

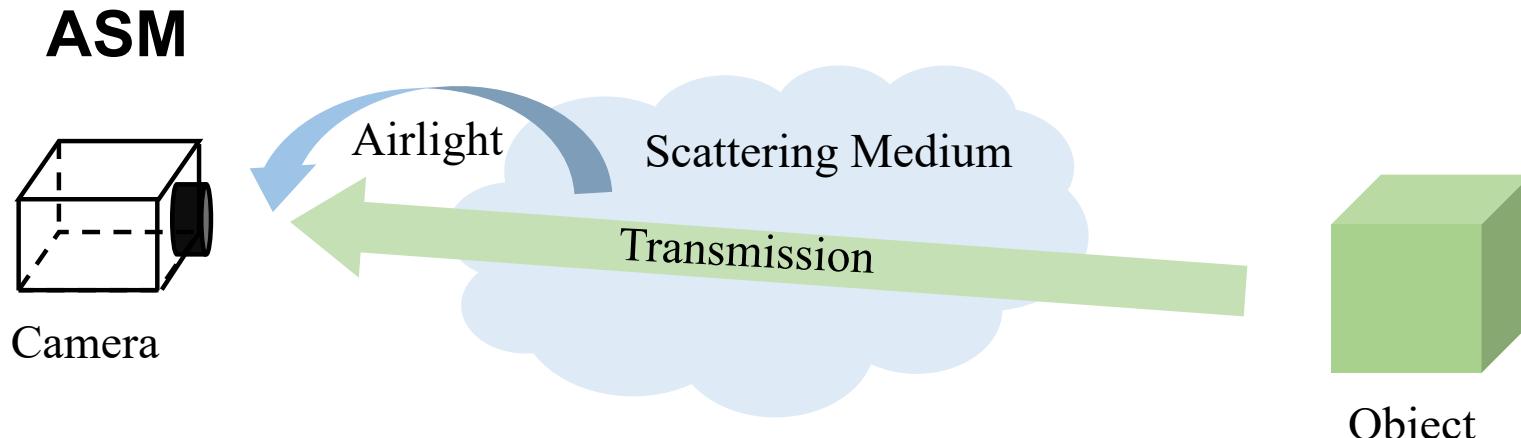
SynFog: A Photo-realistic Synthetic Fog Dataset based on End-to-end Imaging Simulation for Advancing Real-World Defogging in Autonomous Driving

¹Yiming Xie*, ¹Henglu Wei*, ²Zhenyi Liu, ¹Xiaoyu Wang, ¹Xiangyang Ji

¹Tsinghua University ²Stanford University



Motivations



- Fail to consider accurate global illumination and the actual imaging process.
- Disparity between synthetic and real-world foggy images, limited robustness.

Contributions

End-to-end foggy image simulation pipeline:

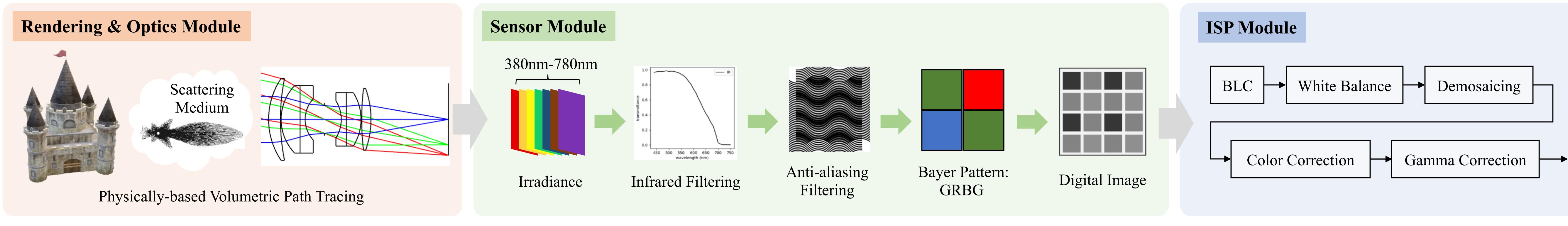
- Accurate light transportation in scattering medium
- Physical characteristics of optics and sensor

SynFog dataset:

- Both skylight and active lighting conditions
- Three levels of fog density
- Pixel-accurate depth data and segmentation labels

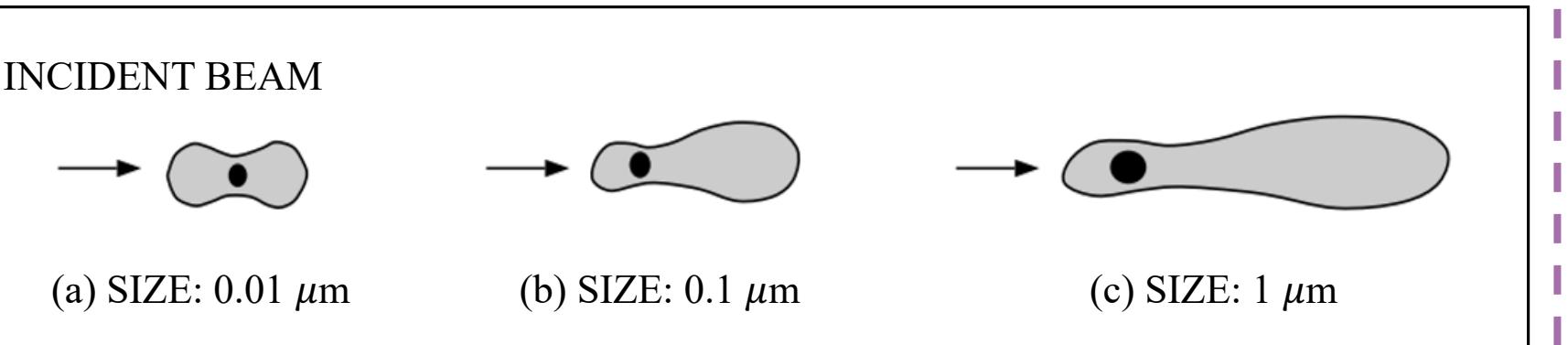


End-to-end Foggy Image Simulation Pipeline



Foggy Scene Rendering

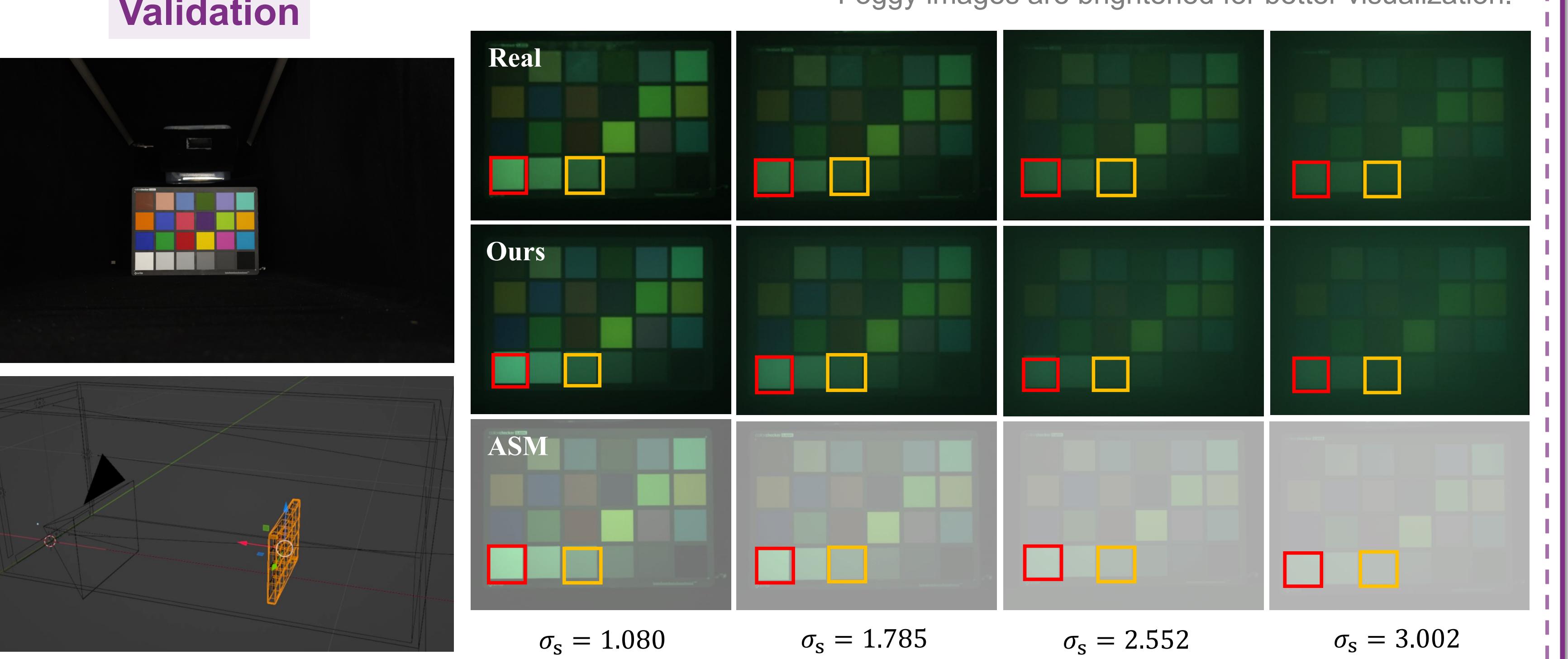
CONDITION	PARTICLE TYPE	RADIUS (μm)	CONCENTRATION (cm^{-3})
AIR	Molecule	10^{-4}	10^{19}
HAZE	Aerosol	$10^{-2} - 1$	$10^3 - 10$
FOG	Water Droplet	$1 - 10$	$100 - 10$
CLOUD	Water Droplet	$1 - 10$	$300 - 10$
RAIN	Water Drop	$10^2 - 10^4$	$10^{-2} - 10^{-5}$



Henyey and Greenstein Phase Function:

$$p_{HG}(\cos \theta) = \frac{1}{4\pi} \frac{1-g^2}{(1+g^2+2g(\cos \theta))^{3/2}}$$

Validation



Foggy images are brightened for better visualization.

Transferability across the Real-to-Virtual Gap



Training Set	O-Haze [2]			Foggy Zurich [11]	Foggy Driving [40]	BeDDE [56]
	PSNR \uparrow	SSIM \uparrow	DHQI [14] \uparrow	DHQI [14] \uparrow	DHQI [14] \uparrow	DHQI [14] \uparrow
Foggy Cityscapes	14.46	0.5737	43.40	52.06	51.55	36.07
Virtual KITTI	13.90	0.5315	42.80	50.94	47.46	33.42
SynFog	15.43	0.6116	44.46	54.16	52.07	43.28

Method	Training Set	FZ [11]	STF [5]	Experimental setting	
		mAP (%)	mAP (%)	mAP (%)	mAP (%)
AECRNet	Foggy Cityscapes	69.7	54.8	AECRNet+SynFog(w/o noise)	
	Virtual KITTI	68.9	53.3	AECRNet+SynFog(w/ noise)	
	SynFog	71.5	55.5		
DehazeFormer	Foggy Cityscapes	67.9	54.9		
	Virtual KITTI	68.5	53.1		
	SynFog- β	59.7	55.3		
	SynFog	69.7	55.3		

