Unsupervised Night Image Enhancement: When Layer Decomposition Meets Light-Effects Suppression

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Problem & Motivation & Challenge

Night Image Problems

- Low Light:

- Light-Effects/Glare/Floodlight:

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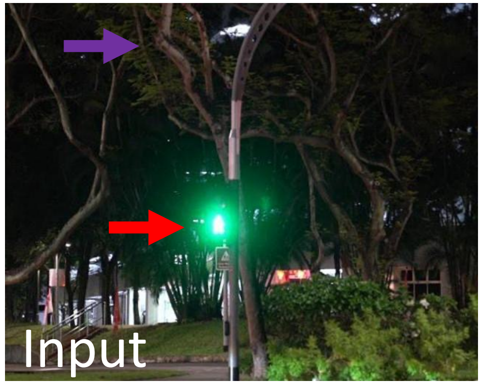
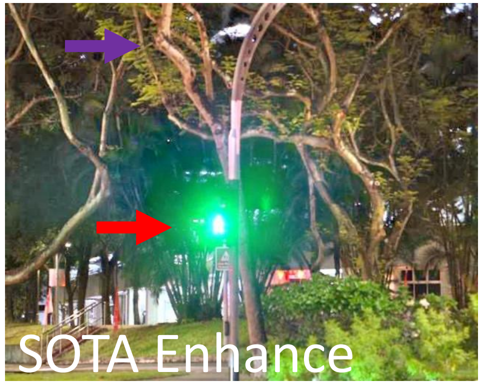
Motivation

- Existing low-light enhancement methods:



✓ Enhance low-light

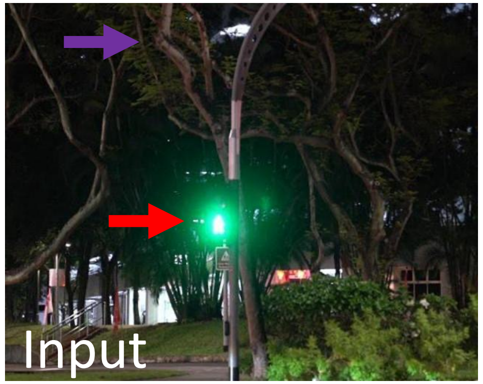
× Over-enhance light-effects



Low-light

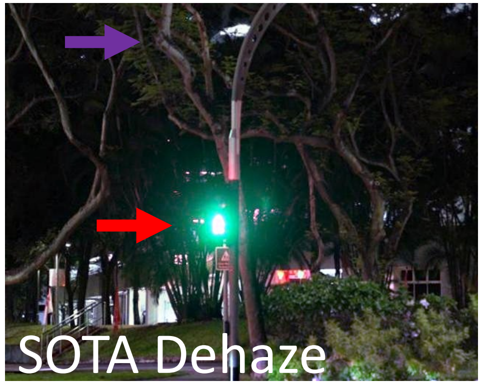
Light-effects

- Existing night dehazing methods:



× Enhance low-light

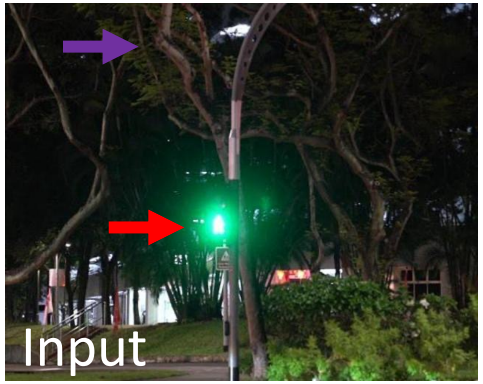
× Suppress light-effects



Main task: ✓ Boost low-light, at the same time, ✓ suppress light-effects.

Challenge

- Our:

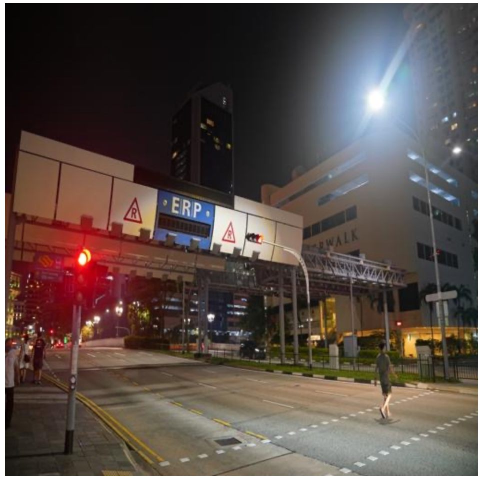


✓ Enhance low-light

✓ Suppress light-effects

Low-light

Light-effects



Challenge:

- Lack of **paired** training data
- Rendering is challenging

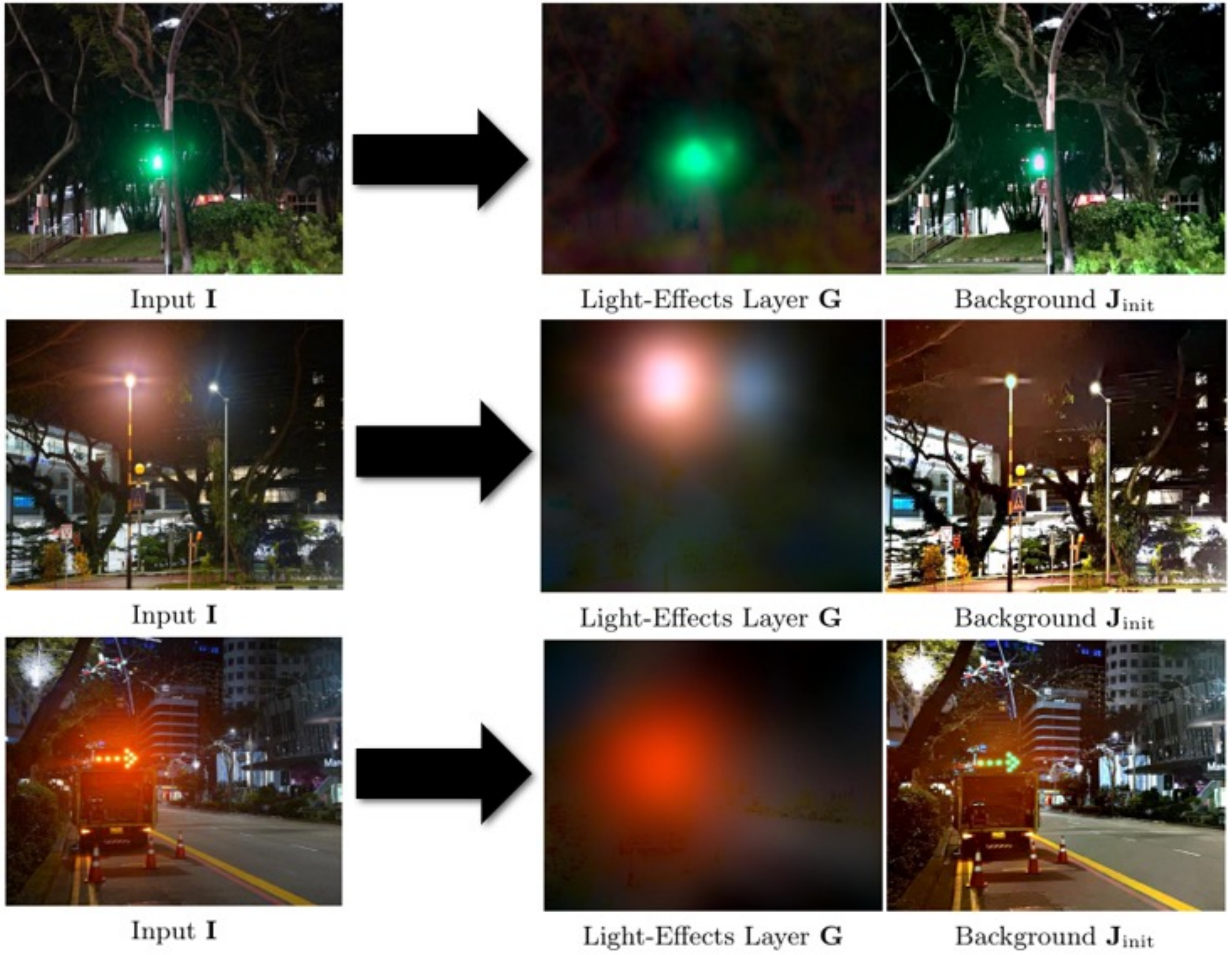
Key Ideas:

- **Unpaired** training data
- Layer Decomposition

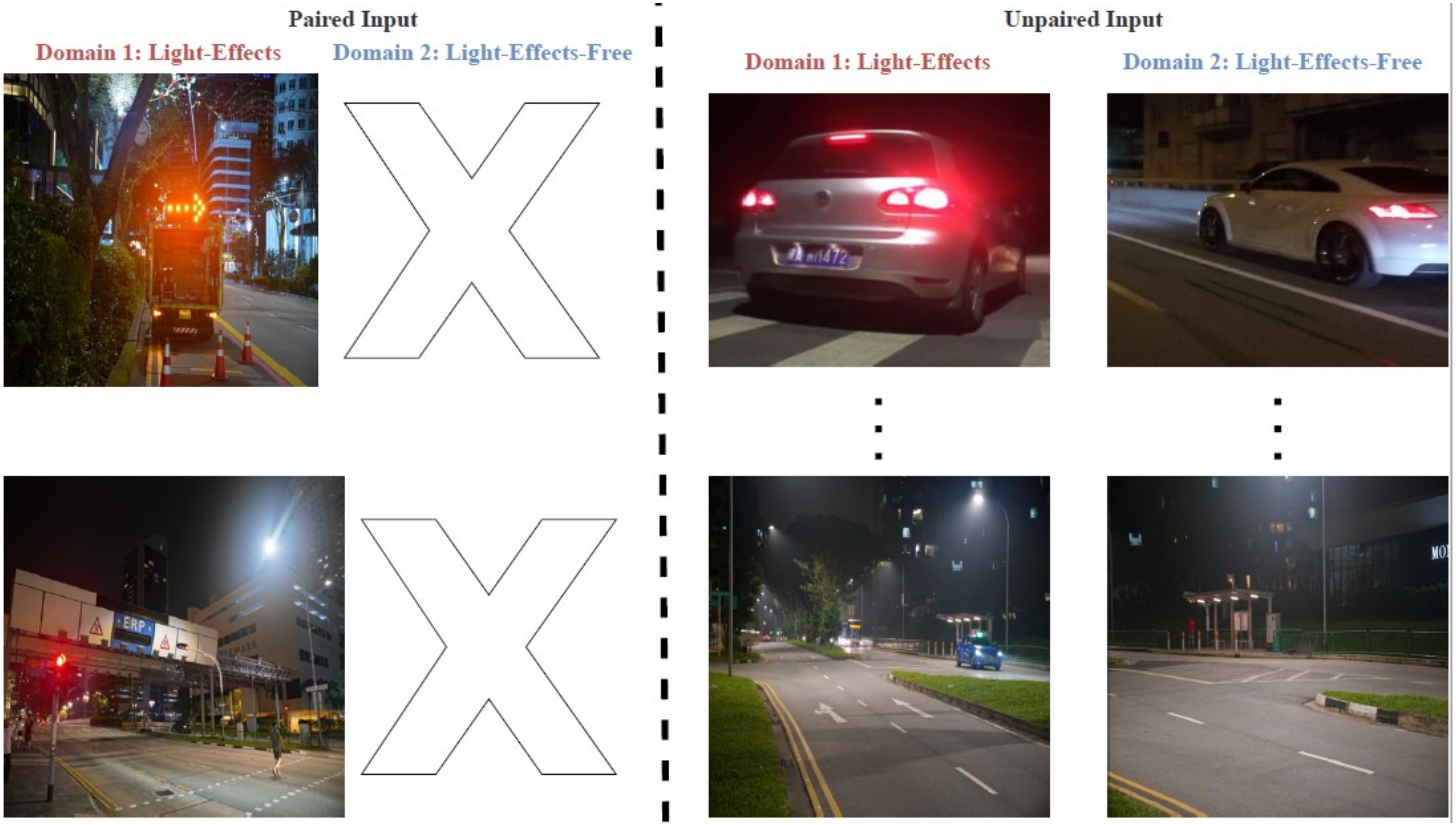
Main task: ✓ Boost low-light, at the same time, ✓ suppress light-effects.

Key Ideas & Contributions

Idea 1: Layer Decomposition

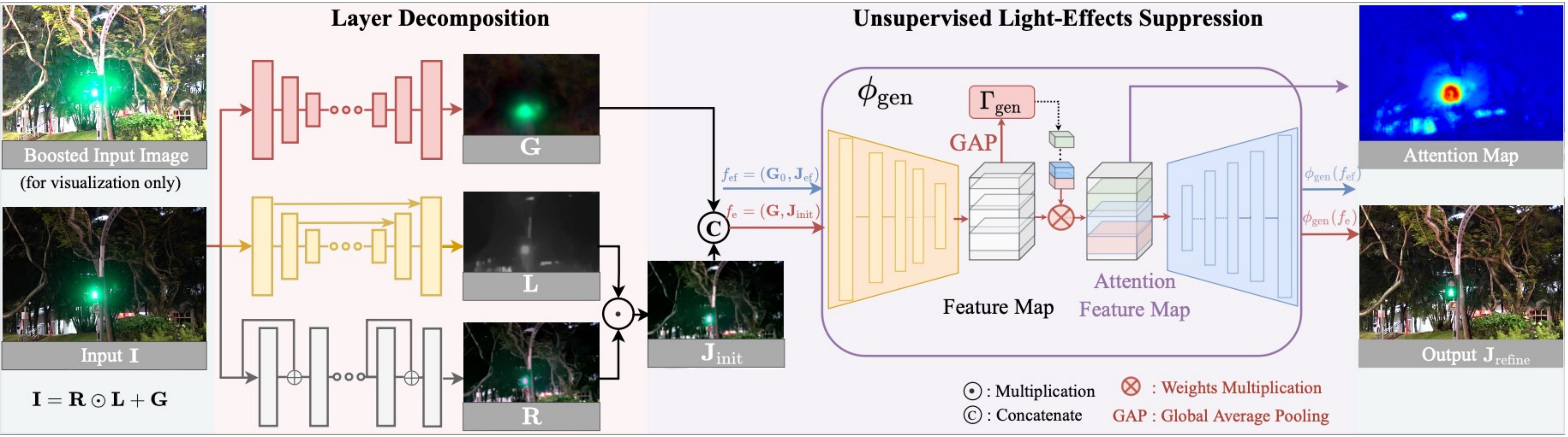


Idea 2: Unpaired Suppression

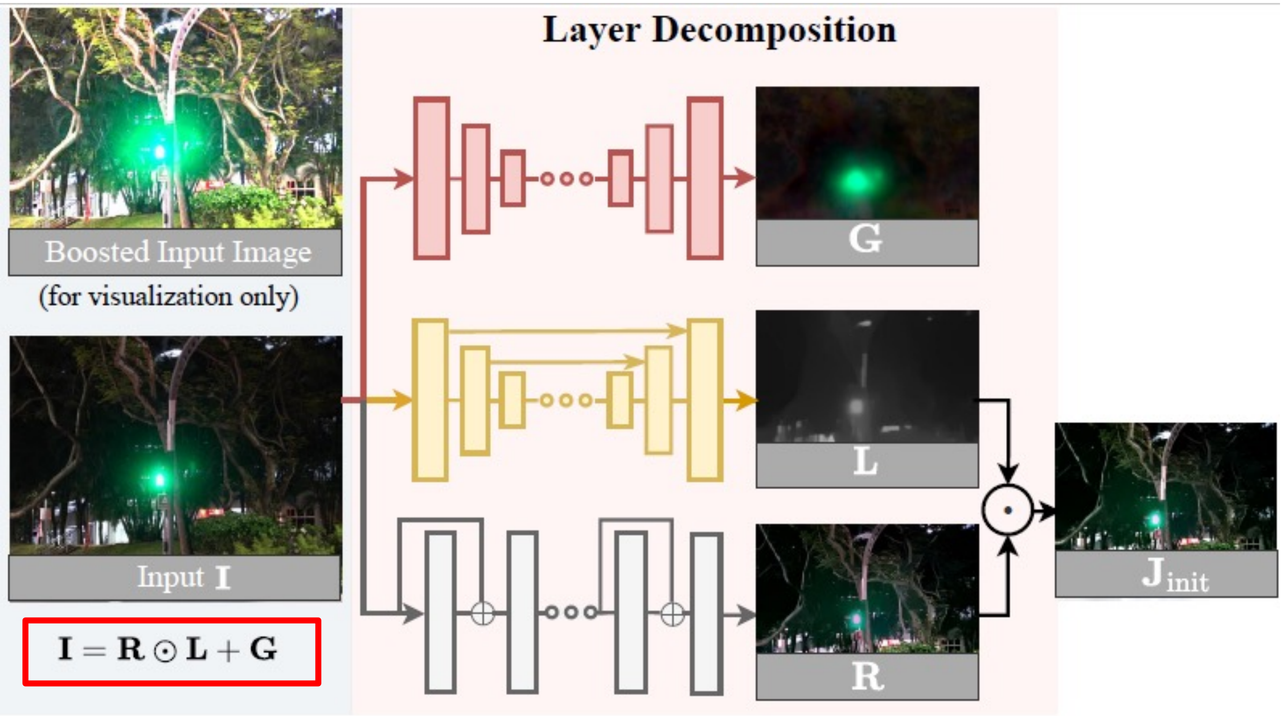


Framework & Losses

Framework: Overview



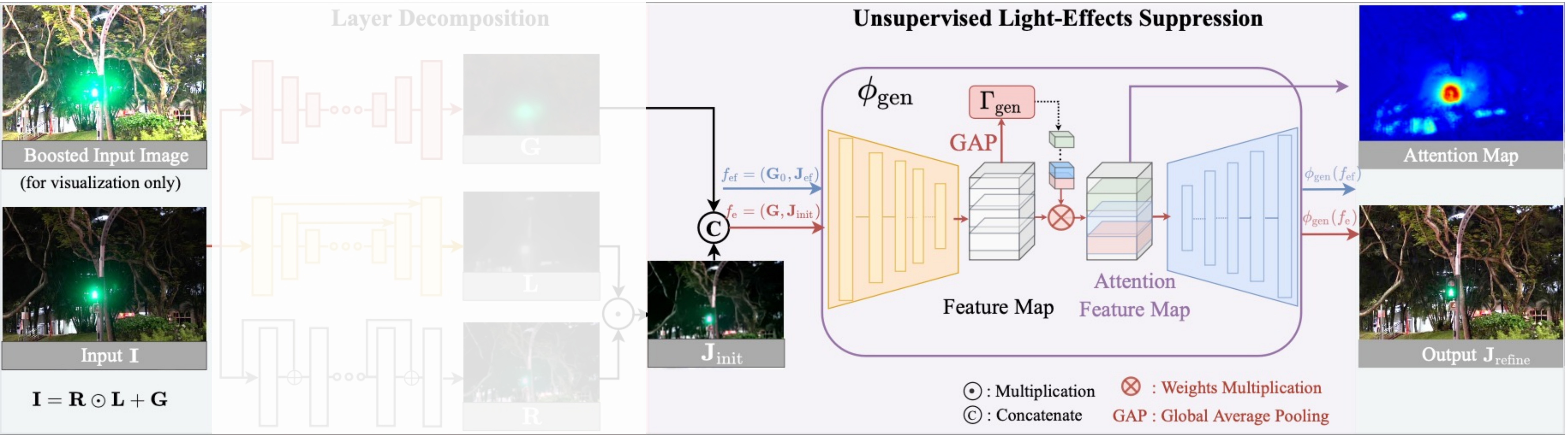
Framework: Layer Decomposition (1/3)



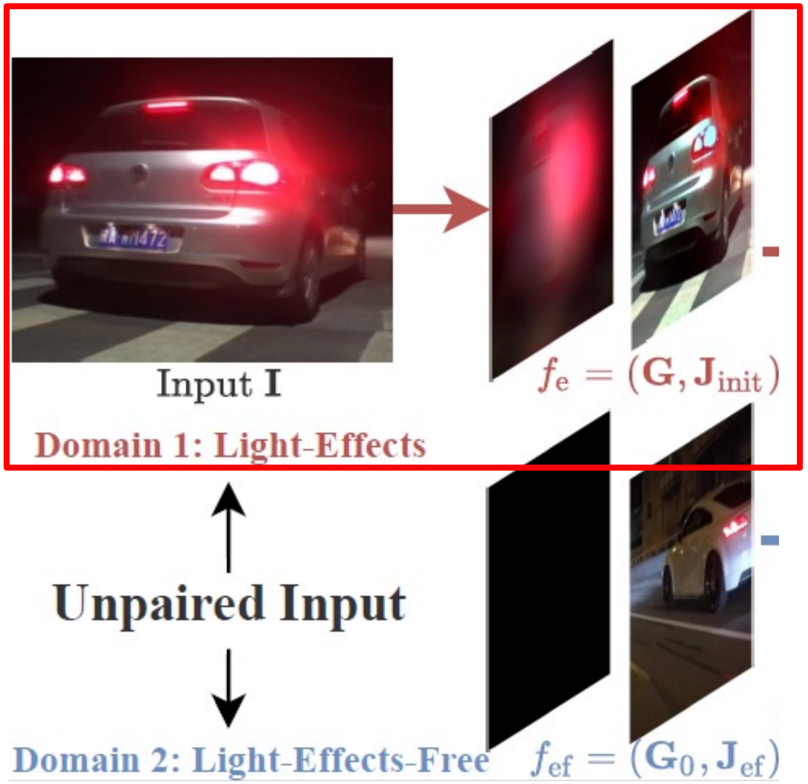
(a) Input (b) Light-Effects Layer **G** (c) Gradient Histogram of **G**

(a) Input **I** (b) **G** (c) **L** (d) **R**

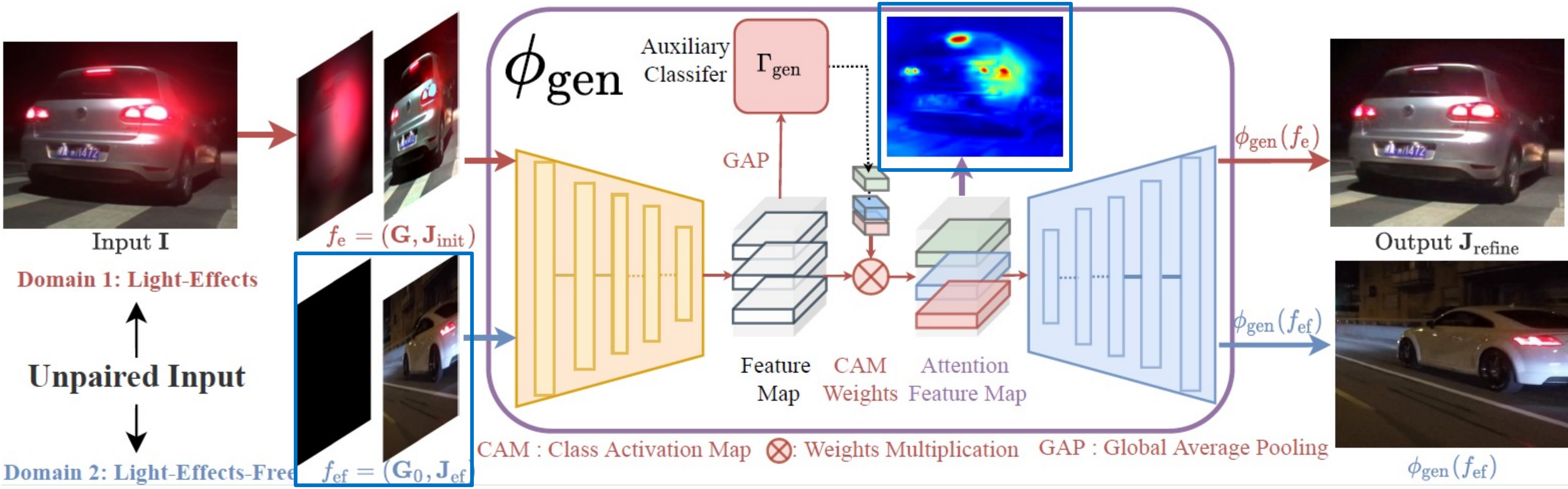
Framework: Overview (2/3)



Framework: Light-effects Suppression

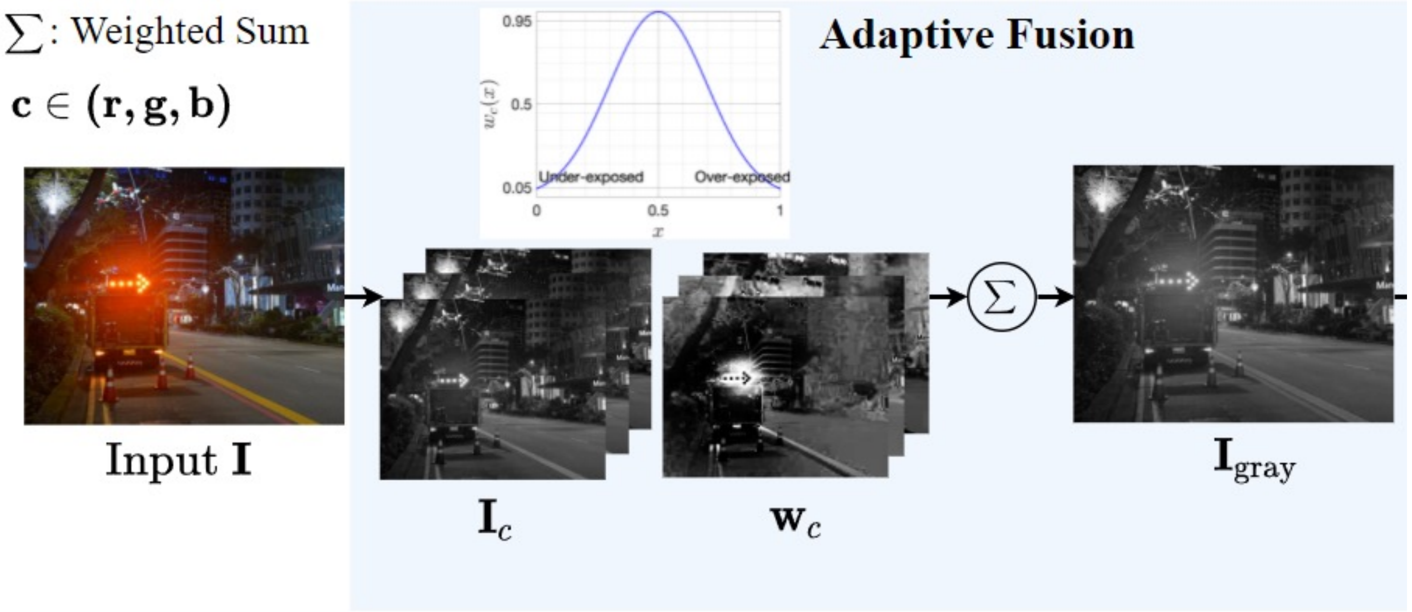


Framework: Light-effects Suppression

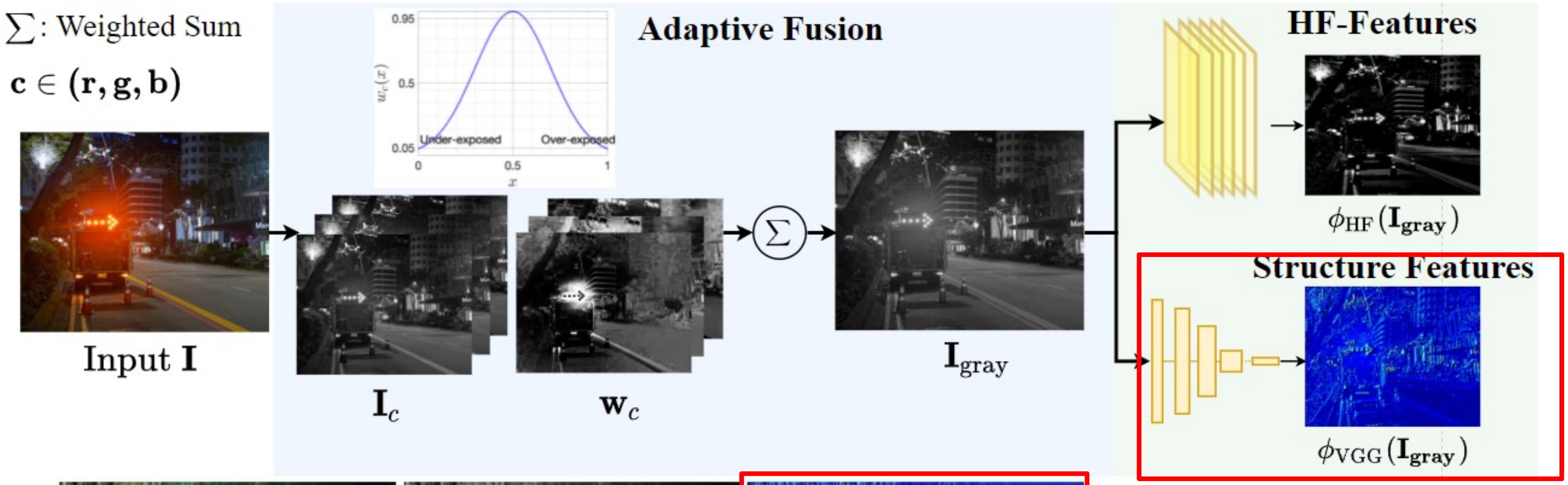


Motivation

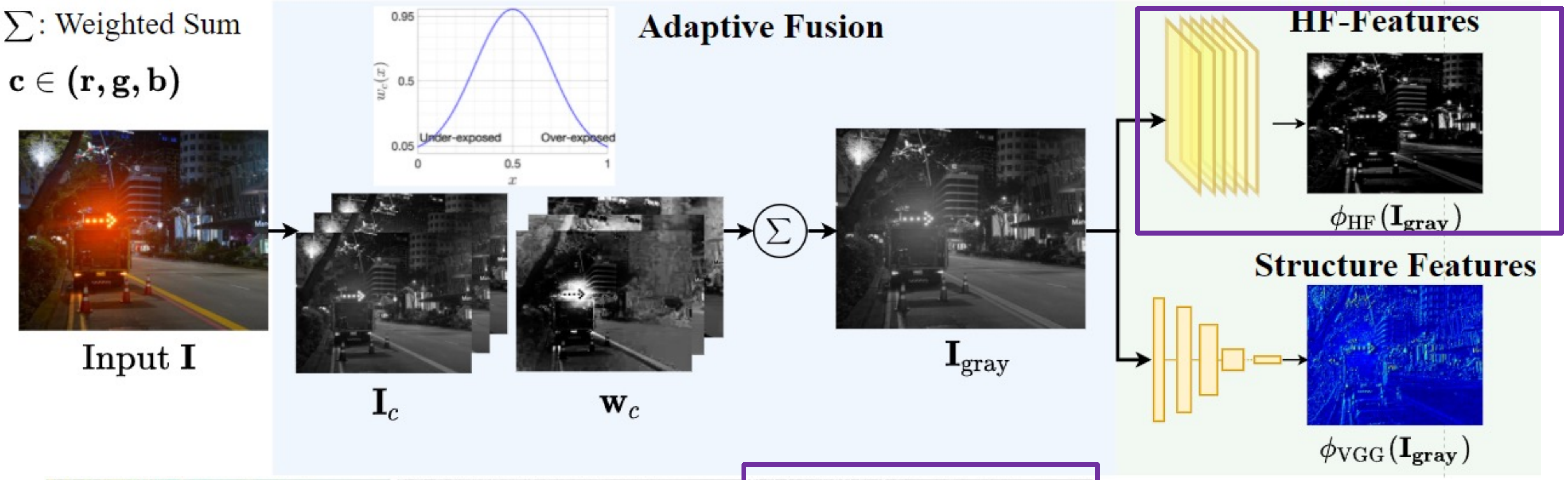
Structure and HF-features Losses (3/3)



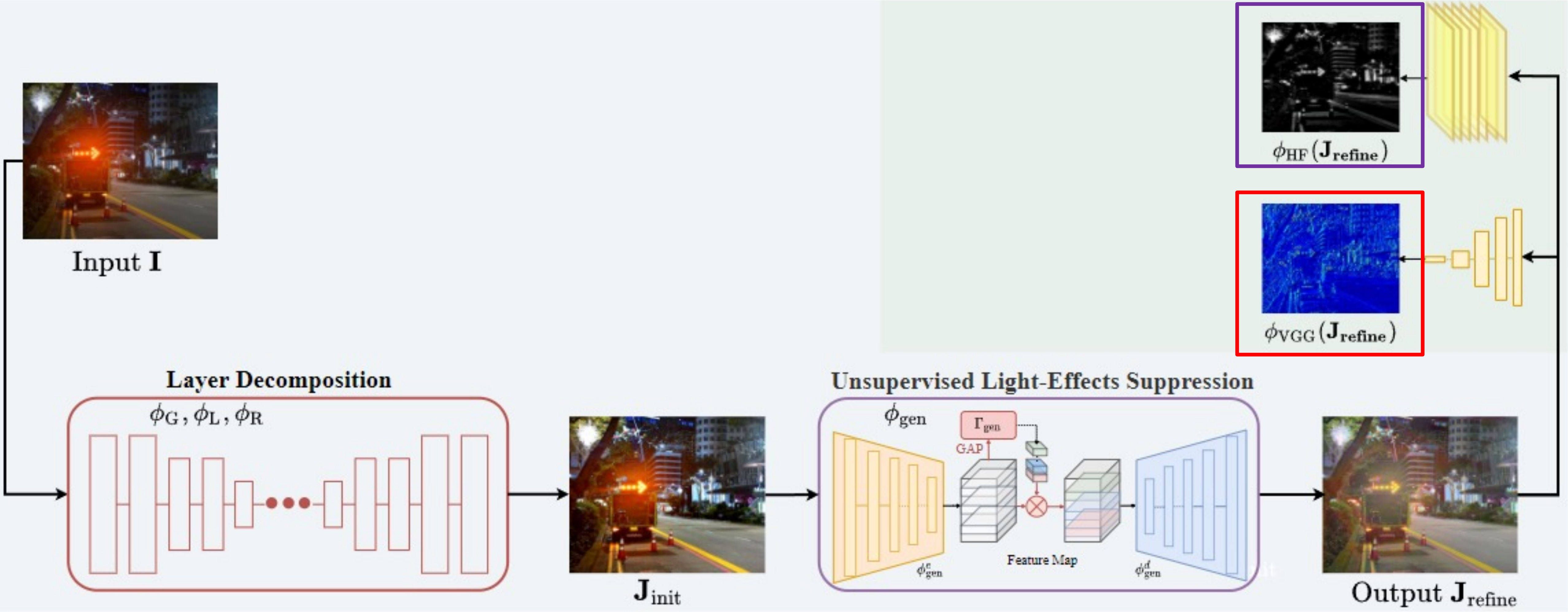
Structure and HF-features Losses



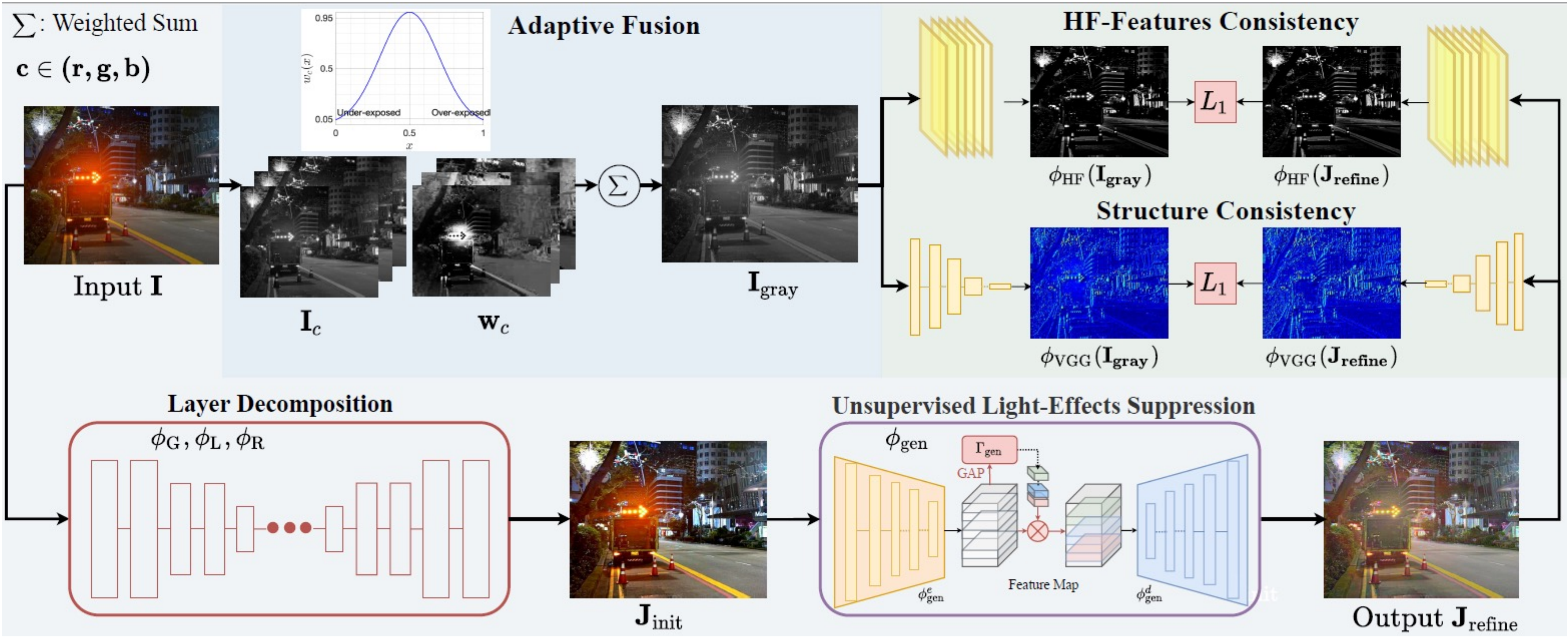
Structure and HF-features Losses



Structure and HF-features Losses



Structure and HF-features Losses



Results & Conclusion

Results: Light-Effects Suppression

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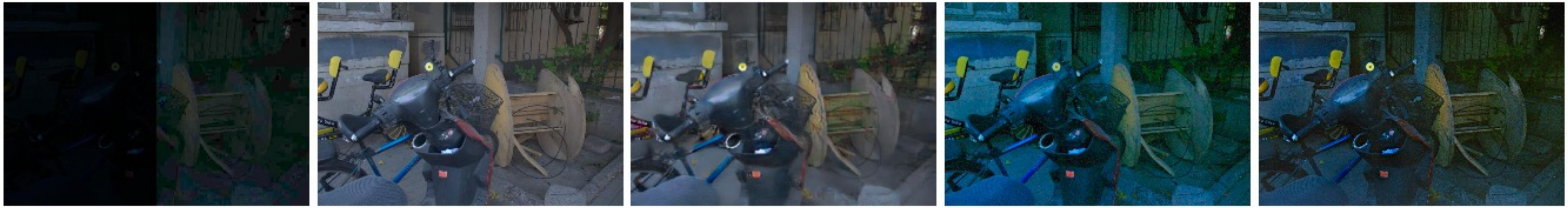
Results: Low-light Enhancement

- LOL-test dataset

- *LOL-Real* dataset



Input Ground Truth Ours Sharma EG

Quantitative Results

User study evaluation on the real night data, our method obtained the highest mean (the max score is 7) and lowest standard deviation.

Three Aspects	EG [15]	Afifi [1]	Yan [38]	Zhang [44]	Li [23]	Sharma [32]	Ours
1.Realism↑	3.3 ± 1.5	5.5 ± 1.3	3.7 ± 2.0	3.5 ± 1.6	3.1 ± 1.8	2.8 ± 1.5	$\mathbf{6.1 \pm 0.8}$
2.L.E. Supp.↑	1.7 ± 0.8	3.1 ± 1.3	4.6 ± 1.4	3.9 ± 1.1	5.2 ± 1.2	3.0 ± 1.5	$\mathbf{6.6 \pm 0.7}$
3.Visibility↑	3.1 ± 1.6	4.2 ± 1.5	4.7 ± 1.5	3.7 ± 1.1	3.8 ± 1.5	3.0 ± 1.4	$\mathbf{6.4 \pm 0.7}$

realistic

light-effects suppressed

good visibility

Quantitative light-effects suppression comparison on the night data.

Learning	-	UL	ZSL	SL	SL	SSL	Opti	Opti	SSL	UL
Datasets	Metrics	EG [15]	ZD+ [19]	RN [7]	Afifi [1]	Yan [38]	Zhang [44]	Li [23]	Sharma [32]	Ours
GTA5 [38]	PSNR↑	10.94	21.13	7.79	15.47	26.99	20.92	21.02	8.14	**29.79**
	SSIM↑	0.31	0.68	0.23	0.53	0.85	0.65	0.64	0.29	**0.88**
Syn-light-effects [27]	PSNR↑	7.38	7.84	6.39	11.31	14.88	16.30	14.66	14.00	**16.95**
	SSIM↑	0.17	0.20	0.16	0.35	0.23	0.38	0.37	0.37	**0.39**

Quantitative comparisons on the *LOL-Real* dataset.

Learning	NA	Opti	Opti	Opti	ZSL	ZSL	ZSL	ZSL	SL
Method	Input	JED [29]	RRM [21]	SRIE [9]	RDIP [48]	MIRNet [43]	RRDNet [50]	ZD [13]	RUAS [24]
PSNR↑	9.72	17.33	17.34	17.34	11.43	12.67	14.85	20.54	15.33
SSIM↑	0.18	0.66	0.68	0.68	0.36	0.41	0.56	0.78	0.52
Learning	SL	SL	SL	SL	SL	SSL	UL	SSL	UL
Method	LLNet [25]	RN [7]	DUPE [34]	SICE [6]	Afifi [1]	DRBN [41]	EG [15]	Sharma [32]	Ours
PSNR↑	17.56	15.47	13.27	19.40	16.38	19.66	18.23	18.34	**25.53**
SSIM↑	0.54	0.56	0.45	0.69	0.53	0.76	0.61	0.64	**0.88**

Quantitative comparisons on the LOL-test dataset

Learning	Method	LOL-test			
		MSE($\times 10^3$)↓	PSNR↑	SSIM↑	LPIPS↓
Opti	LIME [14]	-	16.760	0.560	0.350
SL	RetinexNet [7]	1.651	16.774	0.462	0.474
	KinD++ [47]	1.298	17.752	0.760	**0.198**
	Afifi [1]	4.520	15.300	0.560	0.392
	RUAS [24]	3.920	18.230	0.720	0.350
ZSL	ZeroDCE [13]	3.282	14.861	0.589	0.335
SSL	DRBN [40]	2.359	15.125	0.472	0.316
UL	EnlightenGAN [15]	1.998	17.483	0.677	0.322
SSL	Sharma [32]	3.350	16.880	0.670	0.315
UL	Ours	**1.070**	**21.521**	**0.763**	0.235

Conclusion

- We presented an **unsupervised learning** framework for night image enhancement, which boost dark regions and suppress light-effects simultaneously.
- With unsupervised structure and HF-features consistency loss, our method **restore the background details.**

Input w/o $\mathcal{L}_{\text{gray-feat}}$ w/ $\mathcal{L}_{\text{gray-feat}}$

Thank you!

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CODES AND MODEL:

HTTPS://GITHUB.COM/JINYEYING/NIGHT-ENHANCEMENT