Restoring Images in Adverse Weather Conditions via Histogram Transformer

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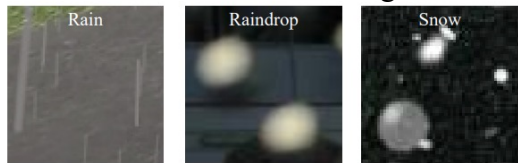[1]CAS, China   [2]UCAS, China   [3]Shenzhen Campus of SYSU, China   [4]Tencent
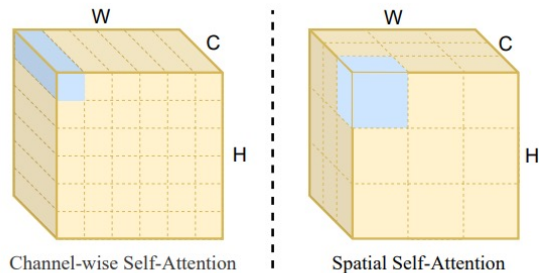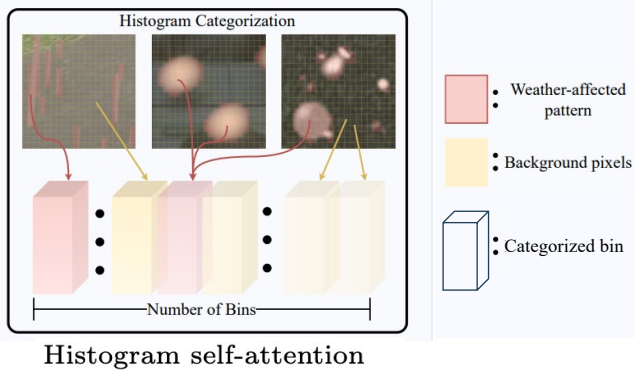
Introduction & Analysis

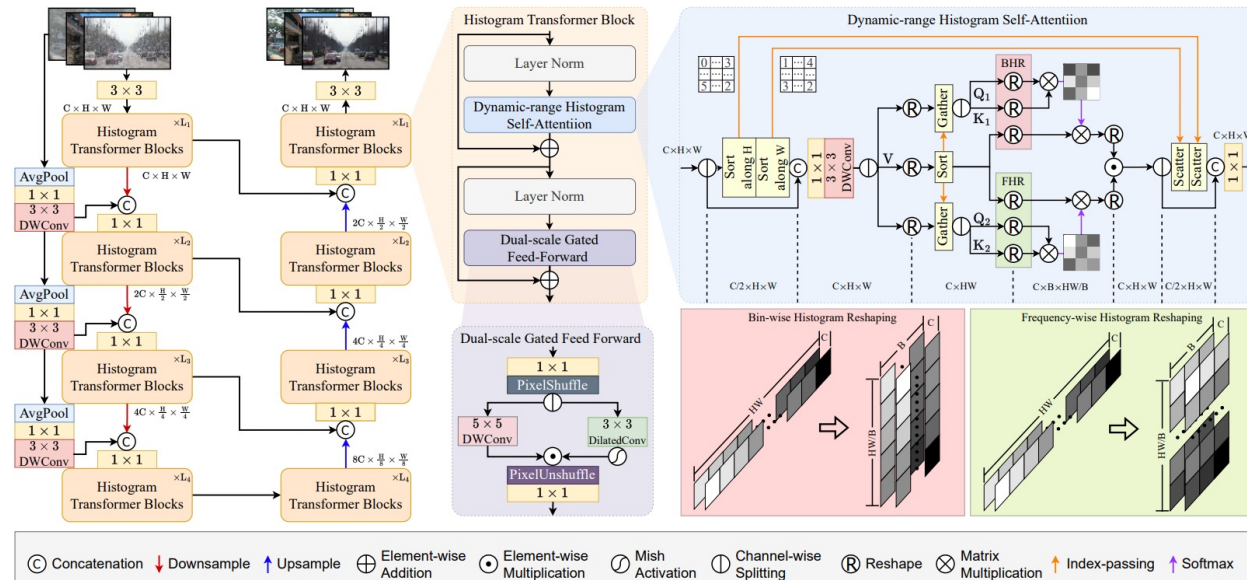- Weather-induced degradation patterns tend to be similar but distinct from the background.

Rain   Raindrop   Snow

- Traditional self-attention is performed either along channel dimension or within a fixed range.

Channel-wise Self-Attention   Spatial Self-Attention

- We categorize pixels affected by adverse weather and background pixels into distinct bins based on descending intensities and then conducts self-attention within and between bins.


Histogram Categorization

- Weather-affected pattern
- Background pixels
- Categorized bin

Number of Bins

Histogram self-attention

Proposed Method: Histogram Transformer

Histogram Transformer Block

Layer Norm → Dynamic-range Histogram Self-Attention → Layer Norm → Dual-scale Gated Feed-Forward

Dynamic-range Histogram Self-Attention

Dual-scale Gated Feed Forward

Bin-wise Histogram Reshaping   Frequency-wise Histogram Reshaping

Ⓒ Concatenation ↓ Downsample ↑ Upsample ⊕ Element-wise Addition ⊙ Element-wise Multiplication Ⱬ Mish Activation Ⓤ Channel-wise Splitting Ⓡ Reshape ⊗ Matrix Multiplication ↑ Index-passing ↑ Softmax

Experiments
Quantitative Results on Adverse Weather Removal

	(a) Image Desnowing				**(b)** Deraining & Dehazing		**(c)** Raindrop Removal	
	Snow100K-S [44]		Snow100K-L [44]		Outdoor-Rain [32]		RainDrop [57]	
	PSNR	SSIM	PSNR	SSIM		PSNR	SSIM		PSNR	SSIM
SPANet [73]	29.92	0.8260	23.70	0.7930	CycleGAN [98]	17.62	0.6560	pix2pix [20]	28.02	0.8547
JSTASR [8]	31.40	0.9012	25.32	0.8076	pix2pix [20]	19.09	0.7100	DuRN [42]	31.24	0.9259
RESCAN [34]	31.51	0.9032	26.08	0.8108	HRGAN [32]	21.56	0.8550	RaindropAttn [59]	31.44	0.9263
DesnowNet [44]	32.33	0.9500	27.17	0.8983	PCNet [21]	26.19	0.9015	AttentiveGAN [57]	31.59	0.9170
DDMSNet [94]	34.34	0.9445	28.85	0.8772	MPRNet [87]	28.03	0.9192	IDT [78]	31.87	0.9313
NAFNet [6]	34.79	0.9497	30.06	0.9017	NAFNet [6]	29.59	0.9027	MAXIM [69]	31.87	0.9352
Restormer [86]	36.01	0.9579	30.36	0.9068	Restormer [86]	30.03	0.9215	Restormer [86]	32.18	0.9408
All-in-One [33]*	-	-	28.33	0.8820	All-in-One [33]*	24.71	0.8980	All-in-One [33]*	31.12	0.9268
TransWeather [70]	32.51	0.9341	29.31	0.8879	TransWeather [70]	28.83	0.9000	TransWeather [70]	30.17	0.9157
Chen et al. [10]	34.42	0.9469	30.22	0.9071	Chen et al. [10]	29.27	0.9147	Chen et al. [10]	31.81	0.9309
WGWSNet [100]	34.31	0.9460	30.16	0.9007	WGWSNet [100]	29.32	0.9207	WGWSNet [100]	32.38	0.9378
WeatherDiff[64] [53]	35.83	0.9566	30.09	0.9041	WeatherDiff[64] [53]	29.64	0.9312	WeatherDiff[64] [53]	30.71	0.9312
WeatherDiff[128] [53]	35.02	0.9516	29.58	0.8941	WeatherDiff[128] [53]	29.72	0.9216	WeatherDiff[128] [53]	29.66	0.9225
AWRCP [82]*	36.92	0.9652	31.92	0.9341	AWRCP [82]*	31.39	0.9329	AWRCP [82]*	31.93	0.9314
Histoformer (Ours)	37.41	0.9656	32.16	0.9261	Histoformer (Ours)	32.08	0.9389	Histoformer (Ours)	33.06	0.9441

Experiments
Visual Results on Adverse Weather Removal

Snow / Heavy Rain / Rain Drop

(a) Input (b) [10] (c) [70] (d) [100] (e) [53] (f) Ours (g) Clean
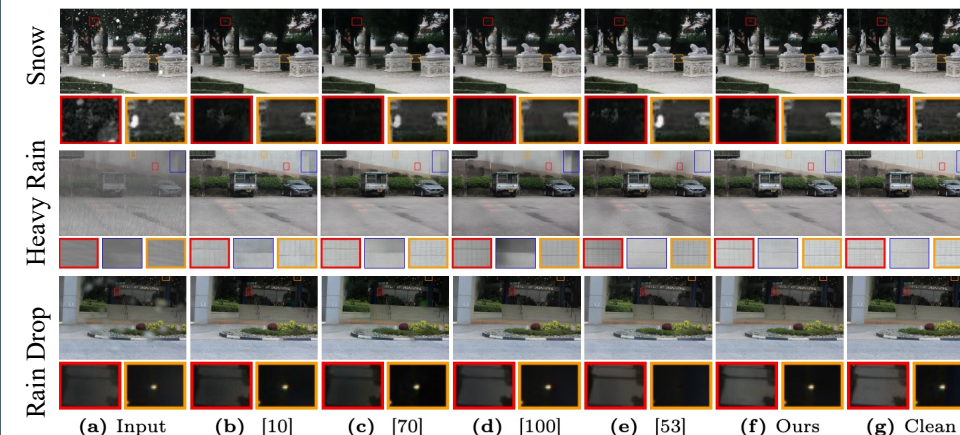
Results on Real-World Adverse Weather Removal

(a) Input (b) [10] (c) [86] (d) [70] (e) [100] (f) [53] (g) Ours
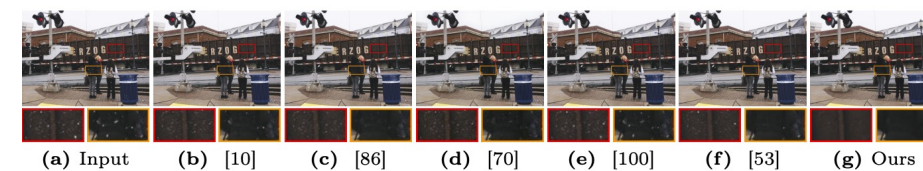
Results on Real-World De-Weathering and Detection

(a) Input   (b) Deweathered by ours