Flare7K: A Phenomenological Nighttime Flare Removal Dataset

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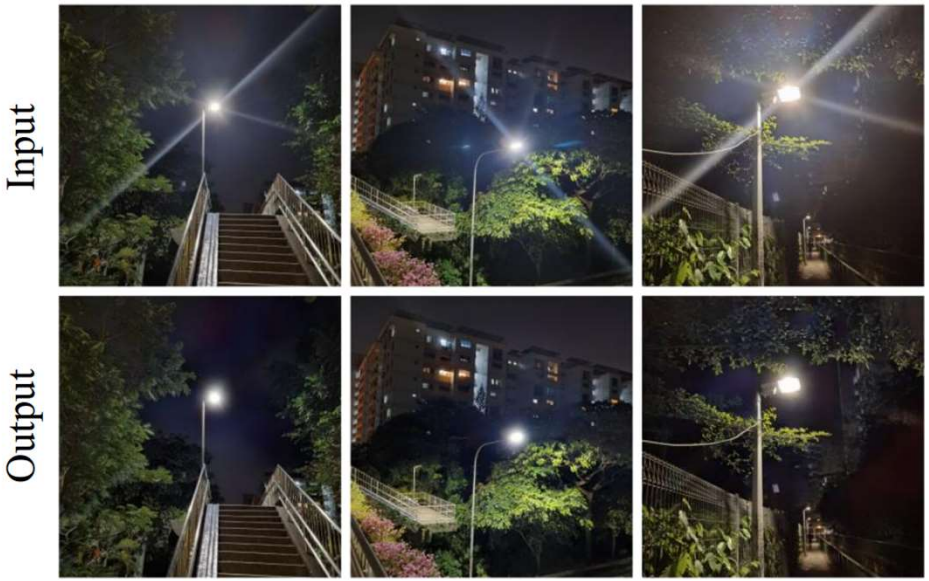
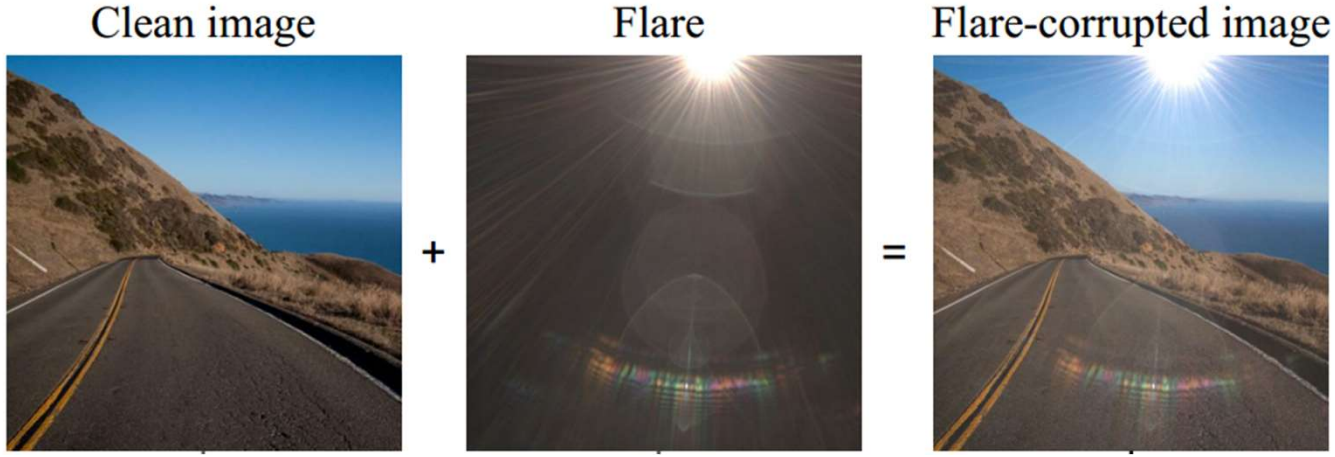
Nighttime Flare Removal

Lens flare is an optical phenomenon in which intense light is scattered and/or reflected in an optical system. It leaves a radial-shaped bright area and light spots on the captured photo. The effects of flares are more severe in the nighttime environment due to the existence of multiple artificial lights. This phenomenon may lead to low contrast and suppressed details around the light sources, degrading the image's visual quality and the performance of vision algorithms.



Nighttime Flare Removal

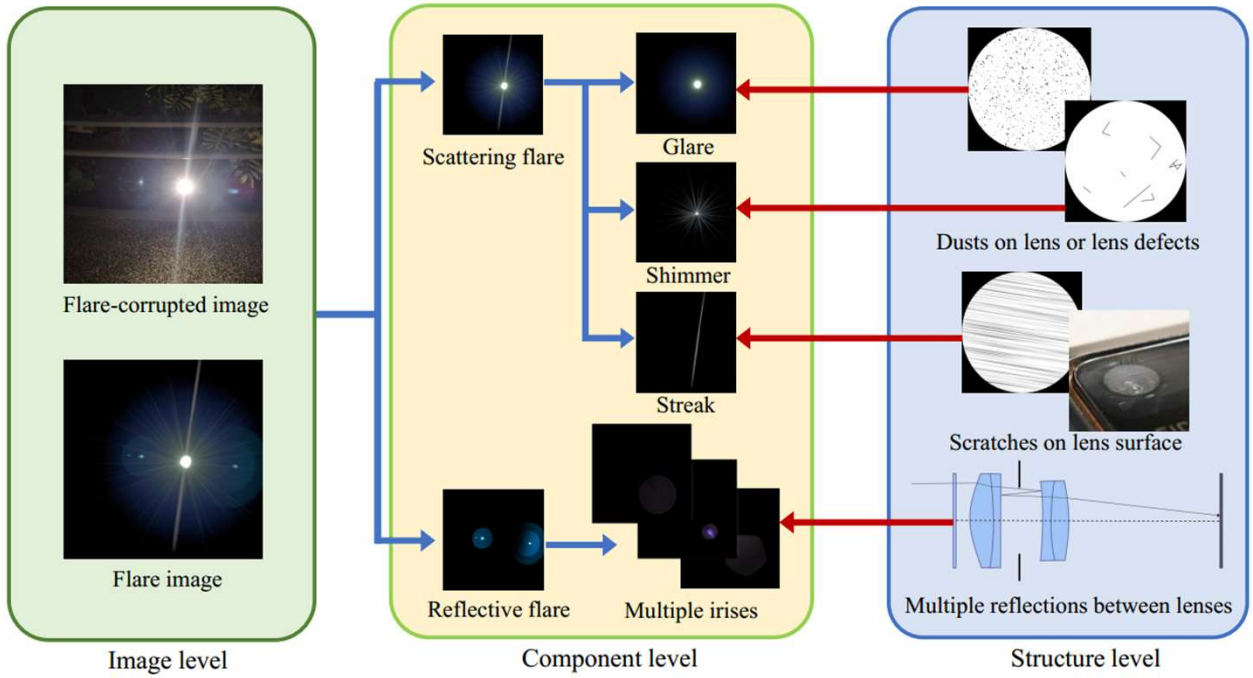
Large-scale data is indispensable for training deep models. However, it is difficult to obtain paired nighttime flare-corrupted/flare-free data in the same location and under the same lighting conditions. The scarcity of paired nighttime flare-corrupted/flare-free data limits the development of deep learning-based nighttime flare removal.



Contributions

- We construct the first large-scale **Flare7K dataset**, providing a valuable benchmark to facilitate the research on this challenging nighttime flare removal task.
- Our dataset offers **rich annotations**, catalyzing new research not only in nighttime flare removal, but also in flare component segmentation, light source extraction, and reflective flare detection.
- Extensive experiments demonstrate that our nighttime flare dataset can help **solve the nighttime flare removal problem** better than existing methods and datasets.

Flare Types

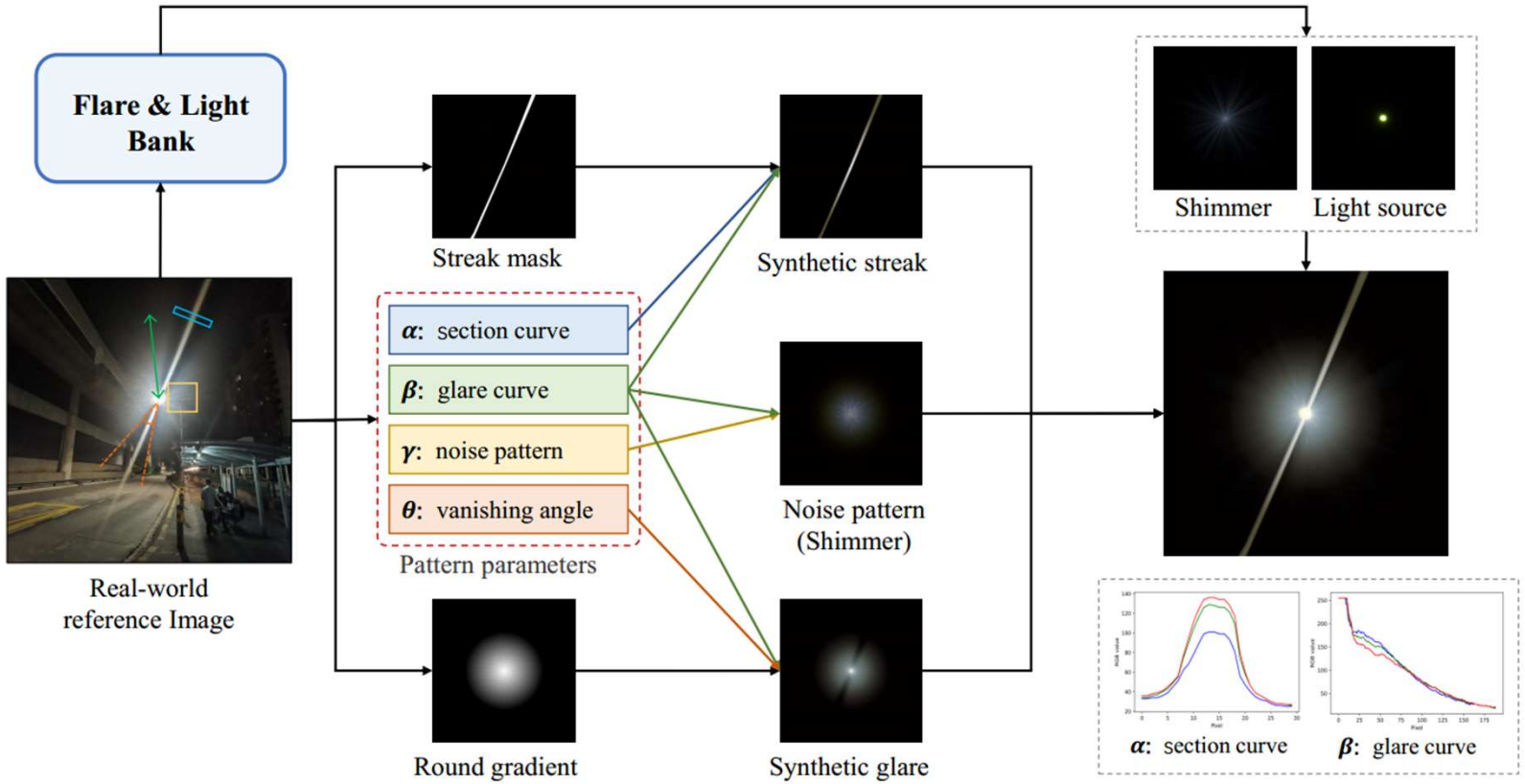


Scattering flares are caused by dust and scratches on the lens. This type of flare will produce radial line patterns. When moving the lens or the light source, the scattering will always wrap around the light.

Reflective flares are caused by multiple reflections between air-glass interfaces in a lens system. Their patterns are determined by the shape of the aperture and lens structure. Such patterns often manifest as a series of circles and polygons on the captured photo. When moving the camera, reflective flares will move in the direction opposite to the light source.

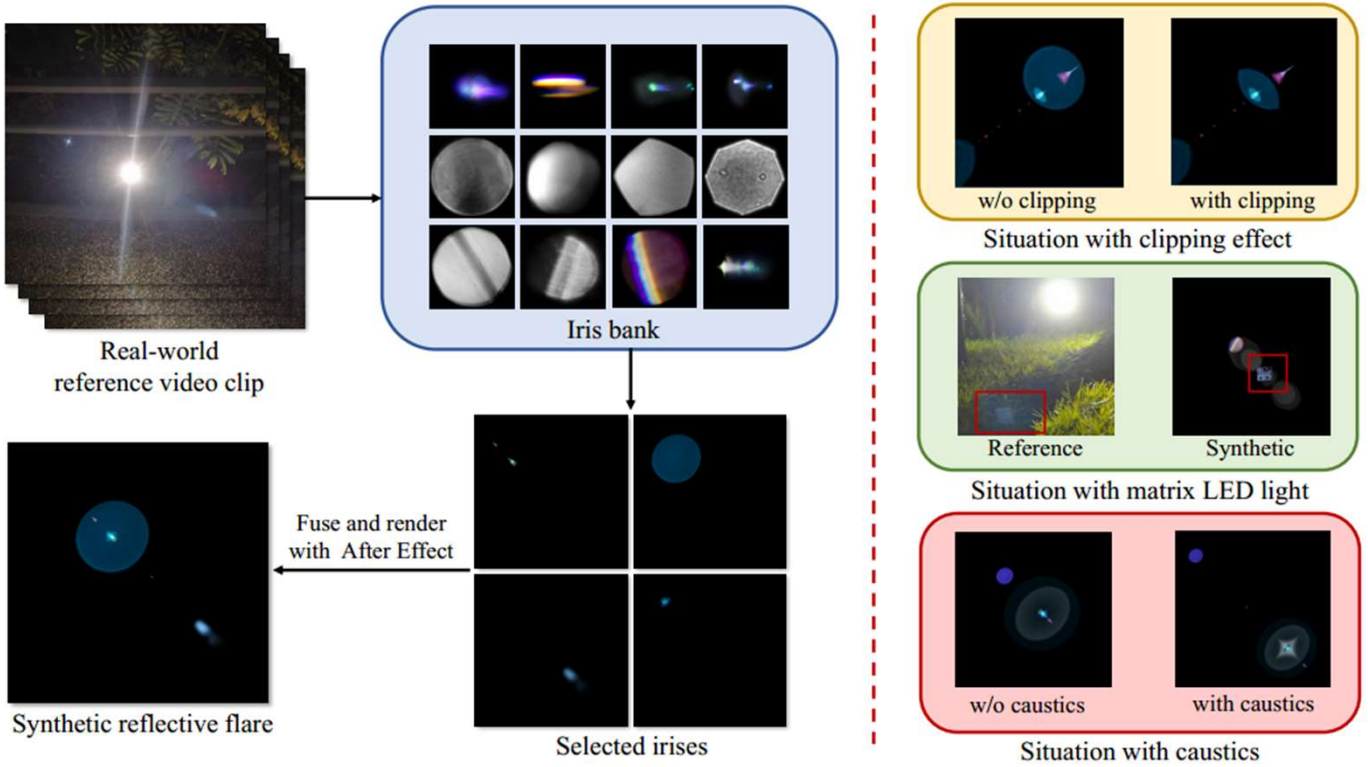
Flare7K Dataset

Scattering flare



Flare7K Dataset

Reflective flares

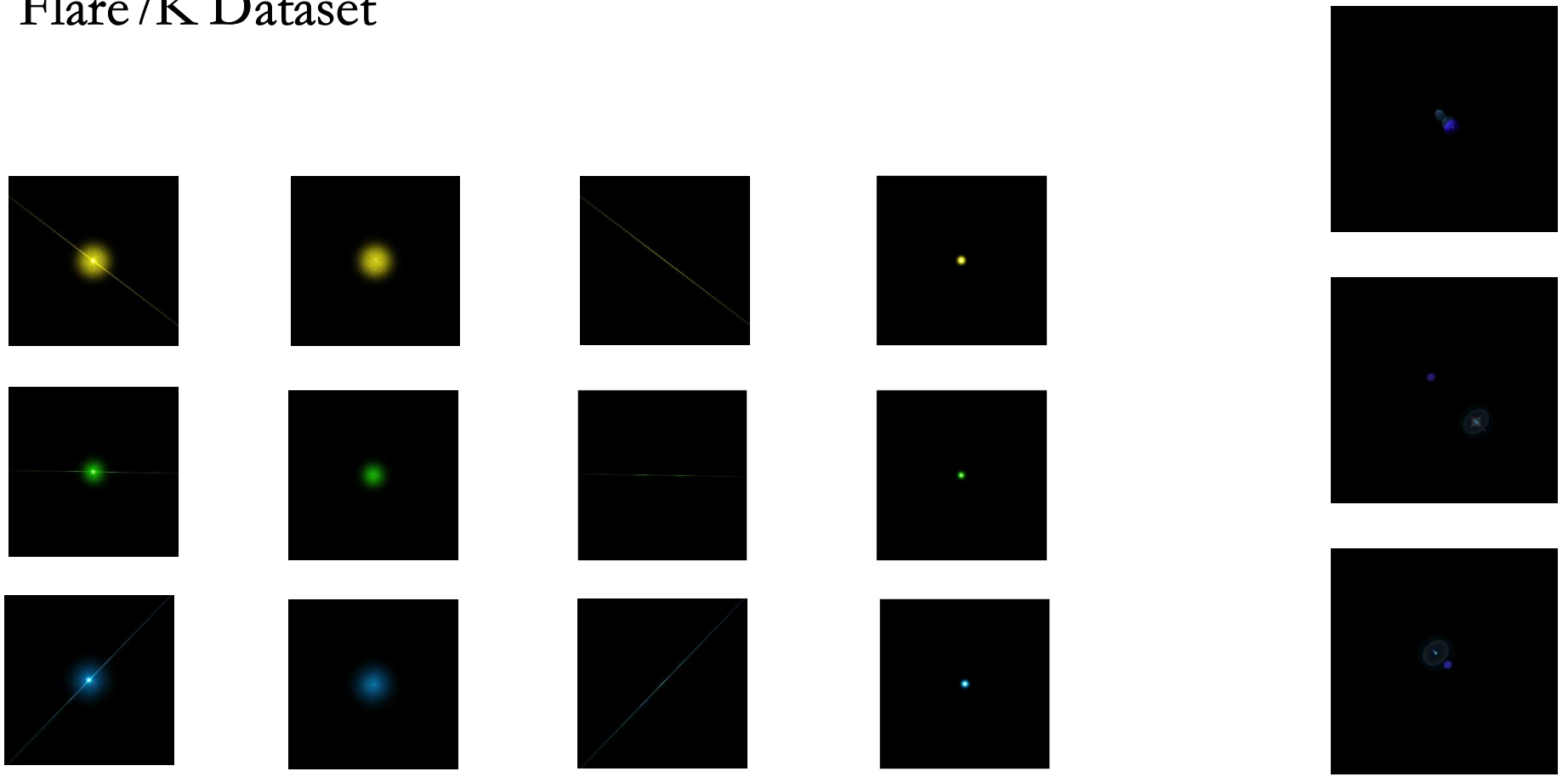


Flare7K Dataset

Flare7K offers 5,000 scattering and 2,000 reflective flare images, consisting of 25 types of scattering flares and 10 types of reflective flares. All flare patterns in our dataset are synthesized based on the observation and statistics of real-world night flares. Since scattering and reflective flare are independent, we generate the respective flare data separately. Thus, different reflective flares can be added to any scattering flare to achieve richer diversity. The 7,000 flare patterns can be randomly added to flare-free images, forming the flare-corrupted and flare-free image pairs that can be used for training deep models.

Besides, each scattering flare image in our dataset can be divided into three parts: light source, streak, and glare. The separation of flare components makes our dataset more interpretable and manipulatable than previous flare datasets.

Flare7K Dataset



Flare | Glare and Shimmer | Streak | Light Source

Scattering Flare

Reflective Flare

Flare7K Dataset

Test Dataset

Synthetic test data collection. We synthesize nighttime flare data using our proposed pipeline, collect 100 pairs of data for the test.

Real test data collection. For most well-designed lenses, the flares of a nighttime scene are caused by the stains on the lens's surface. To reproduce these flares, we use fingers and a cloth to wipe the front lens of the camera to mimic common stains. After that, we use lens tissue to clean the front lens slightly to obtain flare-free images. Finally, we obtain 100 pairs of real-world flare-corrupted/flare-free images as our real-world test dataset.

Synthetic test data

Real test data

Experiments

Qualitative comparison.

(a) Real input (b) Zhang [32] (c) Sharma [21] (d) Wu [27] (e) Ours (f) GT

Experiments

Quantitative comparison.

Data\Method		Input	Previous work			Network trained on our dataset				
			Zhang [32]	Sharma [21]	Wu [27]	U-Net [18]	HINet [3]	MPRNet* [30]	Restormer* [29]	Uformer [25]
Real-world	PSNR↑	22.56	21.02	20.49	24.61	26.11	26.74	26.14	26.28	**26.98**
	SSIM↑	0.857	0.784	0.826	0.871	0.879	0.882	0.878	0.883	**0.890**
	LPIPS↓	0.078	0.174	0.112	0.060	0.055	0.048	0.050	0.054	**0.047**
Synthetic	PSNR↑	22.77	21.04	20.01	27.88	29.07	29.97	29.87	29.45	**30.47**
	SSIM↑	0.921	0.841	0.865	0.952	0.958	0.959	0.959	0.950	**0.965**
	LPIPS↓	0.060	0.136	0.111	0.031	0.022	0.021	0.020	0.025	**0.017**