LW-ISP: A Lightweight Model with ISP and Deep Learning

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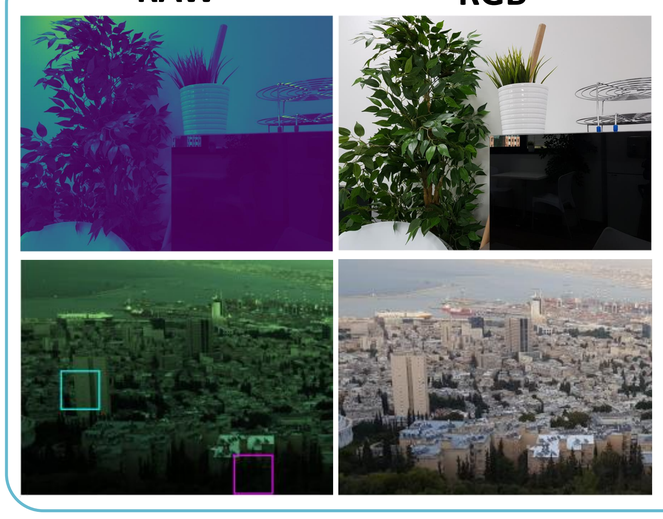
Background

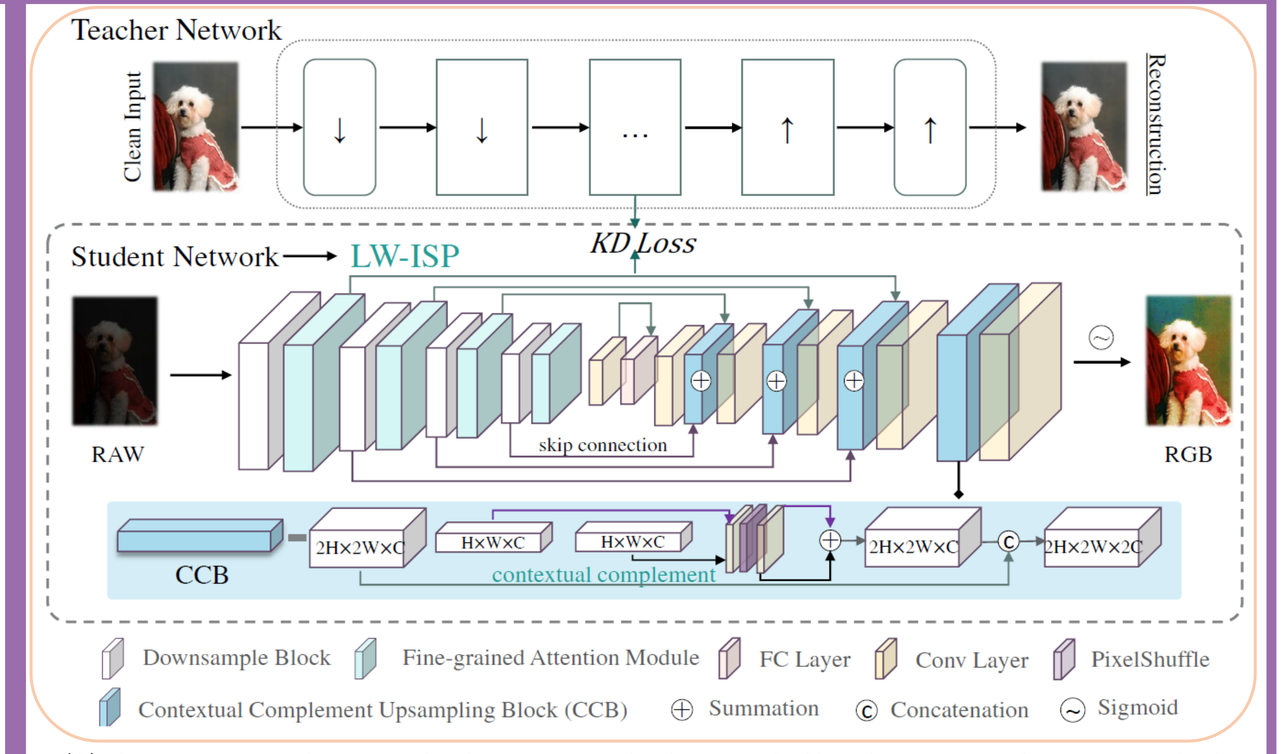


Traditional ISP

1. In the design of the traditional ISP, subtasks are well designed independently, which may lead to the accumulation of errors.
2. The traditional ISP research has rigid barriers such as high talent requirements, long iteration cycles, and high R&D funds.

- Efficiency: The required computing and processing time far **exceed the relevant capabilities** of the mobile site, especially PyNET and PyNET-ca.
- Metric: PSNR, (MS-)SSIM, LPIPS and MOS. The measurement metrics are **inconsistent** with the human perception and cannot comprehensively reflect the quality of the image.

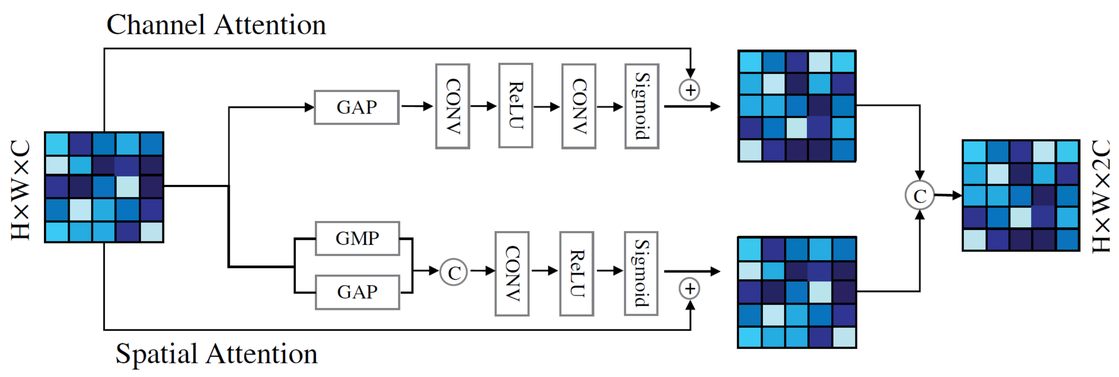
Method: Proposing LW-ISP



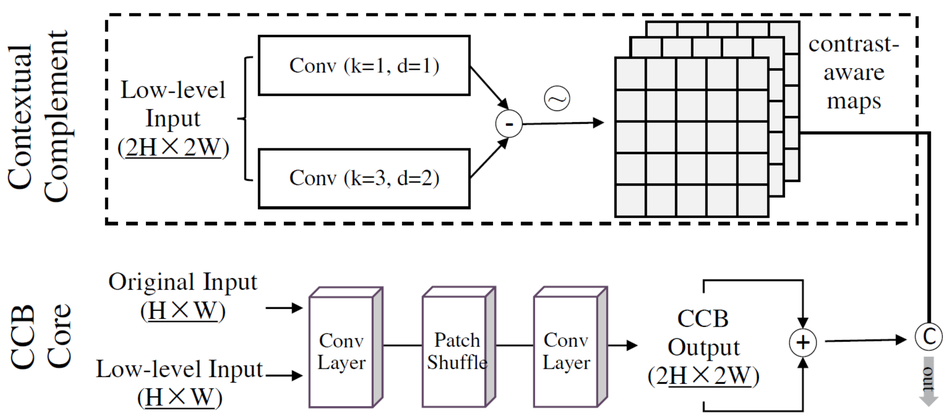
※ The overview of our method **LW-ISP**, The bottom half is the main architecture, which receives RAW input and execution feature reconstruction.

Method: FGAM and CCB

※ Fine-grained attention module (FGAM)

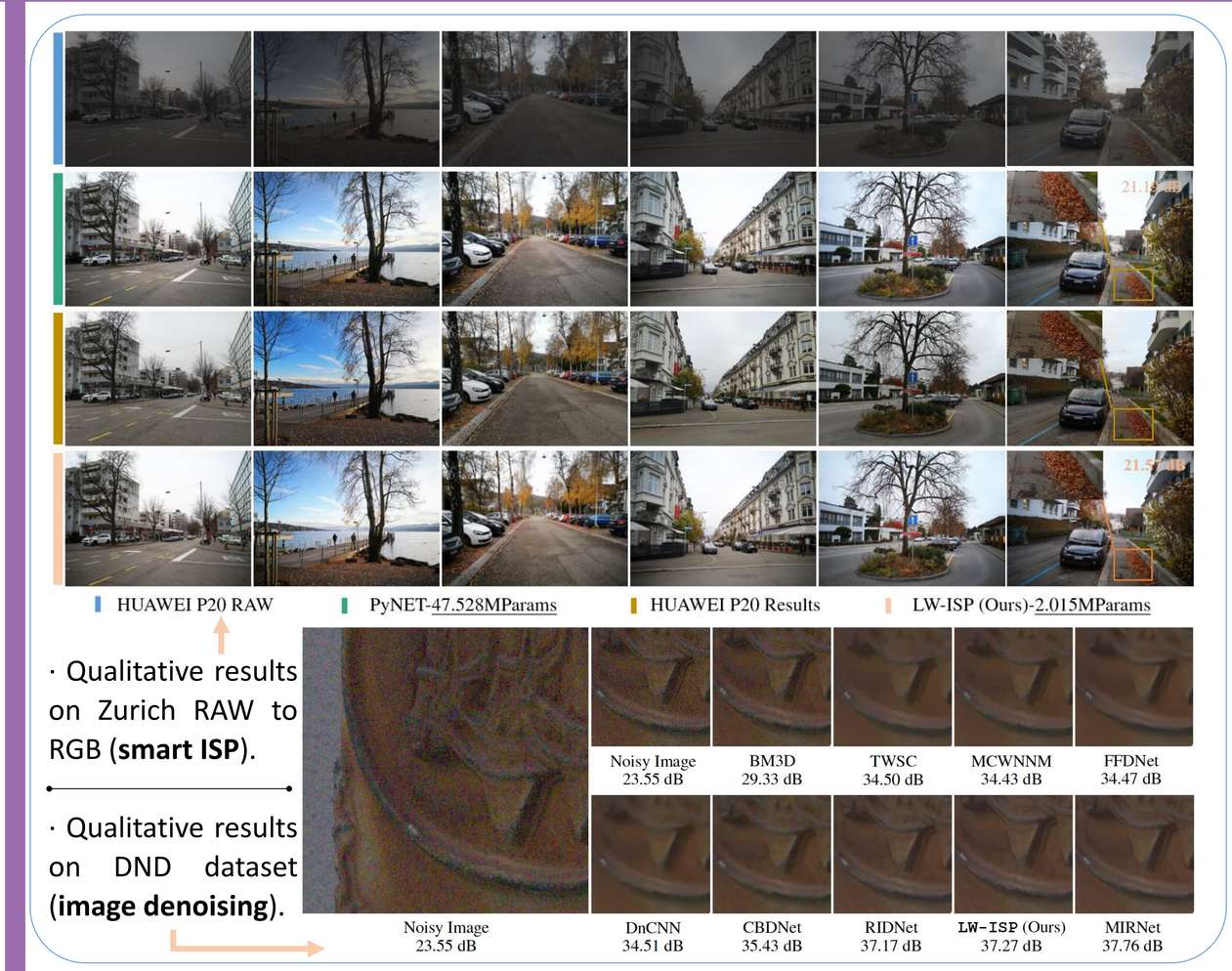


※ Contextual Complement Up-sampling Block (CCB)



$$\mathcal{P}\left(\mathcal{O}^1_{FBU}\right) + \mathcal{P}\left(\mathcal{O}^2_{FBU}\right) = \mathcal{O}_{FAU}$$

Qualitative Comparison



Experiments Results on Smart ISP and Image Denoising

Method	SRCNN[14]	SRGAN[31]	DPED[26]	Pix2Pix[30]	SPADE[37]	NAFNet[10]	PyNET[28]	LW-ISP
PSNR (↑)	18.56	20.06	20.67	20.93	20.96	21.12	21.19	**21.57**
MS-SSIM (↑)	0.8268	0.8501	0.8560	0.8532	0.8586	0.8613	0.8620	**0.8622**
LPIPS (↓)	0.385	0.257	0.343	0.208	0.209	0.194	0.194	**0.160**

Model	Lightweight [13]	HERN [37]	CameraNet [35]	AWNet [15]	Pynet-ca [33]	LW-ISP (Ours)
PSNR (dB)	21.28	21.30	21.35	21.40	21.50	**21.57**
Params.(M)	31.56	39.64	26.53	55.70	56.89	**2.01**

Comparison results on Zurich RAW to RGB dataset (Smart ISP)

Method	DnCNN[56]	BM3D[11]	WNNM[15]	EPLL[58]	CBDNet[17]	RIDNet[2]	VDN[51]	LW-ISP	MIRNet[52]
PSNR	23.66	25.65	25.78	27.11	30.78	38.71	39.28	**39.44**	39.72
SSIM	0.583	0.685	0.809	0.870	0.754	0.914	0.909	**0.918**	0.959

Method	EPLL[23]	BM3D[5]	WNNM[6]	KSVD[2]	TWSC [19]	U-Net[15]	CBDNet[7]	LW-ISP	MIRNet[21]
PSNR	33.51	34.51	34.67	36.49	37.94	38.01	38.06	**39.09**	39.88
SSIM	0.824	0.851	0.865	0.898	0.940	0.938	0.942	**0.948**	0.956

Comparison results on SIDD and DND dataset (Image Denoising)

Model	Number of Parameters
SPADE	97, 480, 899
PyNET	47, 554, 738
LW-ISP w/o FGAM	**1, 660, 777**
LW-ISP w/ FGAM	2, 014, 681

Number of parameters

Model	FLOPs		
	(224,224)	(960,960)	(1440,1984)
SPADE	191.31G	3.16T	10.89T
PyNET	342.698G	5.72T	19.513T
LW-ISP w/o FGAM	**3.441G**	**63.198G**	**195.914G**
LW-ISP w/ FGAM	4.234G	69.198G	211.914G

Comparison of model params

Model	Input Size = (224,224)		
	Meomory Usage	MAdd	MemR+W
SPADE	847.12 MB	382.31 G	1.73 GB
PyNET	2777.14 MB	684.43 G	2.91 GB
LW-ISP w/o FGAM	**165.49 MB**	**6.24 G**	**189.26 MB**
LW-ISP w/ FGAM	182.23 MB	6.99 G	205.52 MB