

# CtrlISP: Rescuing Low-Light RAW Images via Controllable Neural ISP

## Supplementary Material

### 1. Comparison with Advanced RAW Image Denoising Networks

To further evaluate the superiority of our proposed denoising network, we selected several state-of-the-art image restoration networks: Restormer [5], NAFNet [1], and MambaIRV2 [2], to implement RAW-domain denoising networks for comparison. In the experiments, these networks were configured with their baseline default parameters, with only the DenoiseNet module in our framework being replaced, while all other components and experimental settings remained unchanged. The quantitative evaluation metrics of the experimental results are presented in Table 1. Although the comparative methods possess several times more parameters and computational complexity than our proposed DenoiseNet, they exhibit notable gaps in most evaluation metrics, with the exception of the SSIM.

### 2. Comparison with Other Advanced Methods

In addition to methods in the RAW-domain LLIE field, we also compared our approach with the state-of-the-art controllable neural ISP ParamISP [3] and the diffusion-based LLIE method, ExposureDiffusion [4]. First, regarding ParamISP, due to its lack of effective design for handling RAW-domain noise in low-light scenarios, its denoising performance is poor, as evidenced by the quantitative metrics. Moreover, its controllable parameters are limited to imaging parameters such as aperture, shutter, ISP, and focal length, and it cannot achieve comprehensive style control like our proposed CtrlISP. As for ExposureDiffusion, it also does not demonstrate capabilities significantly different from traditional frameworks. Table 1 presents detailed quantitative evaluation metrics. In summary, our proposed CtrlISP maintains a clear advantage even under broader comparative scenarios.

### 3. Experiences on More Real-world data

To validate the out-of-domain generalization capability of the proposed method, we collected real-world test data using camera equipment different from the training set. Specifically, all real-world scenes were captured with a Sony A7M4 camera, while the model was trained exclusively on the SID dataset comprising images taken by a Sony A7S2. In addition to the results presented in the main text, further visualizations of multiple scenarios are provided in Fig 1. Our method achieves consistently stable performance across diverse scene types, particularly in color reproduction, where ColorNet accurately predicts

color styles consistent with the actual scenes when compared to the ground truth. The overall denoising performance is also excellent. Additionally, Fig 2 demonstrates the effects of controllable and stylized enhancement. Collectively, this experiment sufficiently demonstrates the strong out-of-domain generalization ability of the proposed CtrlISP.

### References

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Figure 1. Visualization results of real-world data.

Model	Params	FLOPs	PSNR $\uparrow$	SSIM $\uparrow$	LPIPS $\downarrow$	$\Delta E\downarrow$
Restormer [5]	26.2M	6526.7G	30.57	0.7930	0.3005	6.1497
NAFNet [1]	29.2M	747.9G	30.84	<b>0.7953</b>	0.3111	5.9097
MambaIR V2 [2]	1.3M	3859.5G	28.37	0.7516	0.3656	7.8897
ParamISP [3]	0.71M	1257.1G	28.42	0.7447	0.3136	7.7025
ExposureDiffusion [4]	7.7M	2565.0G	30.66	0.7893	0.3725	5.9583
Ours	2.3M	301.3G	<b>31.02</b>	0.7926	<b>0.3002</b>	<b>5.7499</b>

Table 1. Quantitative results of comparative experiments.



Figure 2. Visualization results of controllability and stylization.