Rethinking No-reference Image Exposure Assessment from Holism to Pixel: Models, Datasets and Benchmarks

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Introduction

☞ What is pixel-level image exposure assessment?

· Pixel-level image exposure assessment (IEA) aims to measures the exposure quality of each pixel.

Input | (a) Brightness Histogram | (b) Our Pixel-level IEA | (c) Zone System Theory
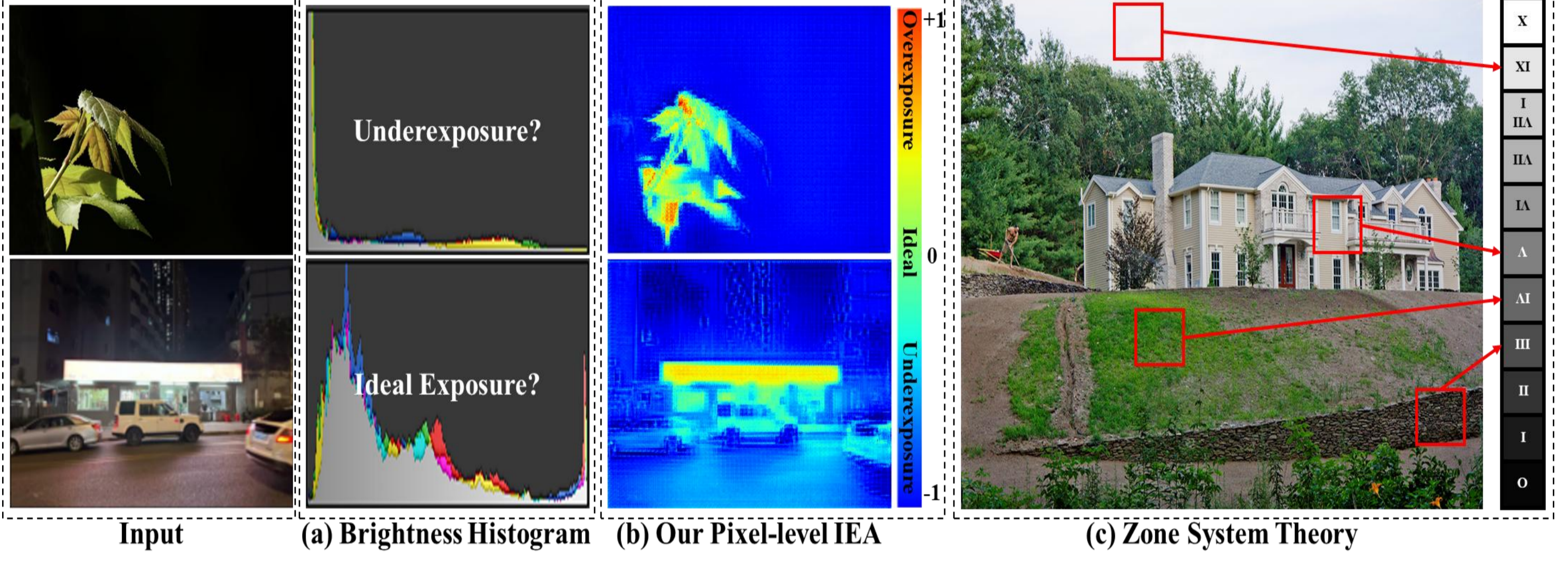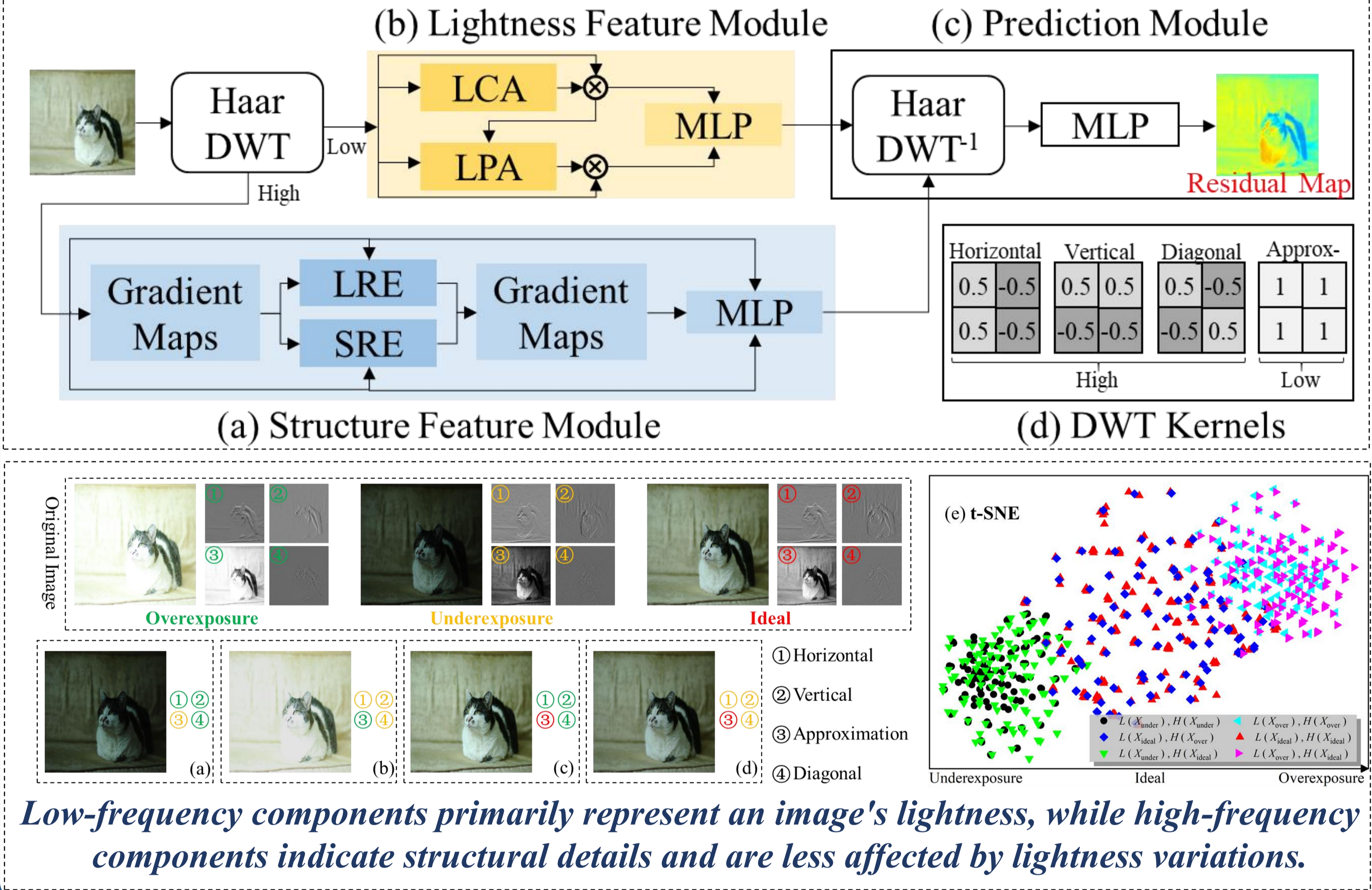
☞ Why Pixel-level IEA is important?

· IEA has become one of the most important criteria to assess if the image meets users' aesthetic preferences.

· IEA is an essential step in imaging measurements among manufacturers to evaluate the performance of smartphones and cameras.

· Pixel-level IEA can provide intuitive and accurate reflection of the exposure conditions in each area.

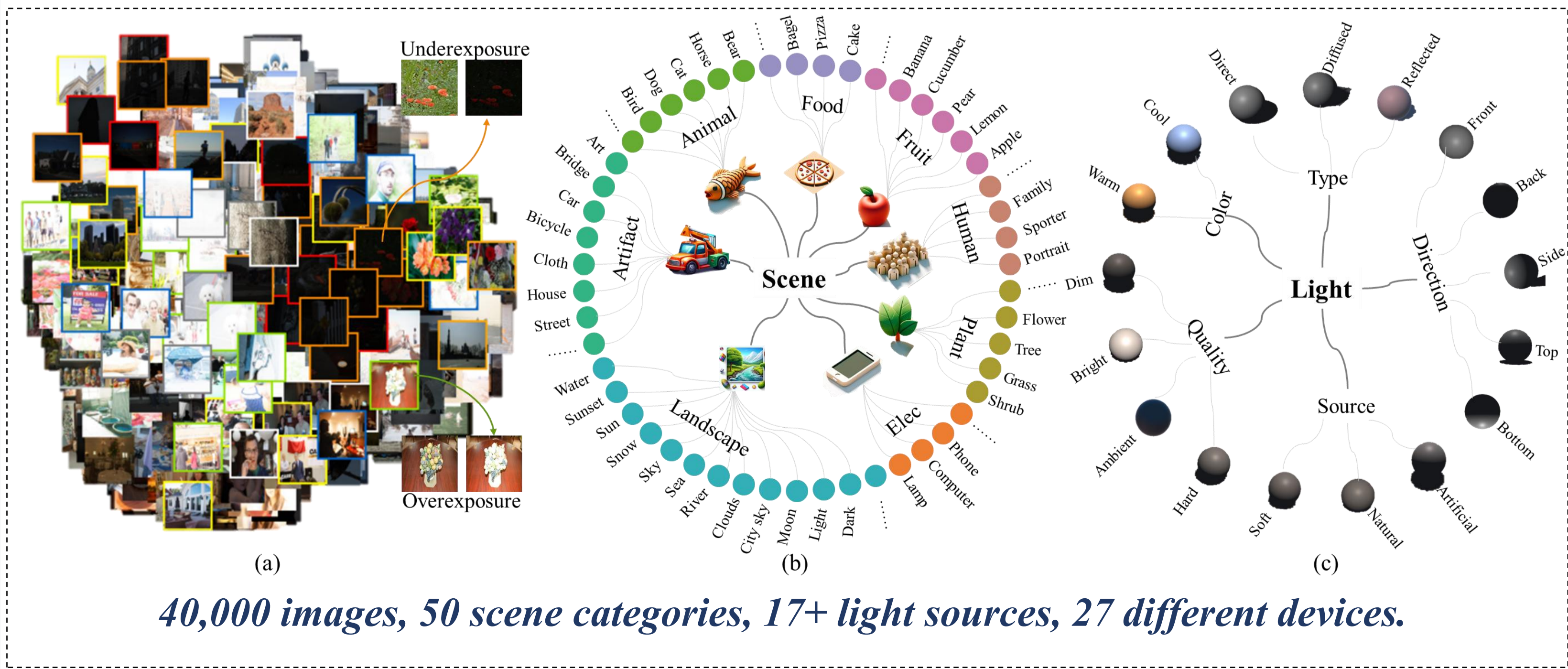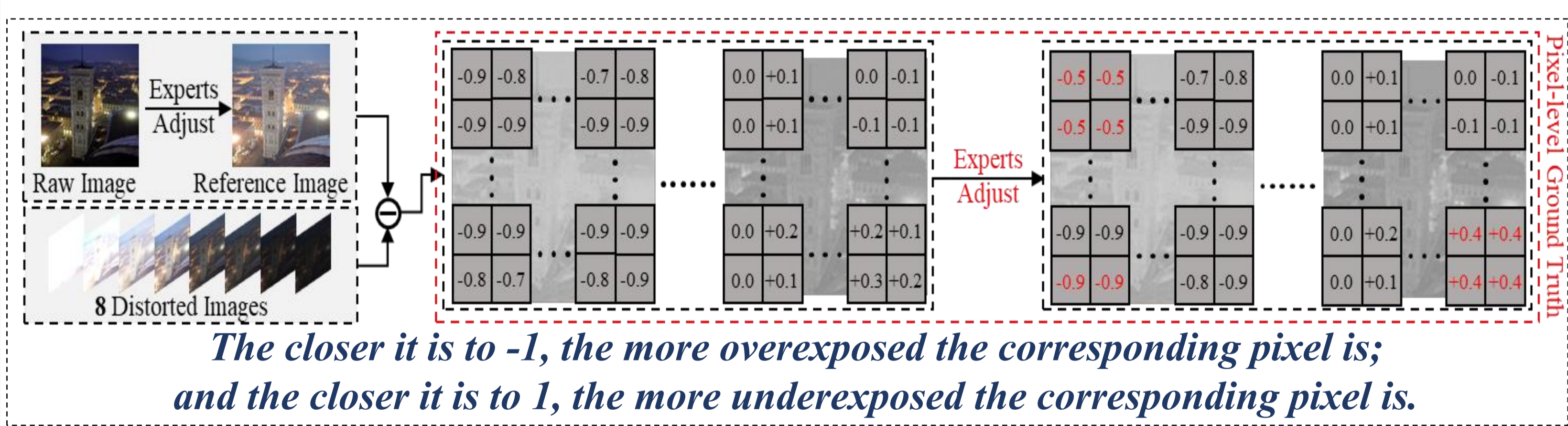· Pixel-level IEA can provide better interpretability and adaptability across diverse scenarios and criteria.

☞ Contributions

· **New IEA paradigm**: the first work to implement a pixel-level evaluation paradigm in IEA.

· **P-IEANet**: show that pixel-level IEA can be executed by decomposing it into criteria-agnostic lightness and structure information using Haar DWT.

· **IEA40K dataset**: a pixel-level dataset with 40K images and the richest annotations thus far.

· **The largest benchmark**: 19 baselines on two datasets as the most complete one for IEA thus far.

P-IEANet

(b) Lightness Feature Module — (c) Prediction Module — (a) Structure Feature Module — (d) DWT Kernels — (e) t-SNE

Low-frequency components primarily represent an image's lightness, while high-frequency components indicate structural details and are less affected by lightness variations.

IEA40K dataset

The closer it is to -1, the more overexposed the corresponding pixel is; and the closer it is to 1, the more underexposed the corresponding pixel is.

40,000 images, 50 scene categories, 17+ light sources, 27 different devices.

Experiment Results

★ Pixel-level IEA benchmark on IEA40K

Pixel level	Light Enhancement / Awareness								IQA / IAA				Ours
	FEC [32]	MSLT [46]	Retinex [47]	PyDiff [48]	SMG [38]	SKF [49]	GSAD [50]	LIT [51]	ArnIQA [52]	ReIQA [53]	DEIQT [54]	MUSIQ [55]	
Params	9M	8M	5M	374M	575M	22M	67M	146M	106M	560M	363.5M	298M	**2.7M**
MAE ↓	0.08	0.10	0.10	0.07	0.09	0.07	0.08	0.05	0.11	0.08	0.08	0.15	**0.03**
SSIM ↑	0.35	0.33	0.42	0.50	0.46	0.44	0.41	0.60	0.50	0.37	0.39	0.24	**0.75**

★ Pixel-level IEA prediction
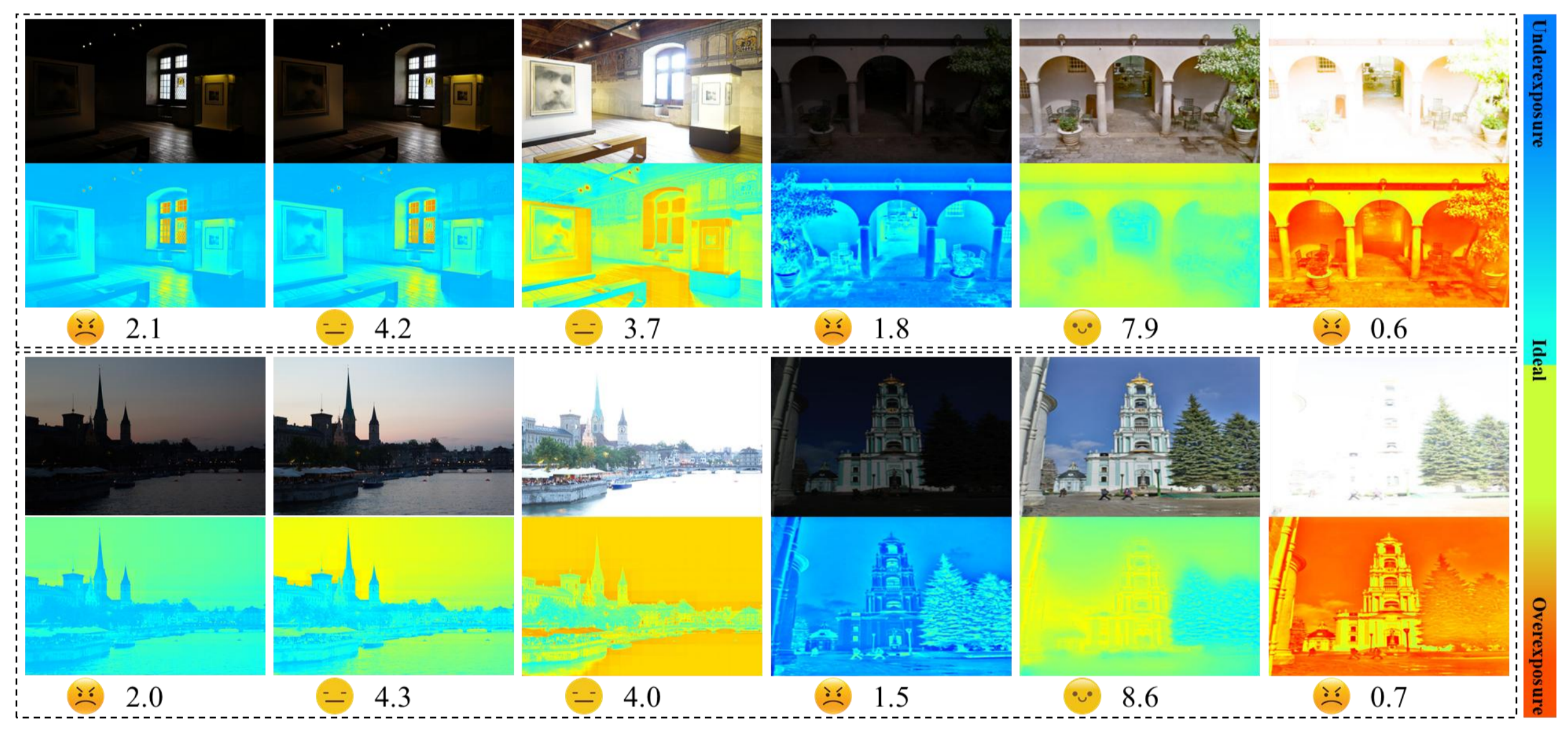
★ Advancing Light Enhancement Methods

Model	LOL-v1		LOLv2-real	
	PSNR↑	SSIM↑	PSNR↑	SSIM↑
Retinex (ICCV'23)	25.16	0.845	22.80	0.840
Retinex*	24.7	0.80	21.9	0.82
Retinex* + P-IEANet	**25.3**	**0.85**	**23.0**	**0.86**
GASD (NIPS'23)	27.839	0.877	28.818	0.895
GASD*	27.1	0.85	28.4	0.86
GASD* + P-IEANet	**28.2**	**0.88**	**29.5**	**0.91**

★ Analyzing Light Enhancement Performance Better