

LiteDVS: A Low-Data-Redundancy Dynamic Vision Sensor with Hybrid Readout and In-Pixel Denoising

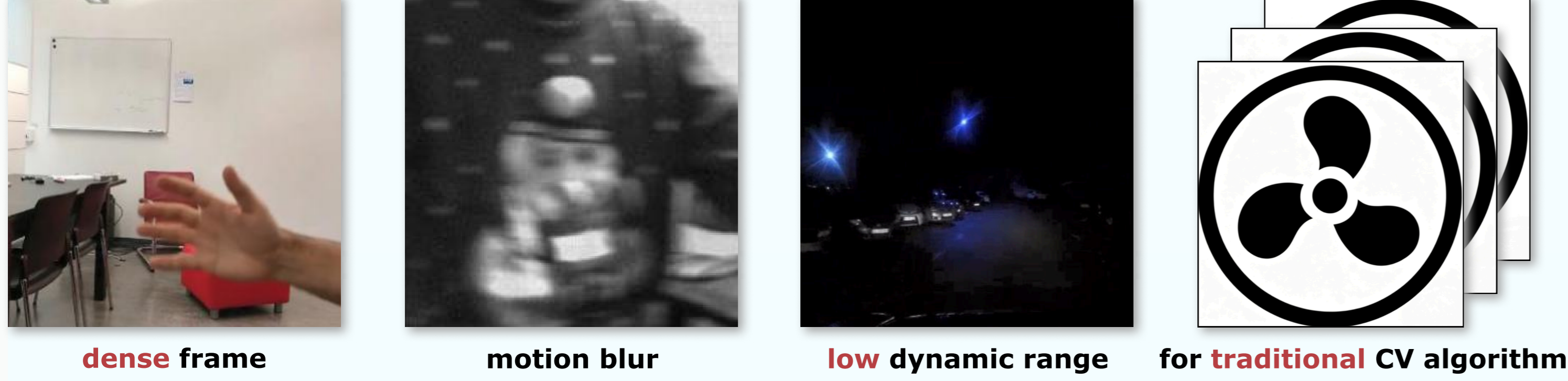
Zichen Kong, Zhongyi Wu, Xiyuan Tang, Yuan Wang



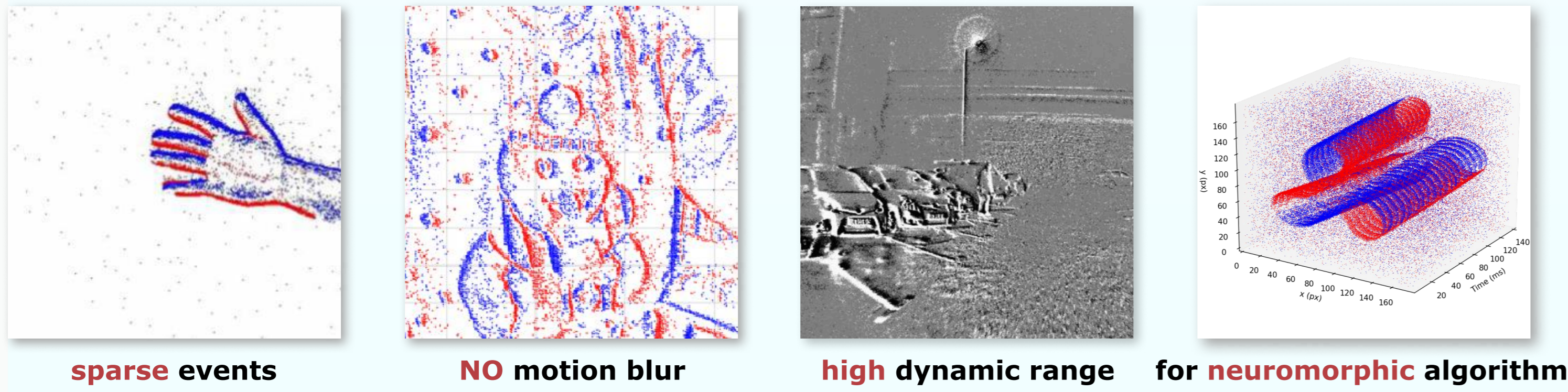
Why Dynamic Vision Sensor (DVS)?

Event-driven vision instead of frame-based imaging. Only brightness changes are captured: **low redundancy, focus on dynamics.**

Frame-Based RGB Image Sensor: (figure source: [1])



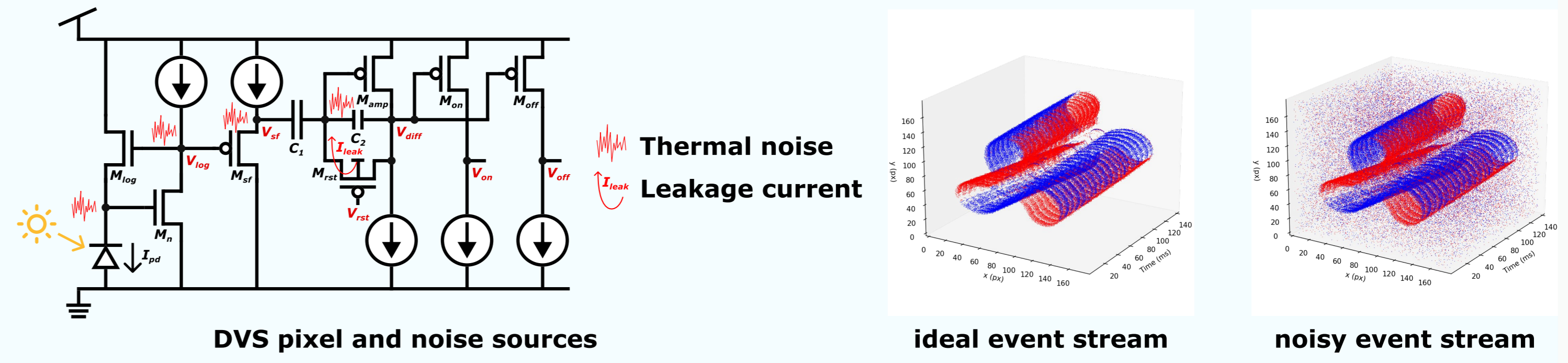
Dynamic Vision Sensor: (figure source: [1])



DVS is not simply a new sensor—it's a new way of seeing dynamic worlds.

Why to Denoise?

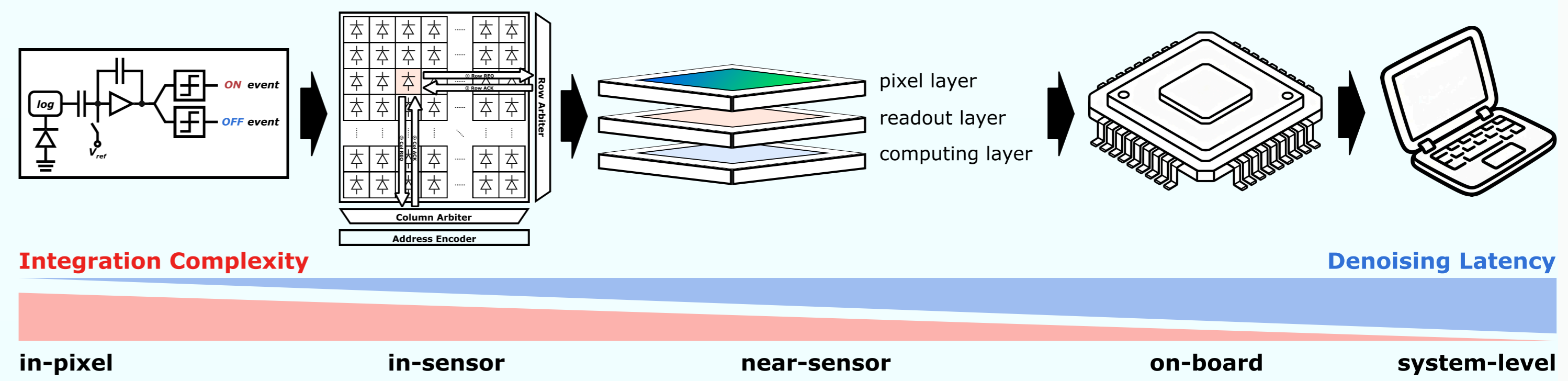
Noise events from non-idealities **degrade data quality and perception reliability.**



Where to Denoise?

The answer is: **as early as possible.**

LiteDVS is **the first to jointly support both event and frame denoising in pixel**, enabling fast, efficient, and tightly integrated front-end noise suppression.



Overview of LiteDVS

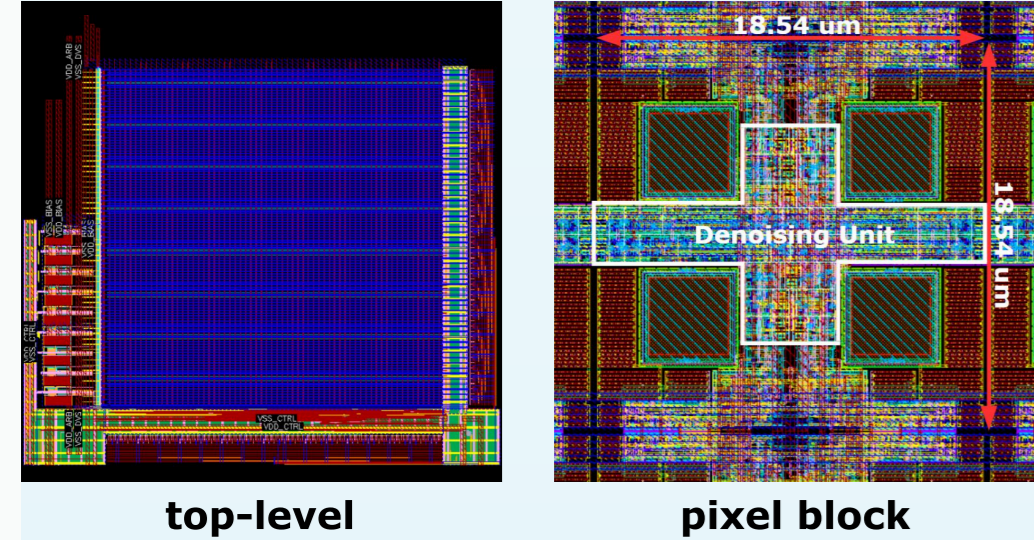
Designed in SMIC 55 nm CMOS and embedded with in-pixel denoising.

Array Organization:
128 × 128 pixels → 64 × 64 blocks
1 shared denoising unit per block

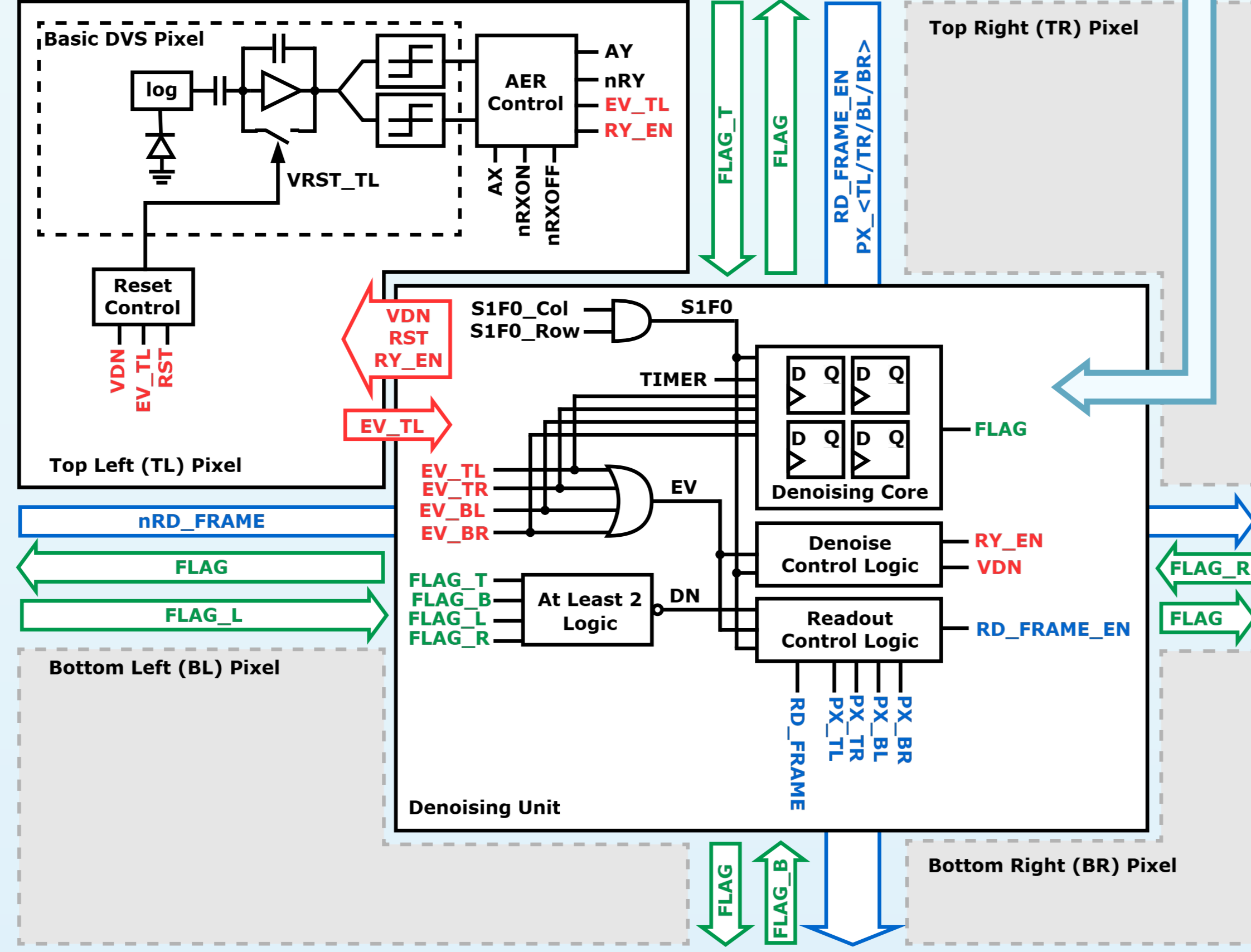
Area Efficiency:
18.54 × 18.54 μm² block size
19.5% filling factor

Shared hardware for dual-mode denoising event-stream + event-frame

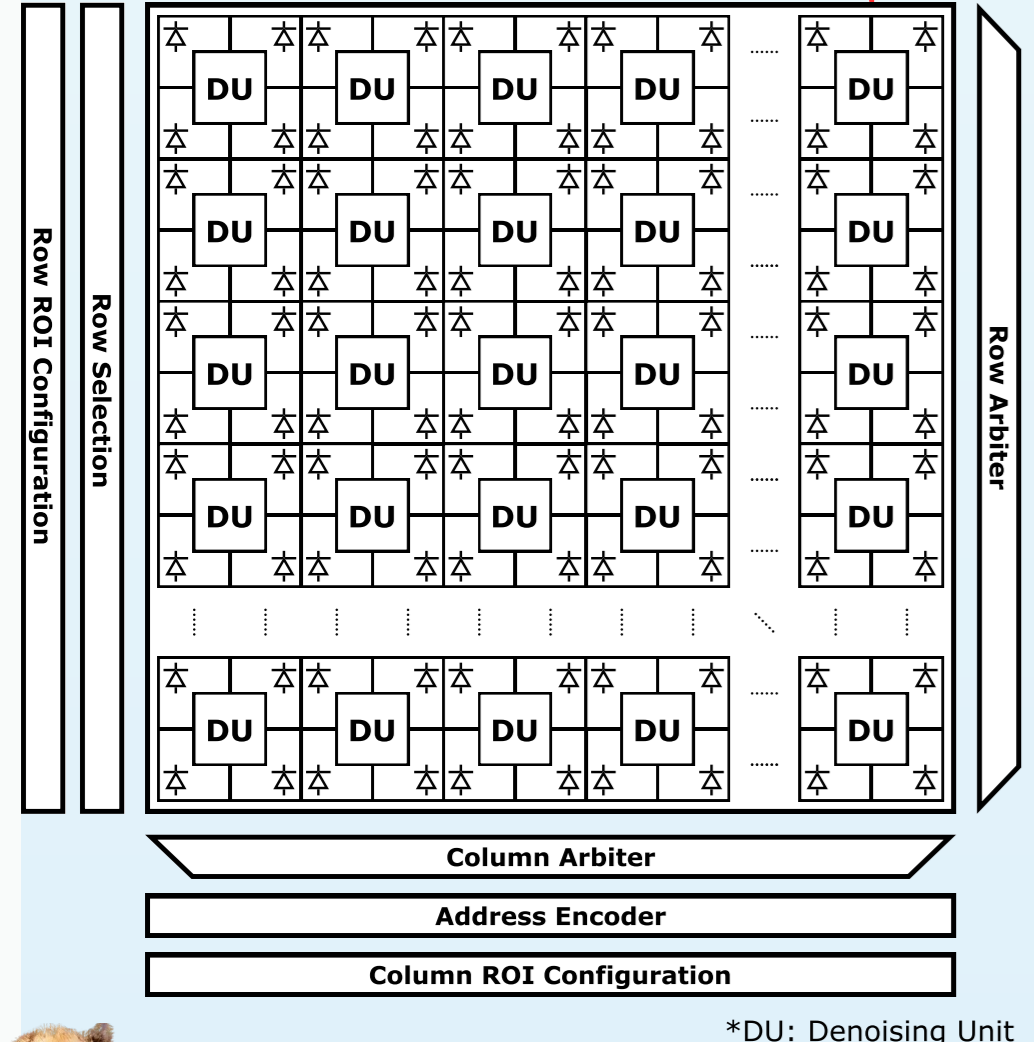
Physical Design:



Architecture of Pixel Block:



Architecture of LiteDVS:

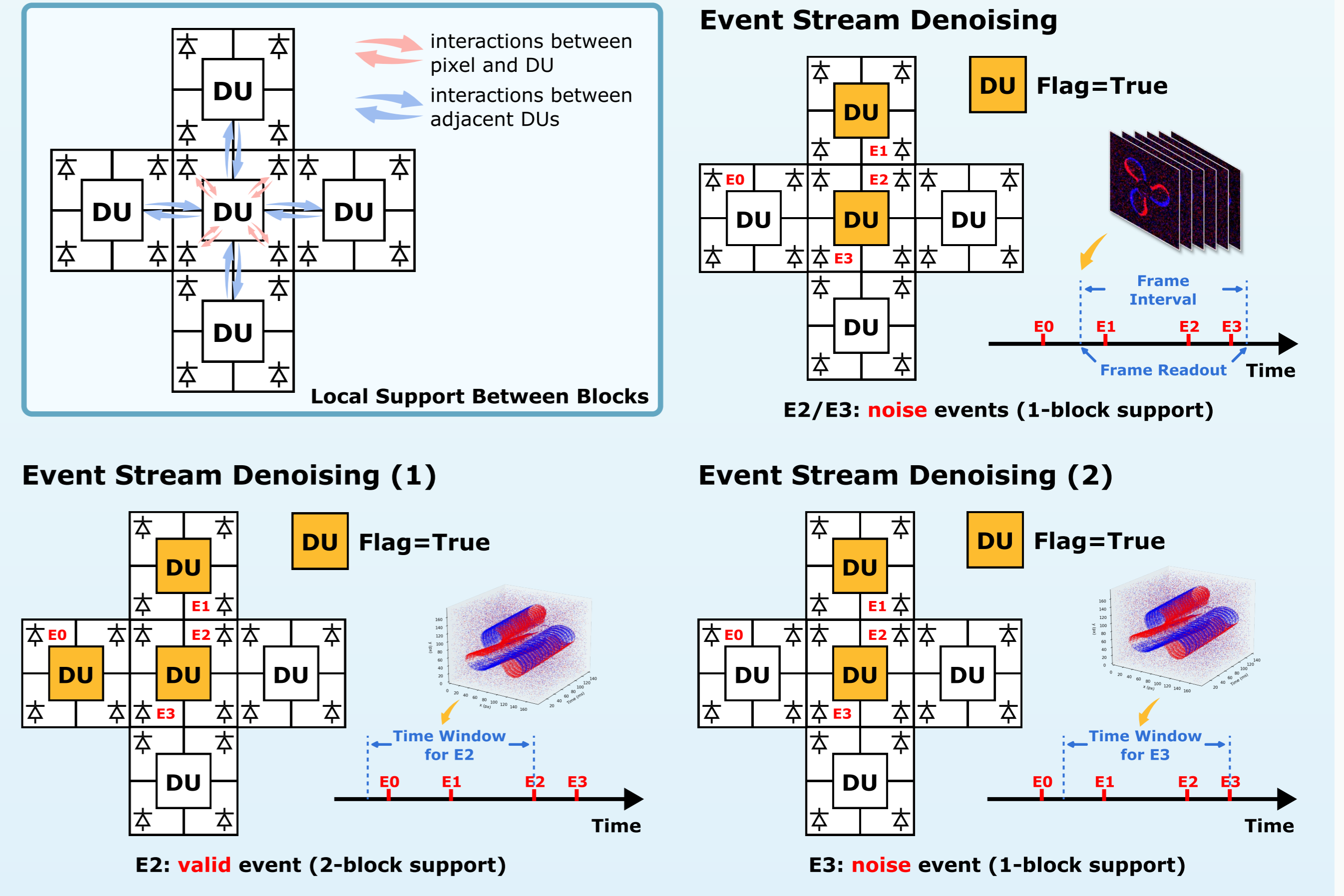


How to Denoise?

Denoising rule: keep an event only if ≥ 2 neighboring blocks are active within a time window.

Block-wise denoising: 4 pixels + 1 denoising unit (DU) per block

Unified dual-mode logic: same criterion for event stream and event frame



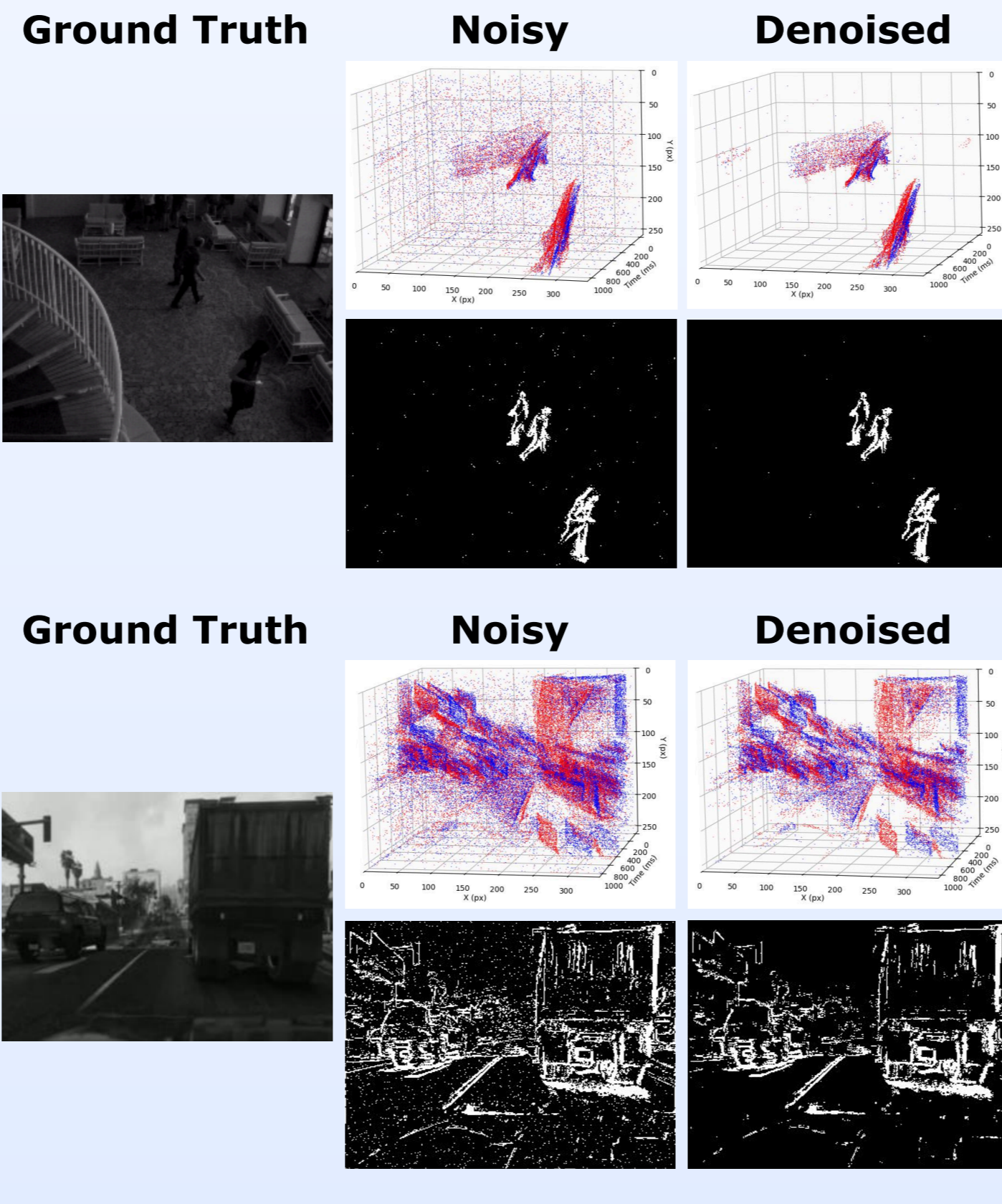
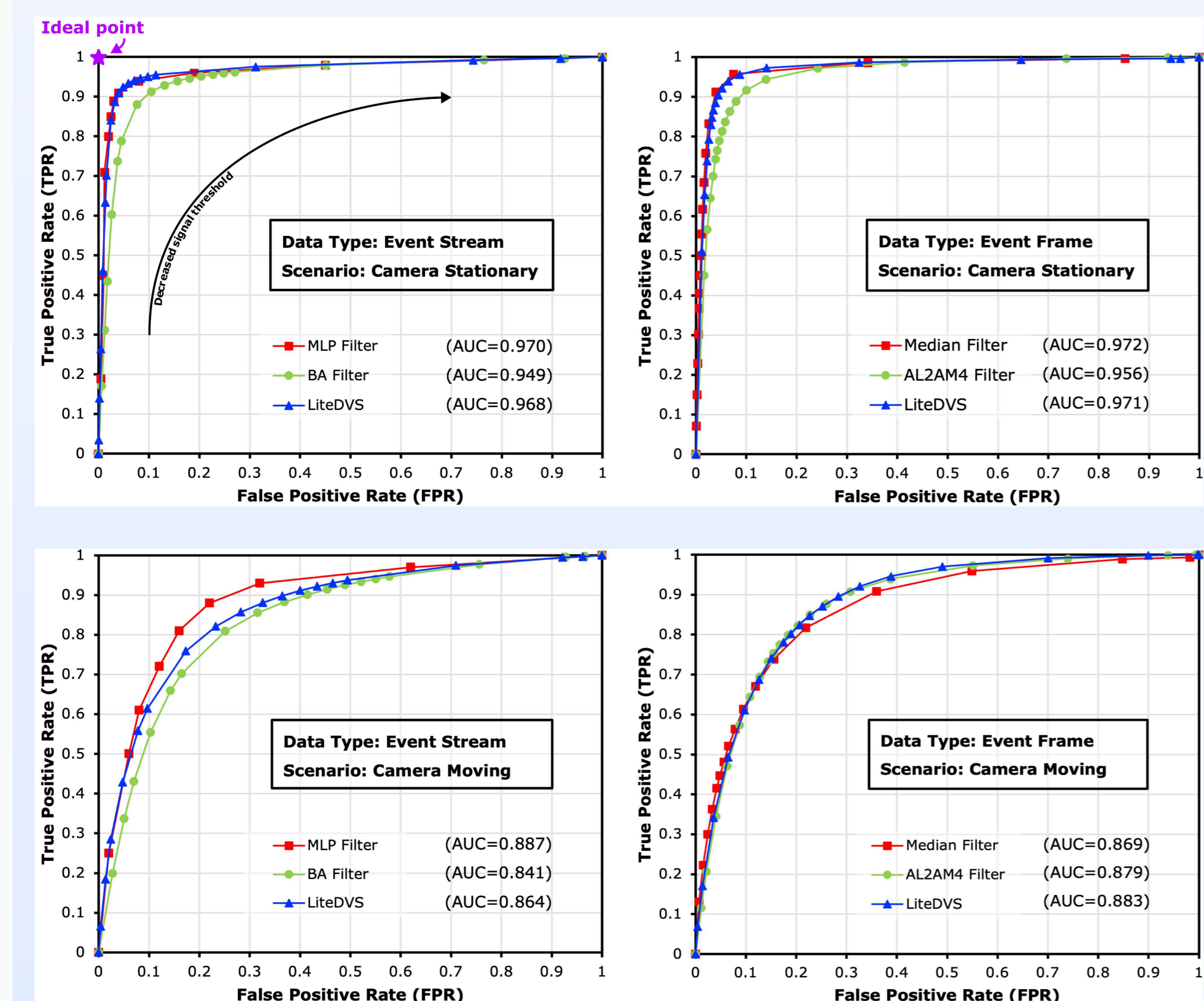
Experimental Results

Robust denoising across scenarios and data formats

Scenarios: stationary (hotel-bar [2]) & moving (driving [2])
Data types: event stream & event frame

AUC summarizes denoising performance across time-window settings (higher is better).

High AUC across all settings
• stationary & moving scenes
• event stream & event frame
Robust and unified denoising



Conclusion

Unified in-pixel denoising with **low energy and area overhead**

- 317 and 41.8 fJ per event for stream and frame denoising, respectively
- 19.5% fill factor for efficient compact in-pixel integration
- Circuit-level results further verify effective hardware deployment

Data Type	This Work		ISCAS' 2015	CVPRW' 2023	JSSC' 2022	VLSI' 2019	Noisy:	Denoised:
	event stream	event frame	event stream	event stream	event frame	event frame		
Algorithm	Modified STCF	Modified STCF	BA Filter	MLP Filter	Median Filter	AL2AM4 Filter		
Implementation	ASIC	ASIC	ASIC	FPGA/ASIC	ASIC	ASIC		
where to denoise	in pixel	in pixel	out-of pixel	out-of pixel	out-of pixel	in pixel		
Technology	55nm	55nm	180nm	65nm	65nm	65nm		
Pixel Pitch(μm)	9.27	9.27	—	—	—	10		
Filling Factor (%)	19.5	19.5	—	—	—	20		
Cell array	128×128	128×128	—	346×260	320×240	132×104		
Denoising Energy (fJ/event)	317/41.8	317/41.8	1.00 × 10 ⁶ @1MPS	~4.00 × 10 ⁶	39	—		
Denoising Latency (ms)	0~	0~	—	43/40	—	—		
AUC	Stationary: 0.864	Moving: 0.883	0.841	0.887	0.869	0.879		
	Stationary: 0.968	Moving: 0.971	0.949	0.970	0.972	0.956		

(simulation results)

To Step Further

- Unified information representation for event-frame fusion
- Optimal visual data utilization for hybrid sensing
- New sensing-computing co-design paradigms

References

- [1] D. Scaramuzza, "Event Cameras: Opportunities and the Road Ahead," presented at CVPR, 2020.
- [2] S. Guo and T. Delbruck, "Low Cost and Latency Event Camera Background Activity Denoising," T-PAMI, 2022.

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