Event-3DGS: Event-based 3D Reconstruction Using 3D Gaussian Splatting

Haiqian Han[1*], Jianing Li[1], Henglu Wei[1], Xiangyang Ji[1] ✉

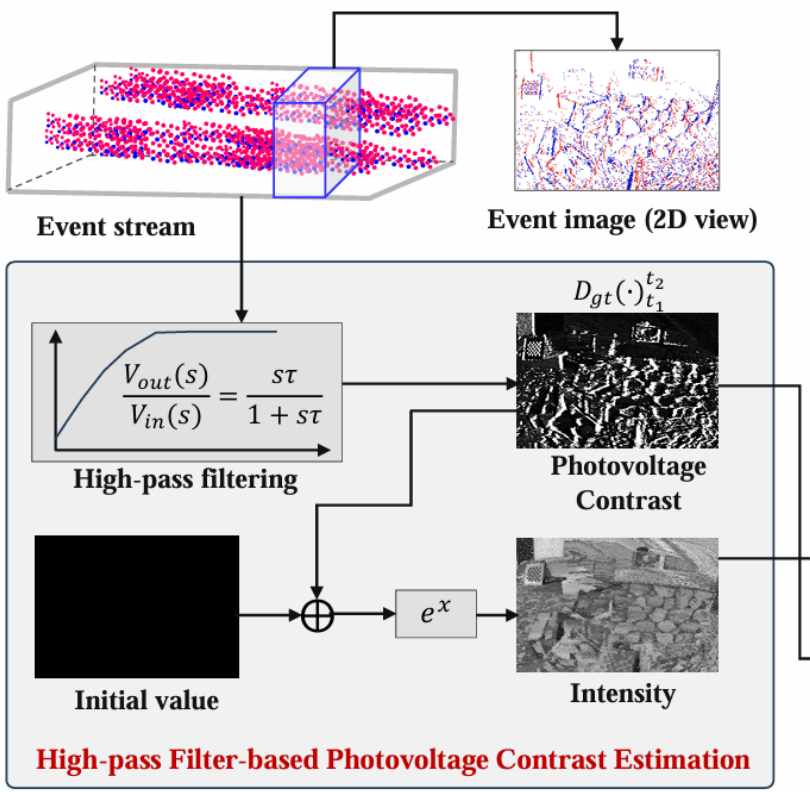
[1] Tsinghua University, Haidian District, Beijing, 100084, P. R. China

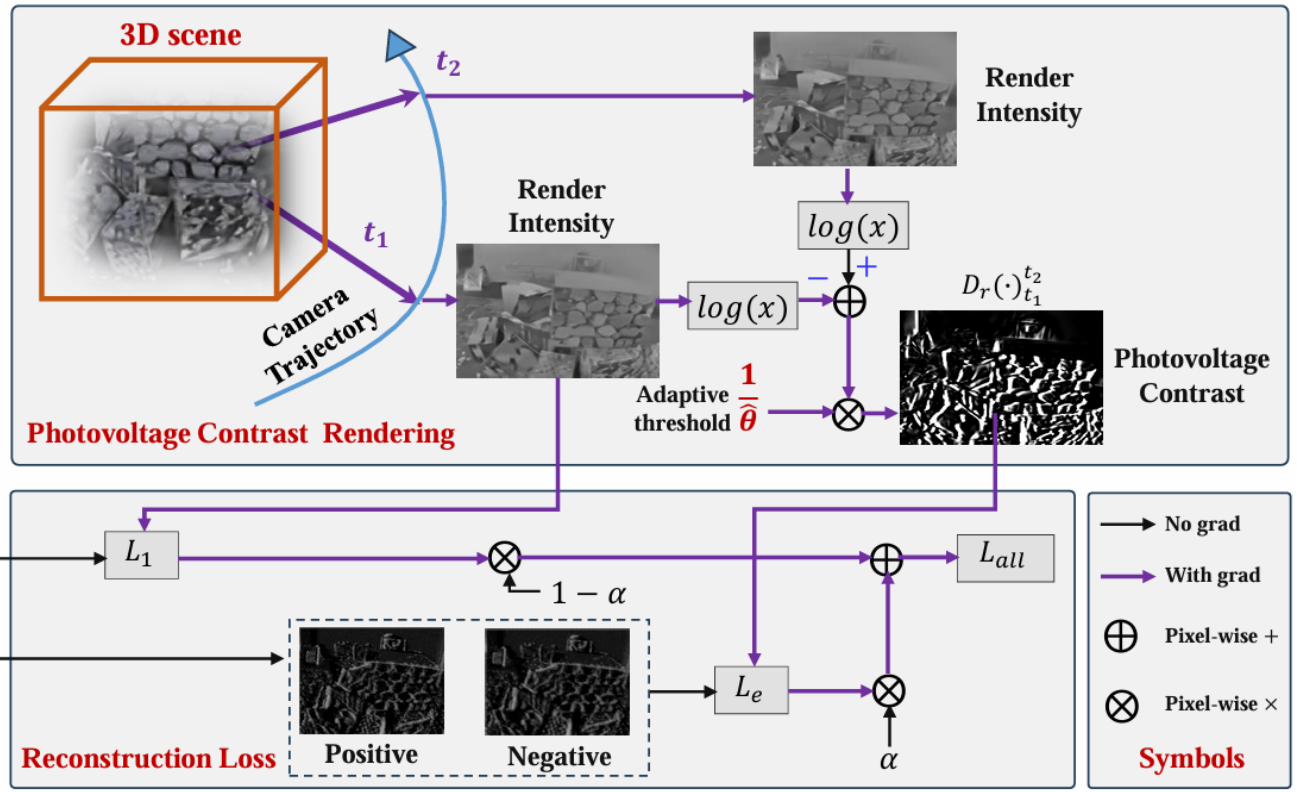
Motivation

- Enhance 3D reconstruction quality and robustness from event data.
- Overcome limitations of exiting methods with 3DGS-based approaches.

Contributions

- First 3DGS framework for Event-based 3D Reconstruction
- High-pass filter module to reduce noise
- Event-based 3D reconstruction loss to improve quality



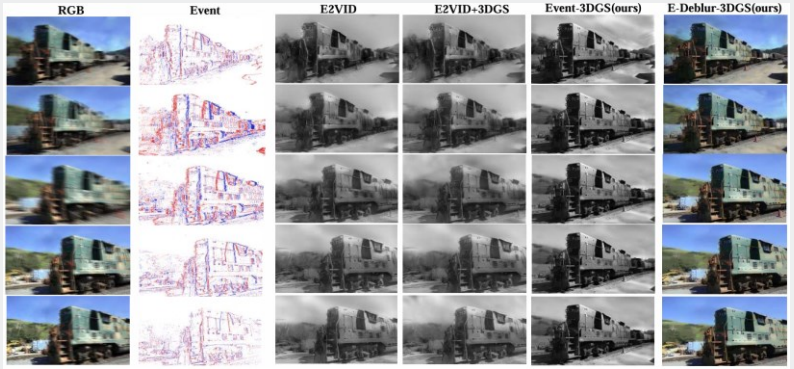


Experiments & Conclusion

Quantization results

Sequence	E2VID [34]			E2VID [34]+3DGS [15]			PI-3DGS			Event-3DGS		
	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS
mic	0.938	19.965	0.048	0.946	19.955	0.068	0.955	21.979	0.060	0.952	21.127	0.063
ship	0.808	16.556	0.108	0.825	16.681	0.122	0.792	16.750	0.177	0.818	17.815	0.147
materials	0.872	18.302	0.084	0.885	18.325	0.094	0.925	20.053	0.062	0.933	20.506	0.060
lego	0.883	19.744	0.075	0.899	20.002	0.084	0.928	23.853	0.056	0.925	23.046	0.058
ficus	0.932	19.795	0.043	0.935	19.626	0.056	0.939	19.880	0.050	0.940	19.939	0.049
drums	0.908	18.312	0.071	0.915	18.288	0.085	0.953	22.643	0.041	0.951	22.568	0.042
chair	0.939	23.842	0.040	0.949	23.866	0.050	0.954	27.024	0.042	0.953	27.336	0.050
Average	0.897	19.502	0.067	0.908	19.535	0.080	0.921	21.740	0.070	**0.925**	**21.762**	**0.067**

Applications for deblurring in reconstruction



Conclusion

- Our method achieves better 3D reconstruction quality and speed
- Our method ensures better performance in extreme noise, fast motion, and low-light conditions.

Acknowledgment

This work is partially supported by the National Natural Science Foundation of China under Grant 20181310845.

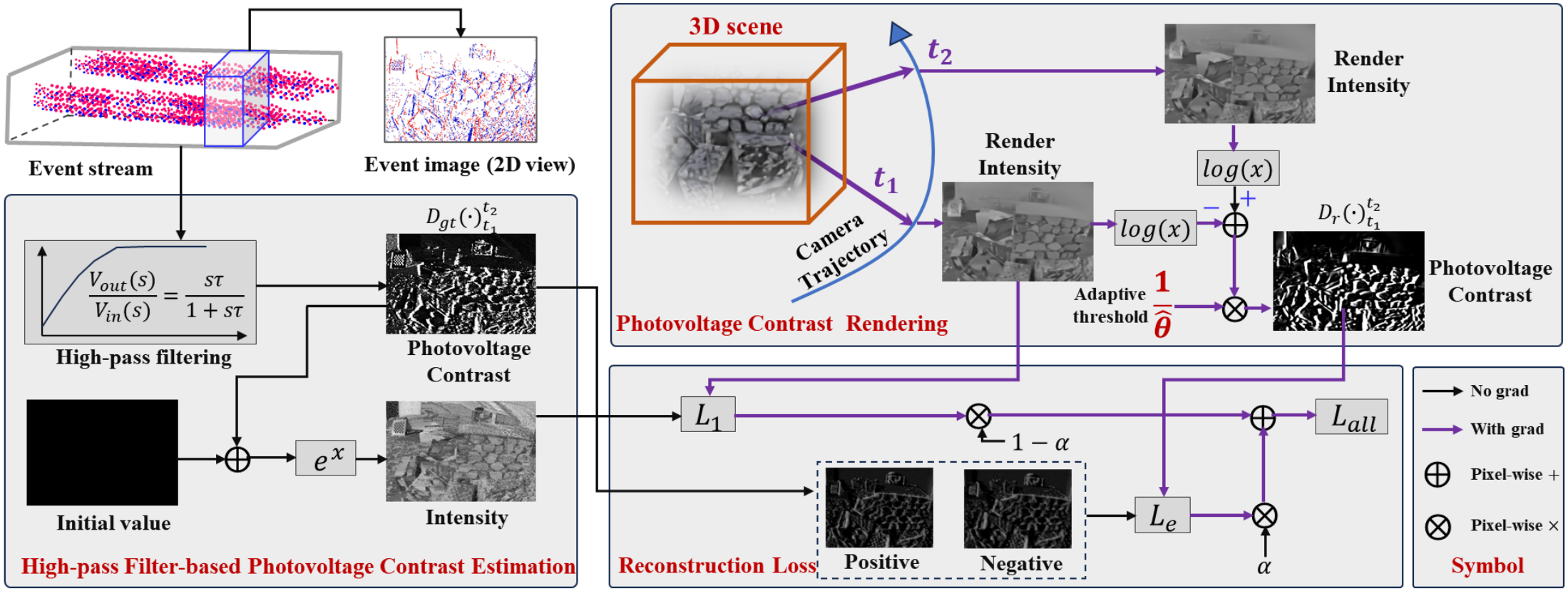
3DGS for Event-based 3D Reconstruction

Motivation

- Enhance 3D reconstruction quality and robustness, especially in low light, high speed scenes.
- 3DGS outperforms NeRF in accuracy and efficiency

Contributions

- First propose 3DGS for 3D scene reconstruction with event cameras
- Develop a noise-robust photovoltage contrast estimation module using high-pass filtering
- Design a loss function to enhance reconstruction quality



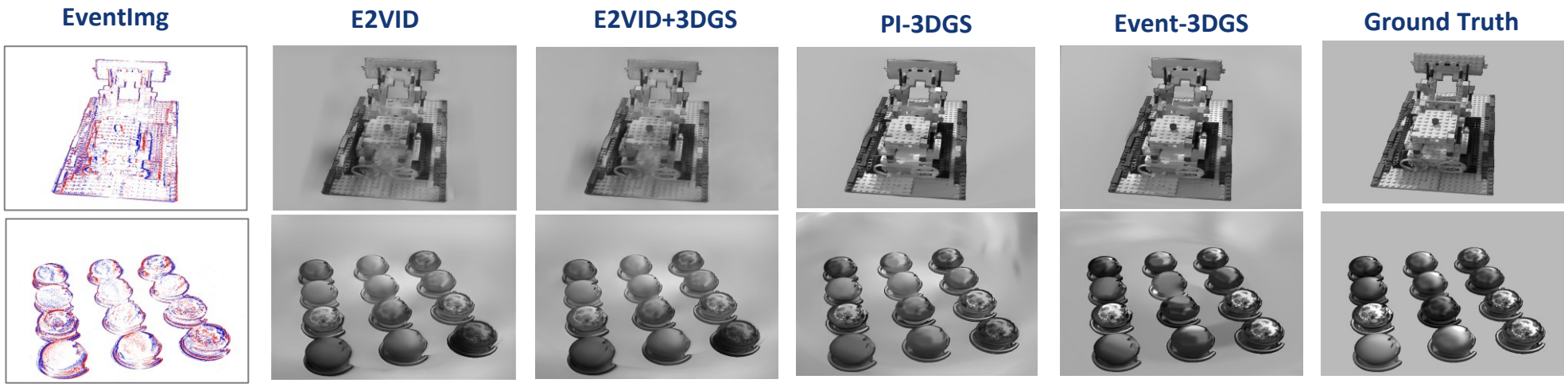
Event-3DGS: Event-based 3D reconstruction using 3D Gaussian splatting, *NeurIPS 2024*.

3DGS for Event-based 3D Reconstruction

Experimental Results

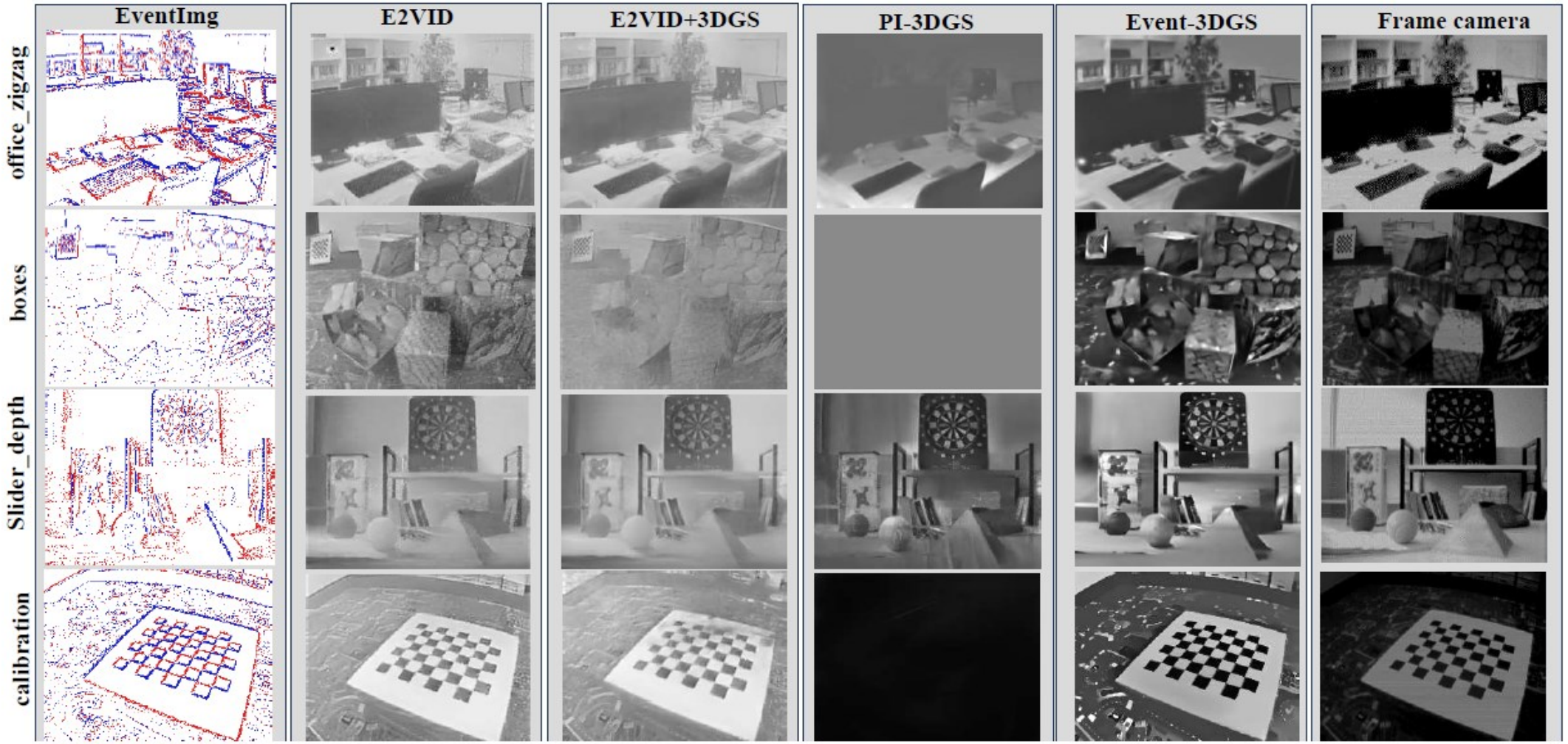
- Our Event3DGS shows significant improvements in reconstruction quality compared to other SOTA methods

Sequence	E2VID [34]			E2VID [34]+3DGS [15]			PI-3DGS			Event-3DGS		
	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS	SSIM	PSNR	LPIPS
mic	0.938	19.965	0.048	0.946	19.955	0.068	0.955	21.979	0.060	0.952	21.127	0.063
ship	0.808	16.556	0.108	0.825	16.681	0.122	0.792	16.750	0.177	0.818	17.815	0.147
materials	0.872	18.302	0.084	0.885	18.325	0.094	0.925	20.053	0.062	0.933	20.506	0.060
lego	0.883	19.744	0.075	0.899	20.002	0.084	0.928	23.853	0.056	0.925	23.046	0.058
ficus	0.932	19.795	0.043	0.935	19.626	0.056	0.939	19.880	0.050	0.940	19.939	0.049
drums	0.908	18.312	0.071	0.915	18.288	0.085	0.953	22.643	0.041	0.951	22.568	0.042
chair	0.939	23.842	0.040	0.949	23.866	0.050	0.954	27.024	0.042	0.953	27.336	0.050
Average	0.897	19.502	0.067	0.908	19.535	0.080	0.921	21.740	0.070	**0.925**	**21.762**	**0.067**



3DGS for Event-based 3D Reconstruction

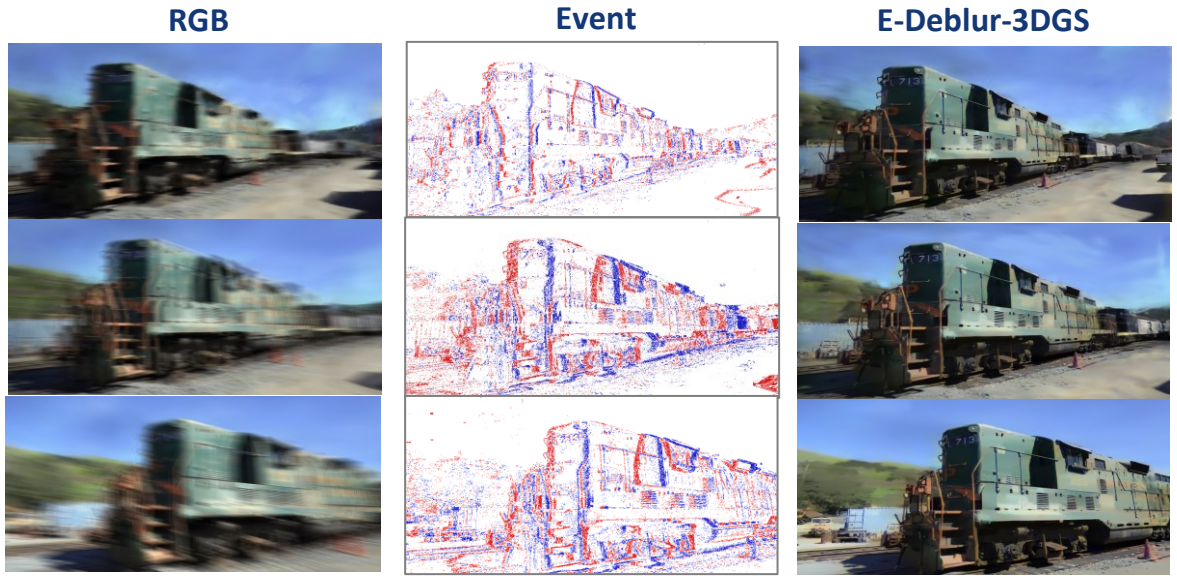
- **Experimental Results**
  - Our Event3DGS can reconstruct scenes with higher quality compared to other SOTA methods



3D Reconstruction Results of Real-World Scenes

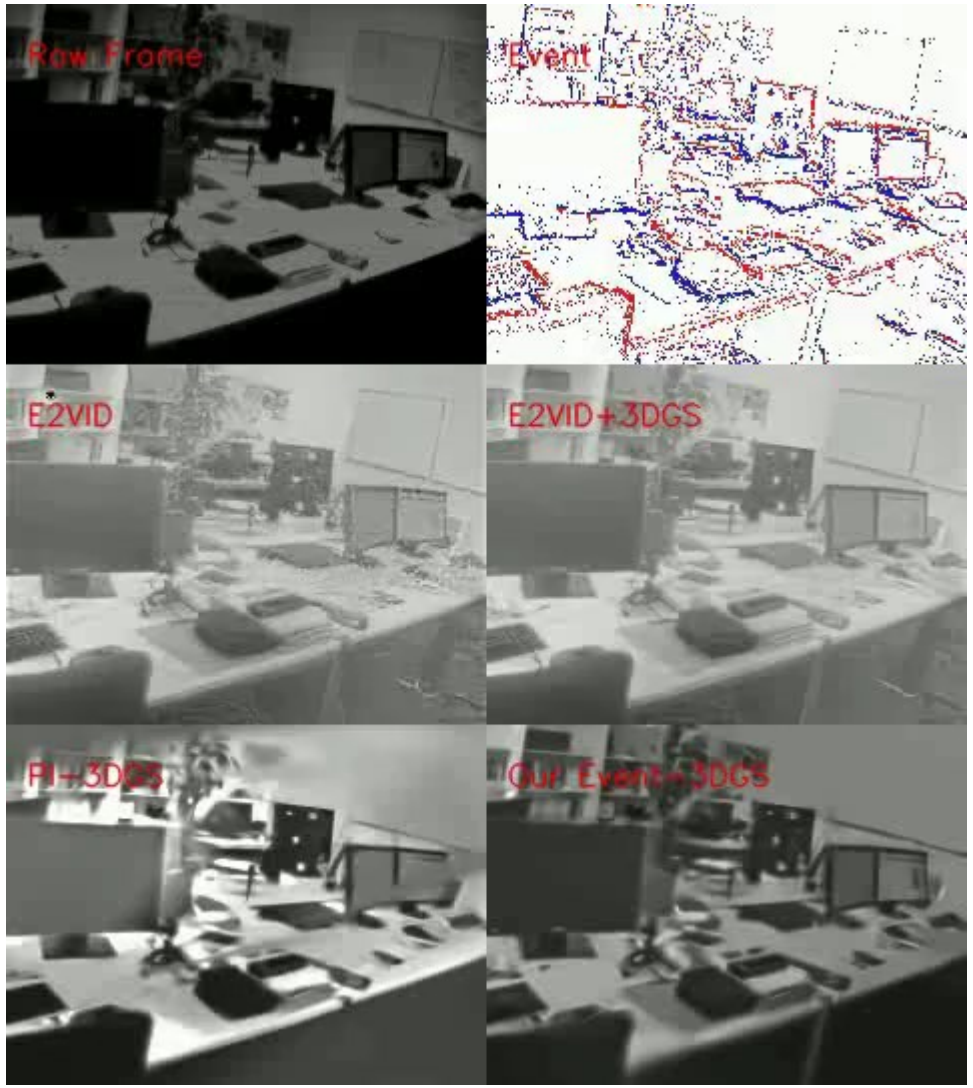
3DGS for Event-based 3D Reconstruction

Experimental Results



Extension: Using Event Data for RGB Deblurring

Extension: Utilizing Multi-channel Event Data for Color Reconstruction



A Demo of 3D Reconstruction Results in an Office Scene