PBFG: A New Physically-Based Dataset and Removal of Lens Flares and Glares

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Contribution

Motivation

Flare and glare degrade night-time visibility and vision tasks, while existing datasets lack realism and diversity, limiting effective removal.

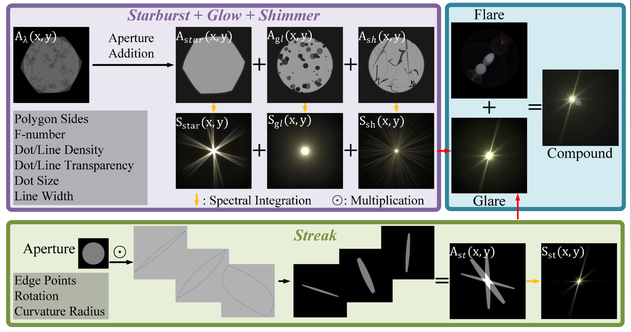
Contributions

- A high-quality physically-based dataset with diverse and realistic flares and glares.
- A spatial-frequency enhanced network that achieves robust and superior flare and glare removal on real-world images.

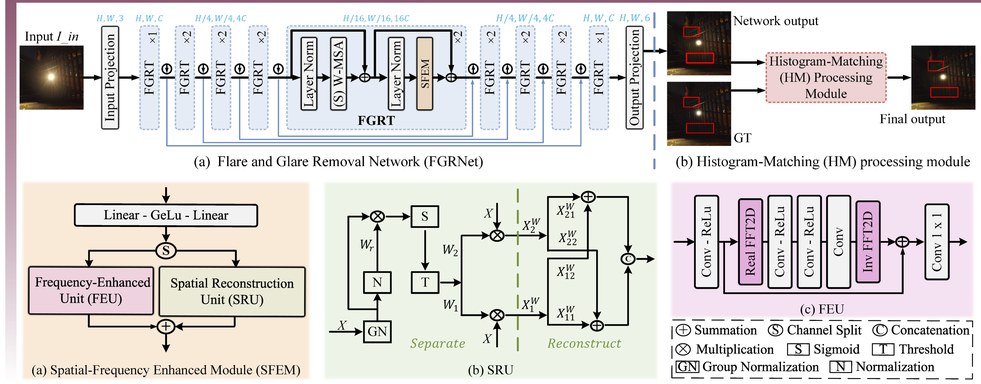
Introduction of the PBFG

- Physically realistic flare and glare synthesis via rendering.
- 2,600 flares and 4,000 glares across 120+168 diverse patterns.
- Accurate diffraction streak reproduction.

Computational rendering scheme of PBFG



Lens Flare and Glare Removal Framework



(a) Flare and Glare Removal Network (FGRNet)
(b) Histogram-Matching (HM) processing module
(a) Spatial-Frequency Enhanced Module (SFEM)
(b) SRU
(c) FEU

Experiments and Results

Statistics

Dataset	Statistics			Annotations					
	Syn	Real	Type (f+g)	Flare	Light Src	Streak	Glow	Shimmer	Starburst
Wu et al.	3,000	2,001	2 + 1	×	×	×	×	×	×
Flare7K	7,000	0	25 + 10	✓	✓	✓	✓	✓	×
Flare-R	0	962	-	×	✓	×	×	×	×
FlareReal600	0	500	-	×	✓	×	×	×	×
Lan et al.	0	3,275	-	×	×	×	×	×	×
PBFG (Ours)	6,600	0	120 + 168	✓	✓	✓	✓	✓	✓
PBStar (Ours)	1,000	0	0 + 42	×	×	×	×	×	✓

Best real-world flare and glare removal with PBFG

PBFG enables the most realistic and effective flare and glare removal, with models trained on it outperforming all other datasets on real-world images.

Quantitative evaluation on real-world nighttime images

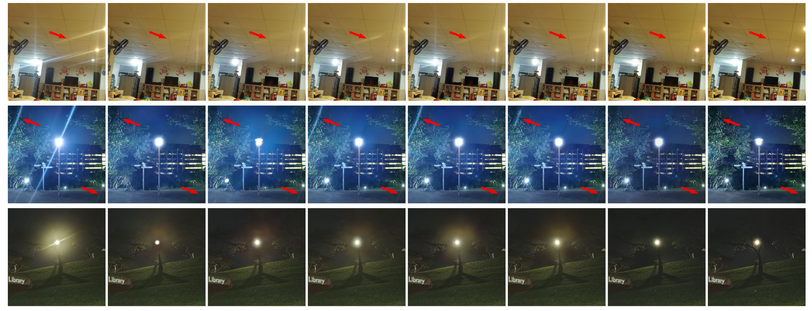
Methods	Training Dataset: Flare7K					Training Dataset: Flare7K++					Training Dataset: PBFG (Ours)				
	PSNR↑	SSIM↑	LPIPS↓	G-PSNR↑	S-PSNR↑	PSNR↑	SSIM↑	LPIPS↓	G-PSNR↑	S-PSNR↑	PSNR↑	SSIM↑	LPIPS↓	G-PSNR↑	S-PSNR↑
Wu et al.	23.539	0.864	0.0742	20.019	15.448	24.124	0.869	0.0556	21.967	16.762	25.601	0.877	0.0518	23.485	18.213
Flare7K	26.321	0.885	0.0519	23.245	21.069	27.052	0.887	0.0461	23.498	21.848	27.630	0.890	0.0452	23.956	22.872
Zhou et al.	25.013	0.851	0.0564	21.183	20.312	25.902	0.876	0.0501	22.982	20.939	26.494	0.884	0.0471	23.539	21.514
FF-Former	26.810	0.896	0.0511	23.443	22.170	27.618	0.896	0.0455	23.629	22.917	27.975	0.898	0.0447	24.290	23.374
Qu et al.	27.491	0.894	0.0506	23.841	23.014	27.583	0.896	0.0459	23.701	23.039	28.018	0.897	0.0451	24.530	23.182
Flare7K++	27.010	0.886	0.0502	23.289	21.474	27.316	0.889	0.0453	23.543	22.181	27.920	0.896	0.0455	24.330	23.115
Zou et al.	27.232	0.891	0.0500	23.767	22.349	27.479	0.894	0.0450	23.776	22.472	27.992	0.897	0.0448	24.361	23.392
Flare-Free Vision	27.109	0.890	0.0503	23.278	21.931	27.407	0.892	0.0452	23.687	22.391	28.020	0.897	0.0446	24.372	23.448
Sparse-UFormer	27.574	0.894	0.0498	23.884	22.082	27.774	0.897	0.0449	24.003	23.215	28.075	0.898	0.0448	24.407	23.613
FGRNet (Ours)	**28.228**	**0.896**	**0.0457**	**24.653**	**23.387**	**28.318**	**0.898**	**0.0433**	**24.830**	**23.582**	**28.659**	**0.898**	**0.0426**	**25.444**	**24.385**
FGRNet + HM (Ours)	**29.330**	**0.919**	**0.0448**	**26.800**	**23.919**	**29.858**	**0.926**	**0.0423**	**26.987**	**24.654**	**30.366**	**0.927**	**0.0403**	**27.549**	**25.706**

Ablation Study

FEU enhances global frequency but may lose subtle lights, while SRU preserves lights but misses weak streaks; combining FEU+SRU balances both, enabling robust flare/glare removal with detail preservation.

Training Dataset	Model	PSNR (dB)↑	SSIM↑	LPIPS↓	G-PSNR↑	S-PSNR↑
Flare7K	Uformer	27.711	0.897	0.0532	25.189	21.774
	Uformer + SRU	28.570	0.912	0.0516	25.738	21.871
	Uformer + FEU	29.010	0.913	0.0503	26.106	23.141
	FGRNet (Ours)	**29.330**	**0.919**	**0.0448**	**26.800**	**23.919**
Flare7K++	Uformer	28.619	0.898	0.0453	25.279	22.417
	Uformer + SRU	29.035	0.919	0.0436	26.282	22.634
	Uformer + FEU	29.466	0.924	0.0426	26.317	23.739
	FGRNet (Ours)	**29.858**	**0.926**	**0.0423**	**26.987**	**24.654**
PBFG (Ours)	Uformer	29.124	0.902	0.0448	25.444	23.313
	Uformer + SRU	29.508	0.921	0.0443	26.837	23.362
	Uformer + FEU	29.932	0.925	0.0422	26.872	24.648
	FGRNet (Ours)	**30.366**	**0.927**	**0.0403**	**27.549**	**25.706**

Visual comparison of flare and glare removal on real images



Generalization on real-world flare/glare removal