DATE 26

DESIGN, AUTOMATION AND TEST IN EUROPE

THE EUROPEAN EVENT FOR ELECTRONIC SYSTEM DESIGN & TEST

20 – 22 APRIL 2026
VERONA, ITALY

PALAZZO DELLA GRAN GUARDIA

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

Zichen Kong, Zhongyi Wu, Xiyuan Tang, Yuan Wang

Peking University

Outline

- **Introduction**
- Proposed LiteDVS
- Experimental Results
- Conclusion

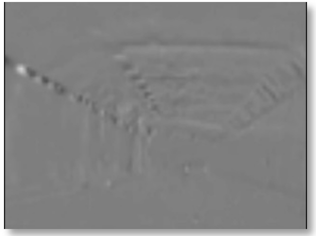
Introduction

➢ Why Dynamic Vision Sensor (DVS)?

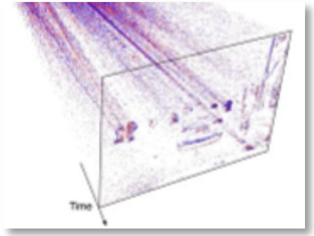
- Event-driven vision instead of frame-based imaging.
- Only brightness changes are captured: low redundancy, focus on dynamics

sparse events

high frame rate



high dynamic range

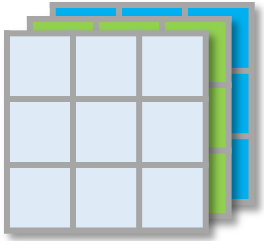


for neuromorphic CV

dense frame

low frame rate

low dynamic range



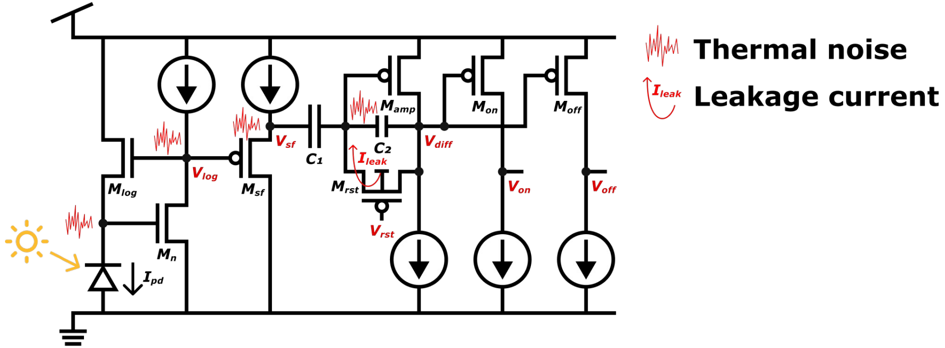
for traditional CV

D. Scaramuzza, “Event Cameras: Opportunities and the Road Ahead,” presented at CVPR, 2020.

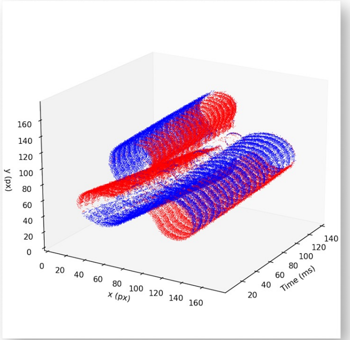
Introduction

➤ Why to Denoise?

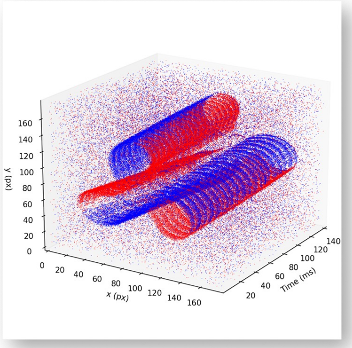
- DVS noise generates spurious events and degrades event stream quality and visual perception reliability.
- It mainly stems from dark current, thermal noise, device mismatch.



DVS pixel and noise sources



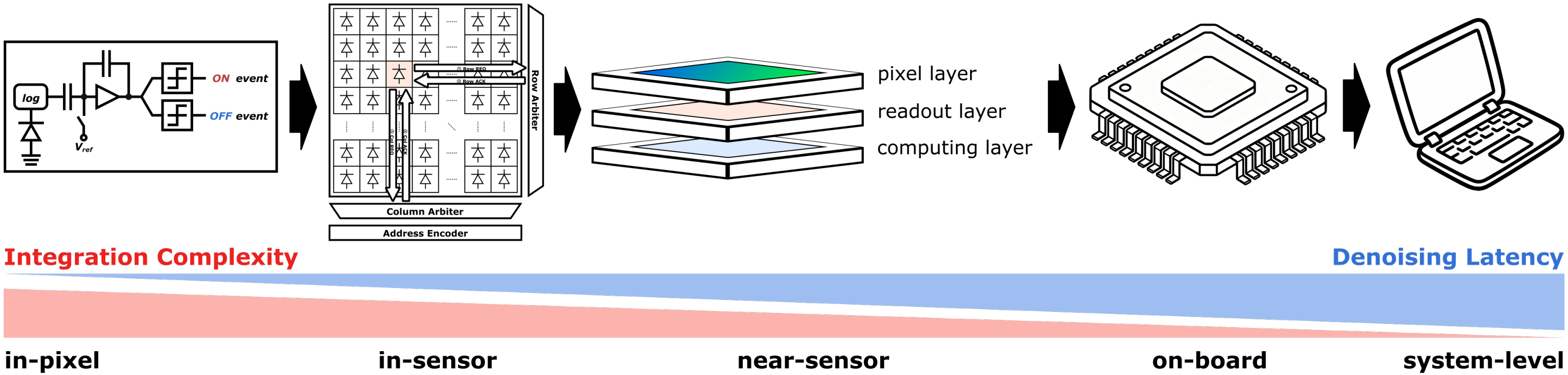
ideal event stream



noisy event stream

Introduction

➢ **Where to Denoise?**

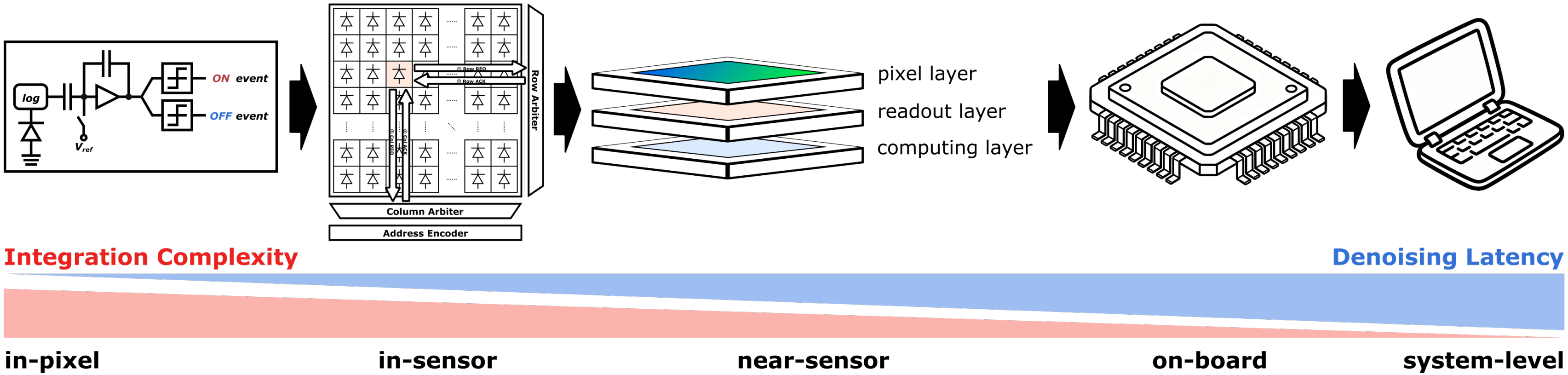


Introduction

➢ Where to Denoise?

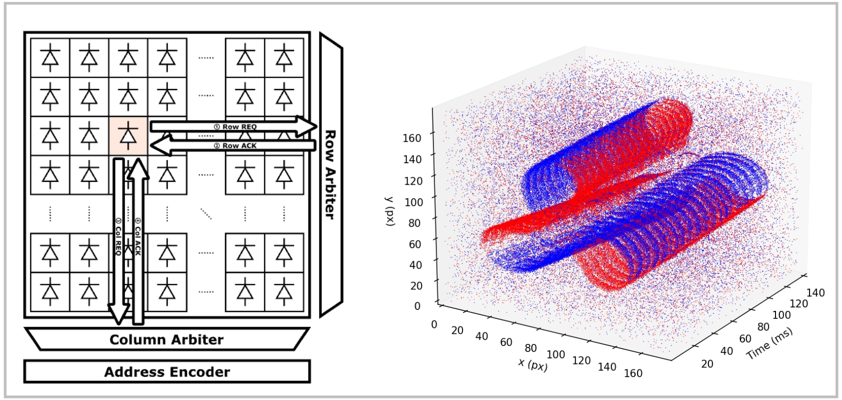
- The answer is:

AS EARLY AS POSSIBLE

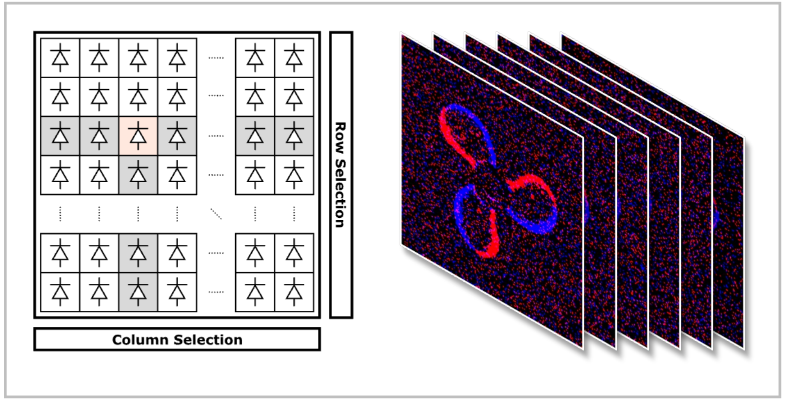


➢ What to Denoise?

- There are mainly two types of readout methods for dynamic vision sensors:
  - Event-mode: For latency-sensitive applications such as obstacle avoidance
  - Frame-mode: For traditional CV algorithms



event-mode



frame-mode

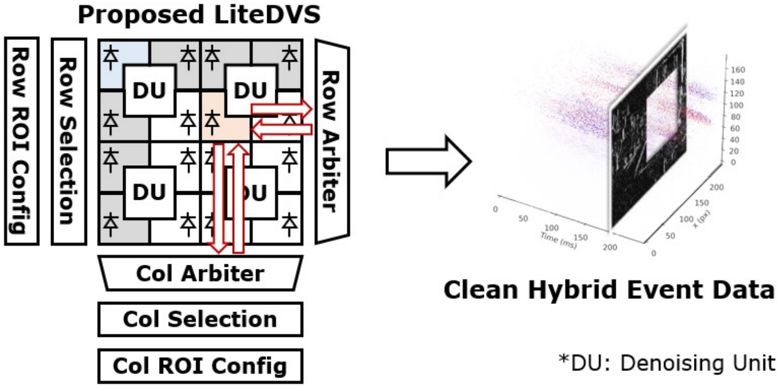
Outline

- Introduction
- **Proposed LiteDVS**
- Experimental Results
- Conclusion

Proposed LiteDVS

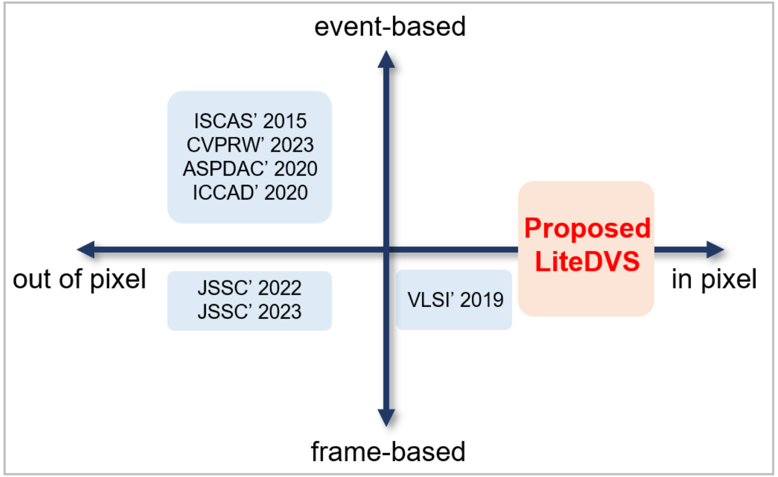
➢ Dual-Mode In-Pixel Denoising

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



*DU: Denoising Unit

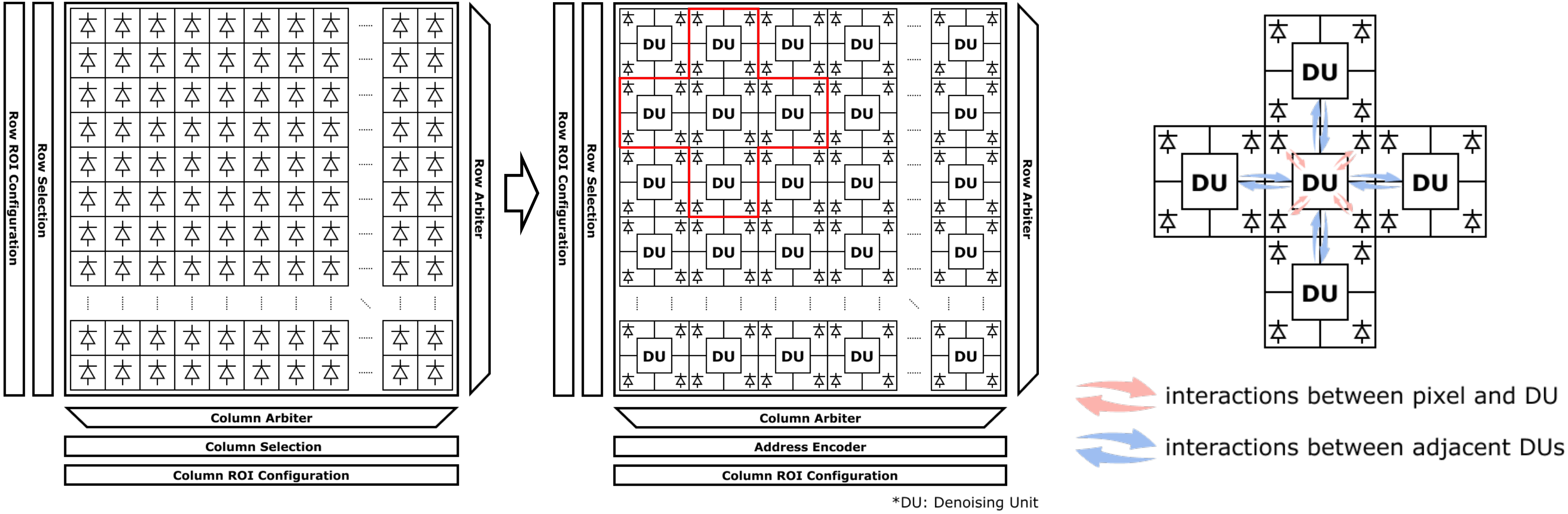
DVS denoising works implemented on hardware



Proposed LiteDVS

➢ How to Denoise?——Block-Wise Denoising Strategy

- DU interacts with adjacent DUs and the pixels within its own block.

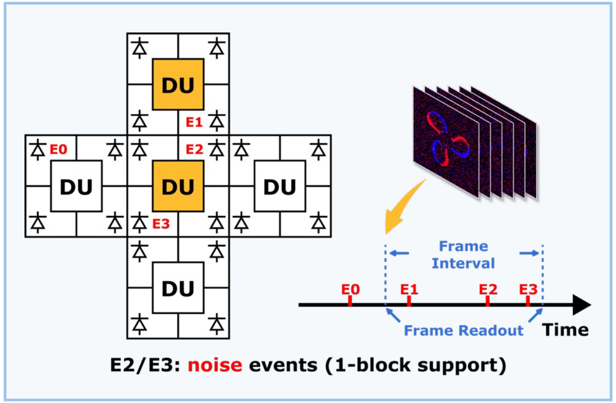


Proposed LiteDVS

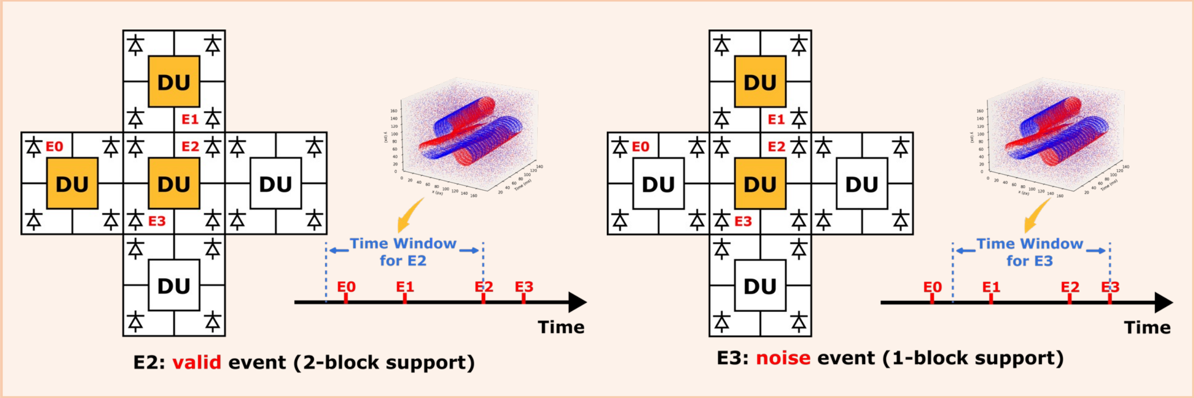
➢ How to Denoise?

- **Denoising rule:** keep an event only if ≥ 2 neighboring blocks are active within a time window
- **Unified dual-mode logic:** same criterion for event stream and event frame

Event Frame Denoising:



Event Stream Denoising:



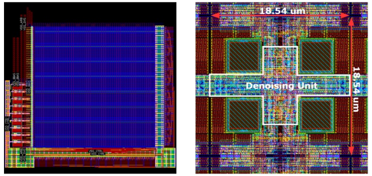
DU Flag=True

Proposed LiteDVS

➢ Circuit Implementation

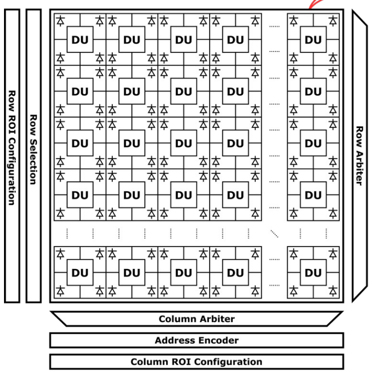
- Designed in SMIC 55 nm CMOS and embedded with in-pixel denoising.
- 128 × 128 pixels → 64 × 64 blocks

Layout of LiteDVS:



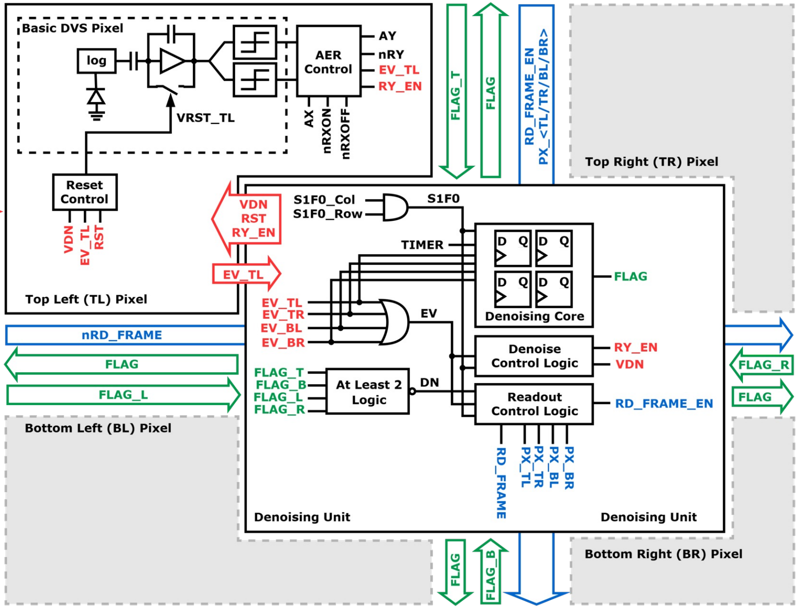
top-level   pixel block

Architecture of LiteDVS:



*DU: Denoising Unit

Architecture of Pixel Block:



Area Efficiency:

18.54 × 18.54 μm² block size

19.5% filling factor

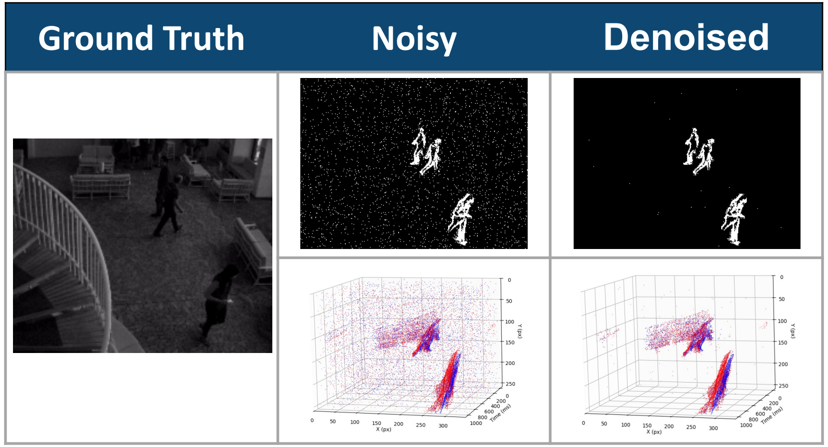
Outline

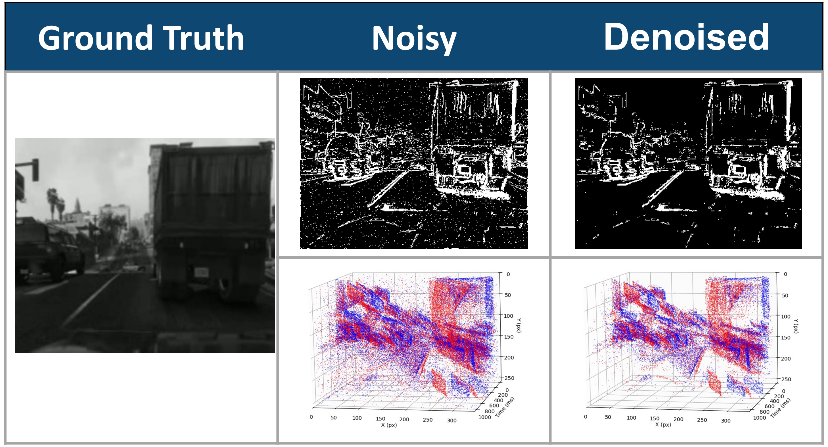
- Introduction
- Denoising Algorithm
- **Experimental Results**
- Conclusion

Experimental Results

➢Robust Denoising Across Scenarios and Data Formats

- ✓ Camera stationary & moving scenes
- ✓ event stream & event frame





S. Guo and T. Delbruck, "Low Cost and Latency Event Camera Background Activity Denoising," T-PAMI, 2022.

Experimental Results

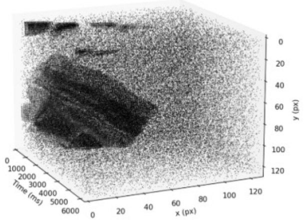
➢In-Pixel Denoising with Low Energy and Area Cost

- 317 and 41.8 fJ per event for stream and frame denoising, respectively
- 19.5% filling factor for efficient compact in-pixel integration

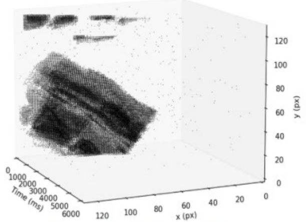
	This Work		ISCAS' 2015	CVPRW' 2023	JSSC' 2022	VLSI' 2019
Data Type	event stream	event frame	event stream	event stream	event frame	event frame
Algorithm	Modified STCF		BA Filter	MLP Filter	Median Filter	AL2AM4 Filter
Implementation	ASIC		ASIC	FPGA/ASIC	ASIC	ASIC
where to denoise	in pixel		out-of pixel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

Noisy Event Frame

Denoised Event Frame



Noisy Event Stream



Denoised Event Stream

Outline

- Introduction
- Denoising Algorithm
- Experimental Results
- **Conclusion**

Conclusion

DATE26

➢ We propose LiteDVS

- **Unified in-pixel denoising** for event stream and event frame
- **Block-wise** algorithm with robust denoising performance
- **Low energy and compact** implementation
- **LiteDVS brings unified denoising into the DVS front end.**

Thanks for your attention!

My Homepage