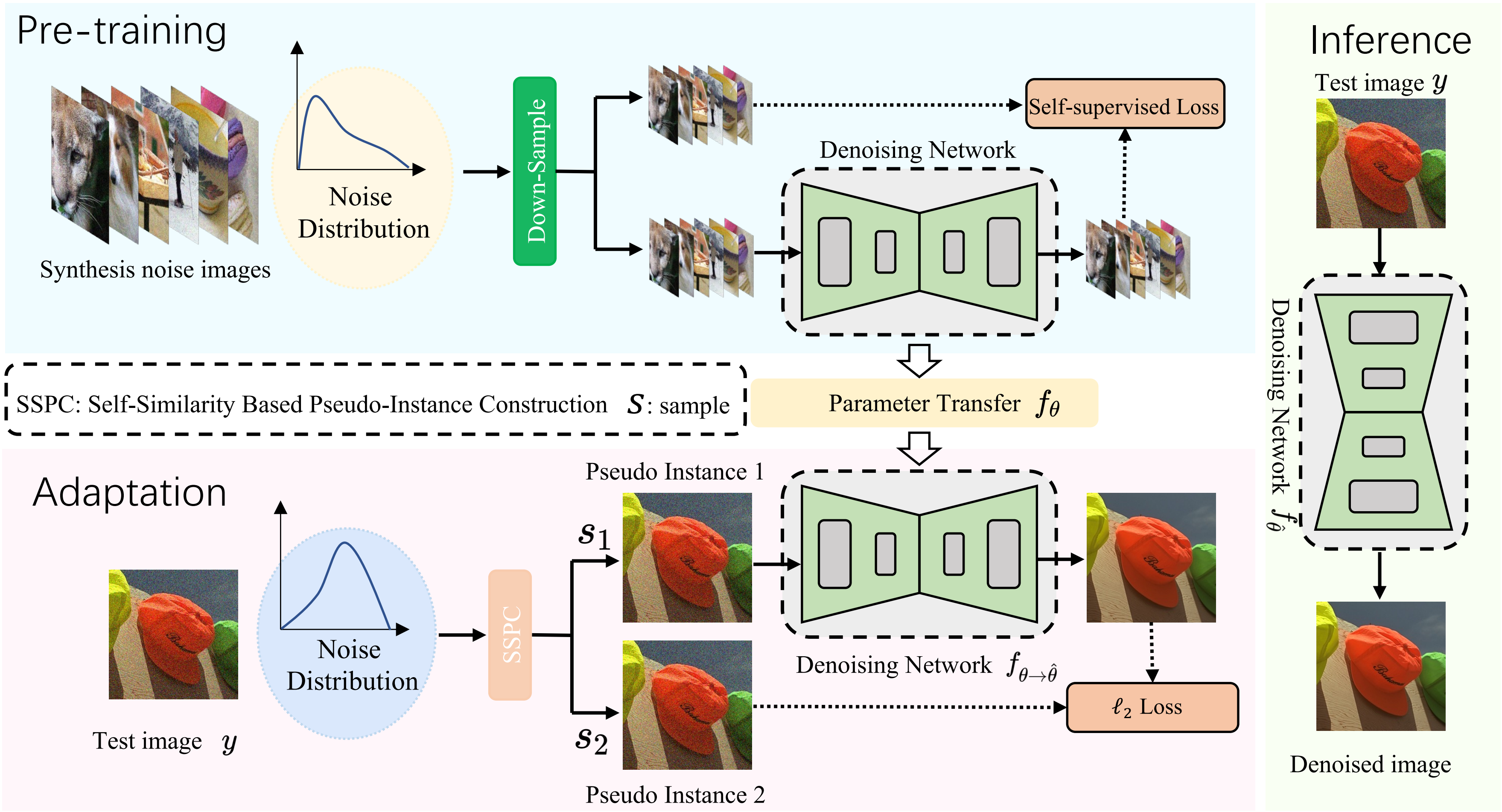
Introduction

Contributions

- We propose a test-time adaptive denoising framework, which adapts the pre-trained denoising model to different target domains during testing.
- We construct a pixel bank based on the self-similarity prior of the test image and sample pseudo-instances from it to perform adaptive fine-tuning of the network.
- We demonstrate that Gaussian denoisers pre-trained on natural images possess a deep denoising prior, which can be quickly adapted through fine-tuning to remove other types of noise.
- The proposed method outperforms existing single-image denoising approaches in terms of both denoising performance and runtime efficiency.

Method

Test-Time Adaptive Denoising framework



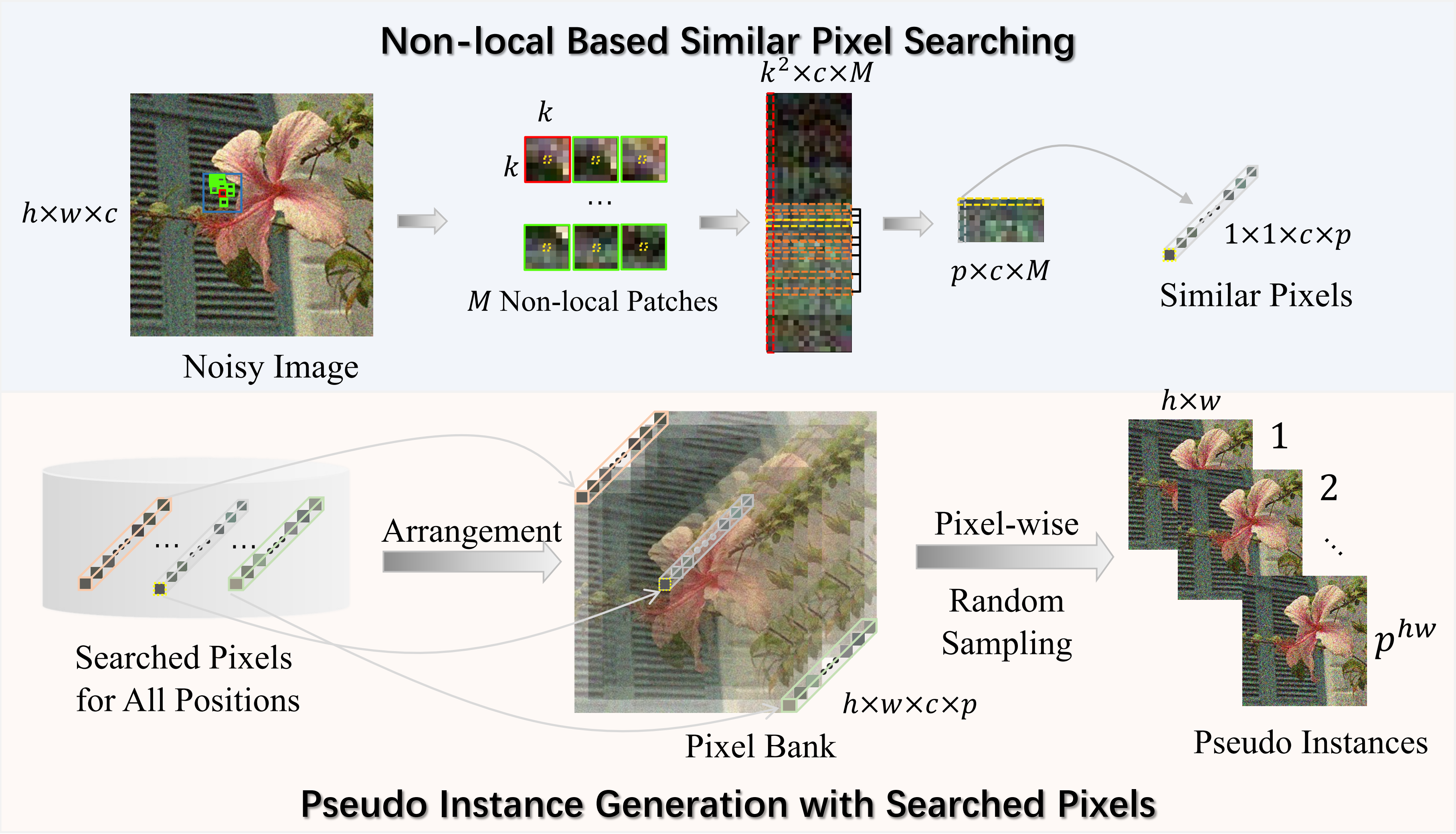
Pre-training: Self-supervised training using synthetic noisy images.

Adaptation: Constructing pseudo-instances from test noisy images to fine-tune the network. Before each iteration, we sample two pseudo instances through the SSPC.

Inference: Inference using the fine-tuned denoising network and the original noisy image.

Method

Self-Similarity Based Pseudo-Instance Construction



Experiments

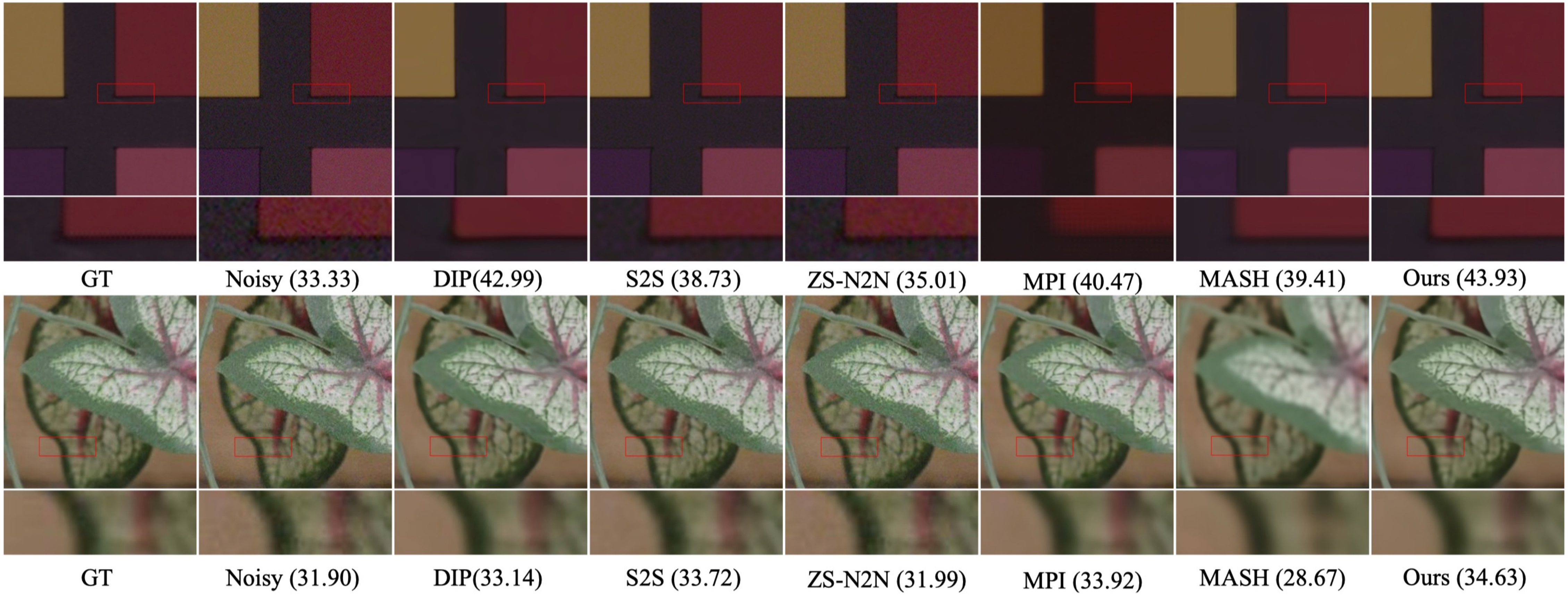
Synthetic Noise

Noise	Method		Kodak24			McMaster18			Kvasir		
Gaussian		σ known?	$\sigma=10$	$\sigma=25$	$\sigma=50$	$\sigma=10$	$\sigma=25$	$\sigma=50$	$\sigma=10$	$\sigma=25$	$\sigma=50$
	DnCNN	yes	36.26	31.53	28.16	36.30	31.85	28.44	37.19	33.11	30.91
	NB2NB	yes	35.81	29.70	28.45	36.06	30.36	28.97	36.98	31.77	31.32
	DnCNN	no	31.88	31.53	17.95	32.47	31.85	18.73	32.61	33.11	17.74
	NB2NB	no	32.66	29.70	20.94	33.19	30.36	21.29	33.69	31.77	21.23
	BM3D	yes	33.74	29.02	25.51	34.51	29.21	24.51	36.13	31.96	28.58
	DIP	no	32.28	27.38	23.95	33.07	27.61	23.03	33.88	29.94	23.82
	S2S	no	29.54	28.39	26.22	30.78	28.71	25.03	36.25	32.52	29.45
	ZS-N2N	no	33.69	29.07	24.81	34.21	28.80	24.02	35.46	31.46	28.05
	MPI	no	**35.52**	30.37	25.05	**35.52**	31.01	25.61	**37.73**	33.00	26.91
	Ours	no	34.75	**30.75**	**27.11**	34.54	**31.20**	**27.77**	37.09	**33.18**	**29.78**
Poisson		λ known?	$\lambda=50$	$\lambda=25$	$\lambda=10$	$\lambda=50$	$\lambda=25$	$\lambda=10$	$\lambda=50$	$\lambda=25$	$\lambda=10$
	DnCNN	yes	31.85	30.13	27.89	32.65	30.97	28.63	33.32	32.07	30.56
	NB2NB	yes	31.87	30.28	28.30	32.87	31.33	29.30	33.48	32.50	31.12
	DnCNN	no	30.86	25.24	17.28	31.49	26.37	18.91	31.80	23.84	16.17
	NB2NB	no	29.62	24.82	19.94	30.42	25.81	20.69	31.01	23.26	18.66
	BM3D	no	28.36	26.58	24.20	27.33	24.77	21.59	28.12	25.34	22.88
	DIP	no	27.51	25.84	23.81	28.73	27.37	24.67	29.21	26.35	25.47
	S2S	no	28.89	28.31	**27.29**	30.11	29.40	**27.71**	32.52	30.50	29.19
	ZS-N2N	no	29.45	27.49	24.92	30.36	28.41	25.75	31.59	30.05	27.90
	MPI	no	30.60	27.98	24.23	31.21	28.78	24.86	32.75	29.64	25.14
	Ours	no	**30.72**	**28.89**	26.64	**31.32**	**29.96**	27.66	**33.21**	**31.38**	**29.25**

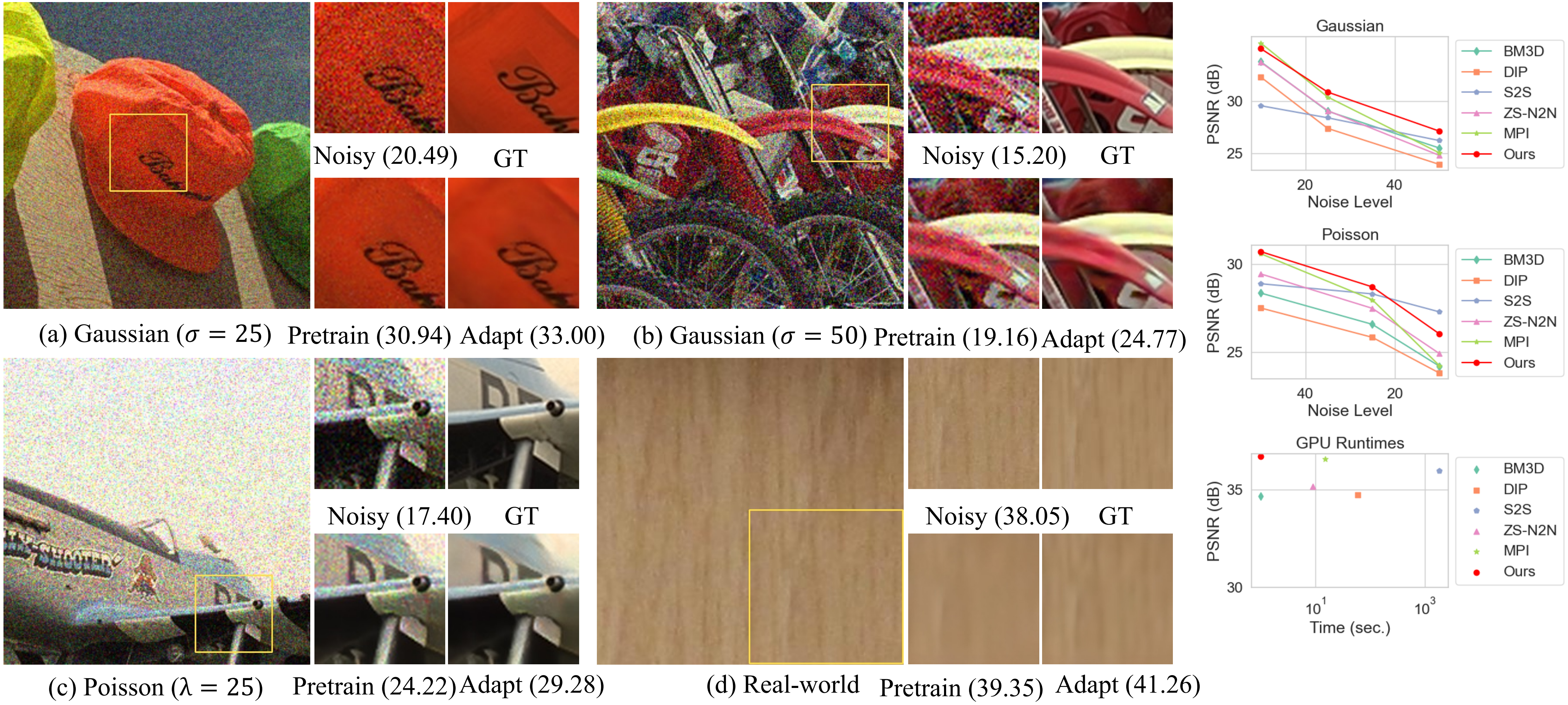
Real Noise

Method	BM3D	DIP	S2S	ZS-N2N	MASH	MPI	Ours
PolyU	34.66	34.75	35.97	35.17	31.97	36.55	**36.71**
SIDD	31.57	32.21	30.18	28.16	35.34	**35.68**	35.49

Experiments



Experiments



Experiments

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Ablation Study

Method	Gaussian			Poisson			Real-world
	σ=10	σ=25	σ=50	λ=50	λ=25	λ=10	
DIP	32.28	27.38	23.95	27.51	25.84	23.81	34.75
S2S	29.54	28.39	26.22	28.89	28.31	**27.29**	35.97
ZS-N2N	33.69	29.07	24.81	29.45	27.49	24.92	35.17
Pre-trained model	32.66	29.70	20.94	29.62	24.82	19.94	36.10
Without pre-train	33.41	29.65	26.63	29.77	28.15	25.59	36.12
Pre-train+Adaptation	**34.63**	**30.75**	**27.11**	**30.51**	**28.89**	26.64	**36.71**

Thanks for your attention!

Any question? Please contact us!

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