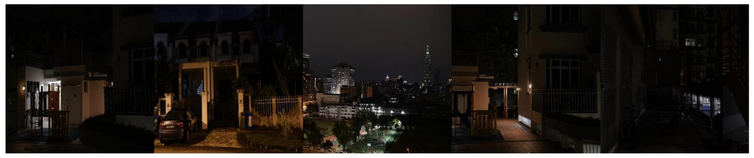
Unsupervised Night Image Enhancement: When Layer Decomposition Meets Light-Effects Suppression

Yeying Jin[1], Wenhan Yang[2], Robby T. Tan[1,3]
[1]National University of Singapore, [2]Nangyang Technological University, [3]Yale-NUS College

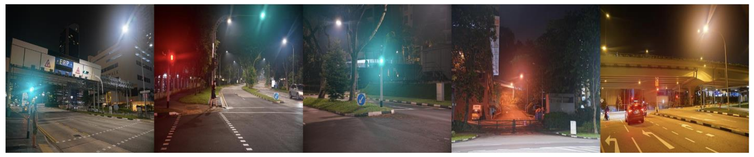
Introduction

Problem of Night Image

➢Low Light:



➢Light-Effects/Glare/Floodlight:



Motivation

➢Existing low-light enhancement methods:

✓ Enhance low-light regions

× Over-enhance light-effects regions

Low-light regions
Light-effects regions

➢Existing night dehazing methods:

× Enhance low-light regions

✓ Suppress glow; × Suppress light-effects

➢Our:

✓ Enhance low-light regions

✓ Suppress light-effects regions

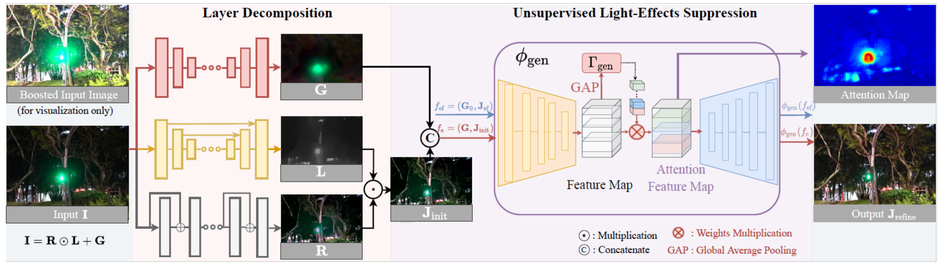
Challenge 1. Lack of paired training data, hard to collect ground truth
2. Rendering physically correct night light-effects images is challenging

Key Idea Model-Based Layer Decomposition + Unpaired Light-Effects Suppression

Main Contributions

To boost dark regions, at the same time, suppress light-effects.
1. We introduce an unsupervised learning network, that integrates layer decomposition and light-effects suppression.
2. We propose utilizing the light-effects layer as guidance, to distinguish light-effects from background regions, e.g., **white/multi-colored light-effects**.
3. We introduce unsupervised losses based on the structure and HF-features consistency, to **restore the background details**.

Method

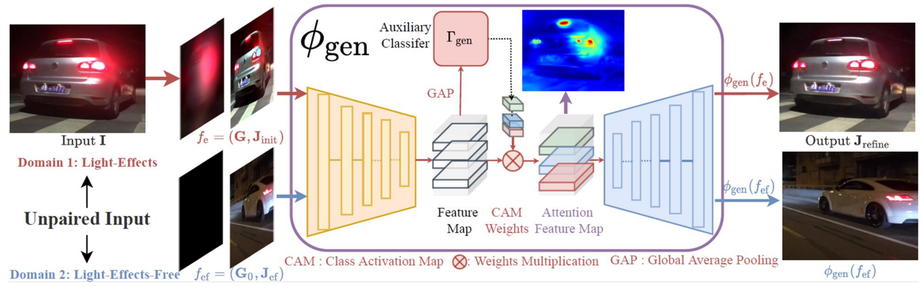


Layer Decomposition

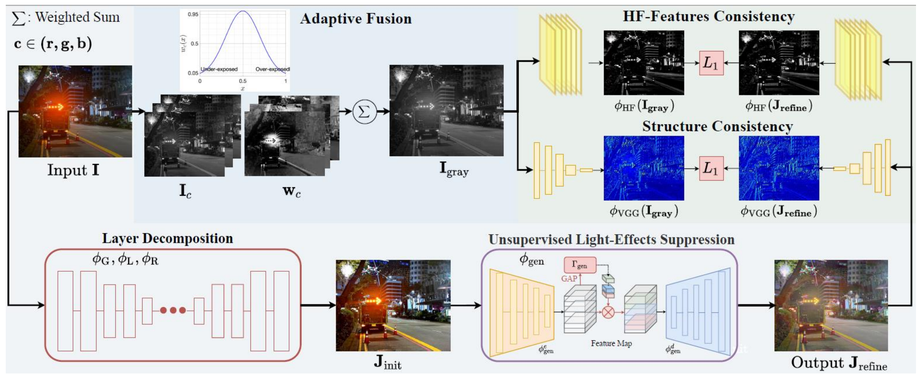
(a) Input **I** (b) **G** (c) **L** (d) **R**

Gradient Histogram of **G**

Light-effects Suppression



Structure and HF-features Losses



Quantitative Results

Light-effects Suppression

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	$\mathbf{6.4 \pm 0.7}$

Low Light Enhancement

Quantitative comparisons on the *LOL-Real* dataset.

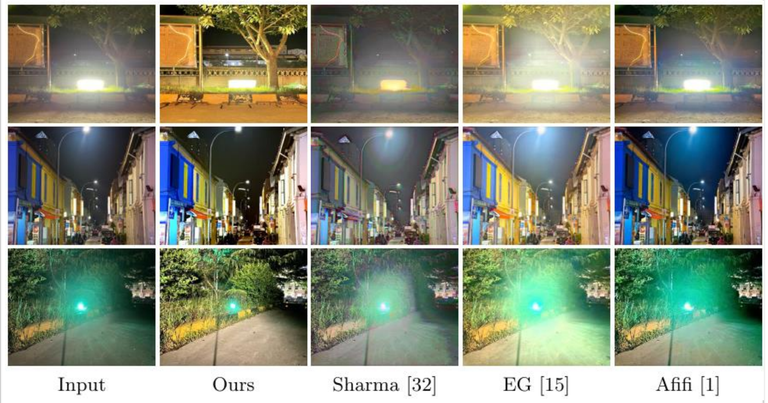
Learning	NA	Opti	Opti	Opti	ZSL	ZSL	ZSL	ZSL	SL
Method	Input	JED [29]	RRM [21]	SRIE [9]	RDIP [48]	MIRNet [43]	RRDNet [50]	ZD [13]	RUAS [24]
PSNR↑	9.72	17.33	17.34	17.34	11.43	12.67	14.85	20.54	15.33
SSIM↑	0.18	0.66	0.68	0.68	0.36	0.41	0.56	0.78	0.52
Learning	SL	SL	SL	SL	SL	SSL	UL	SSL	UL
Method	LLNet [25]	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**

Visual Results

Low Light Enhancement

Input Ground Truth Ours Sharma [32] EG [15]

Light-effects Suppression



Input Ours Sharma [32] EG [15] Afifi [1]

Input Ours Sharma [32] EG [15] Afifi [1]

Input Light-Effects Layer Our Method

Codes, data and model:
https://github.com/jinyeying/night-enhancement