JUNE 18-22, 2023
CVPR
VANCOUVER, CANADA

Project Page

University of Zurich[UZH]
ETH zürich
Institute of Neuroinformatics

THU-PM-147

Deep Polarization Reconstruction with PDAVIS Events

Haiyang Mei[1,2] Zuowen Wang[2] Xin Yang[1] Xiaopeng Wei[1] Tobi Delbruck[2]

[1] Dalian University of Technology, Dalian, China

[2] Institute of Neuroinformatics, University of Zurich and ETH Zurich, Zurich, Switzerland

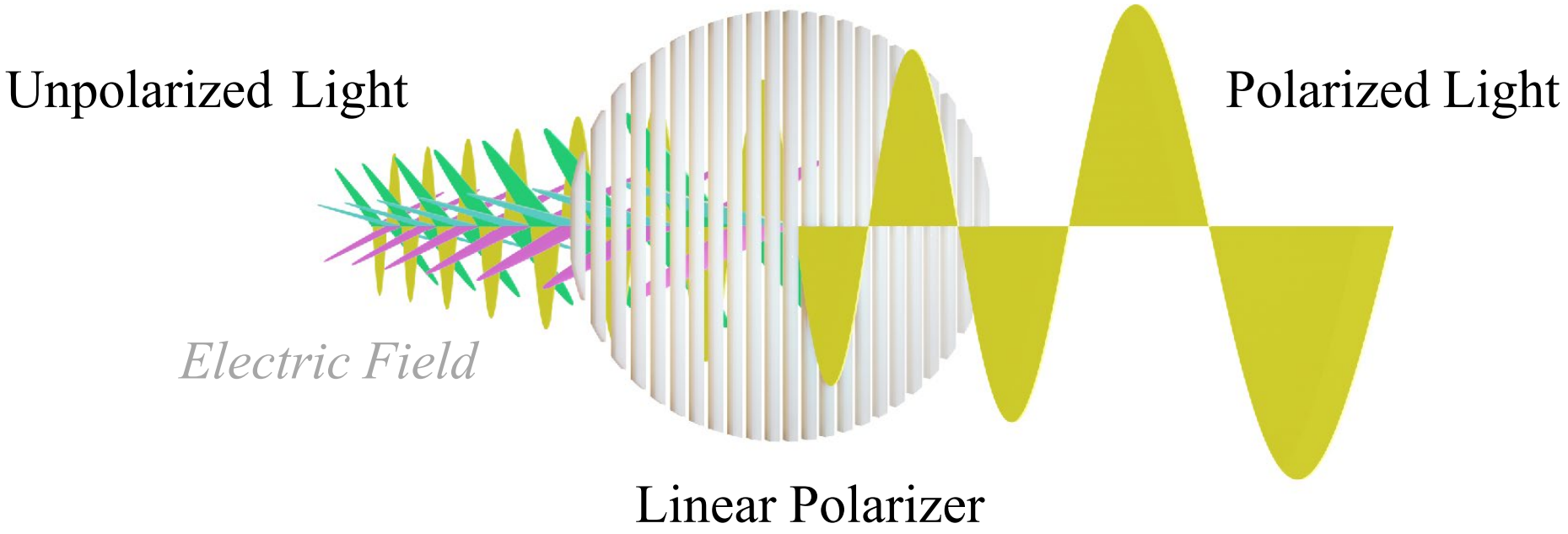
Contact us: tobi@ini.uzh.ch, haiyang.mei@outlook.com, xinyang@dlut.edu.cn

Project Page: https://github.com/SensorsINI/e2p

1. Background --- *Polarization*

University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics

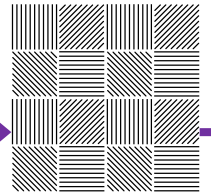
Visual information is encoded in light by intensity, color, and polarization[1]



[1] Cronin, Thomas W., et al. "Visual ecology." Visual Ecology. Princeton University Press, 2014.

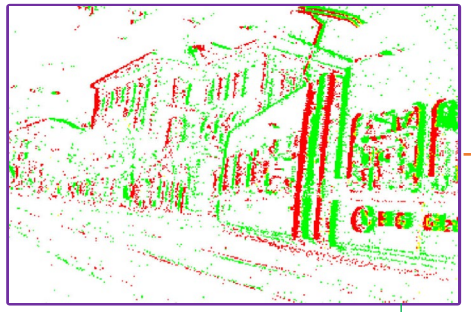
2. Polarization Video Reconstruction

Institute of Neuroinformatics



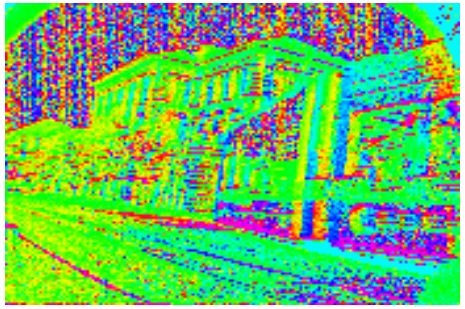
Events

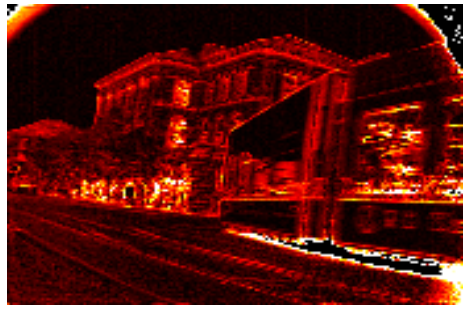
High Dynamic Range
Low Latency

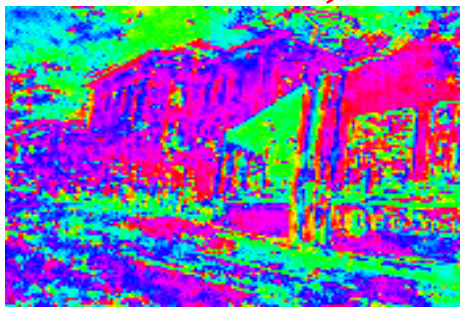


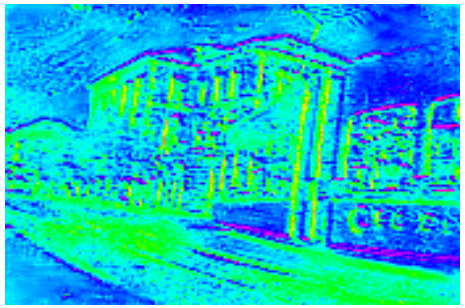
Existing Method

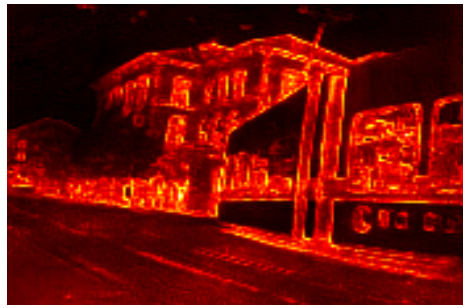
Our Method











Content

University of Zurich[UZH]

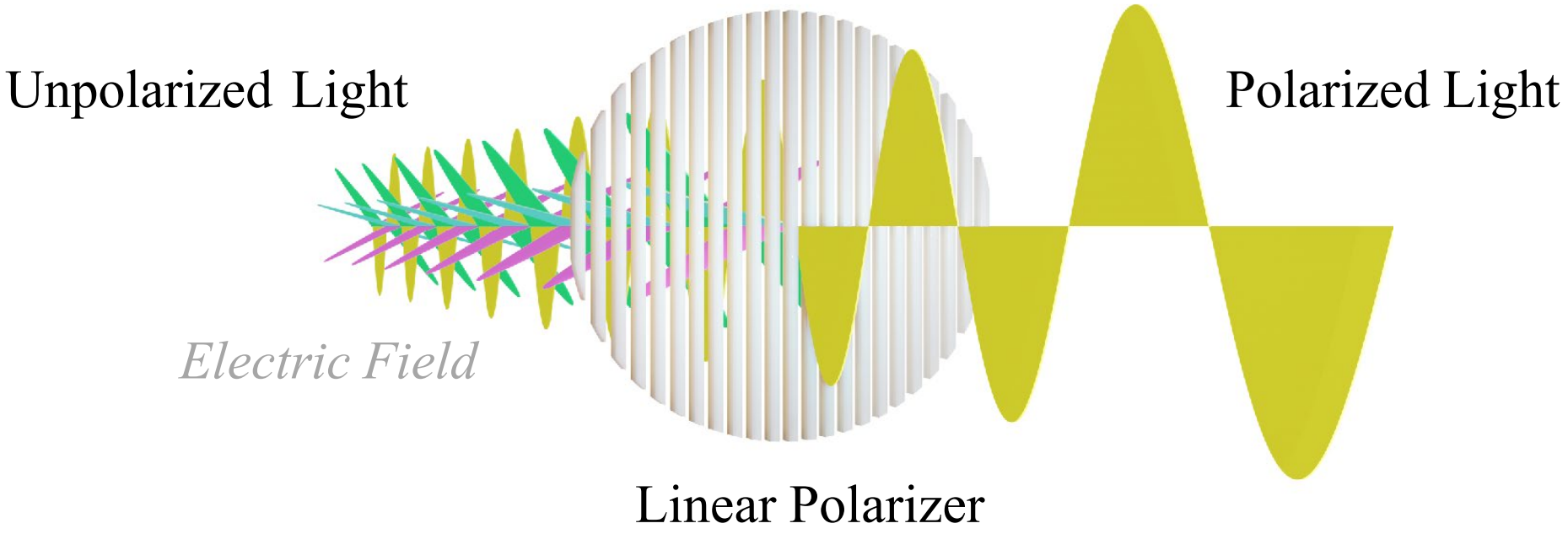
ETH zürich

Institute of Neuroinformatics

1. Background --- *Polarization*

University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics

Visual information is encoded in light by intensity, color, and polarization[1]

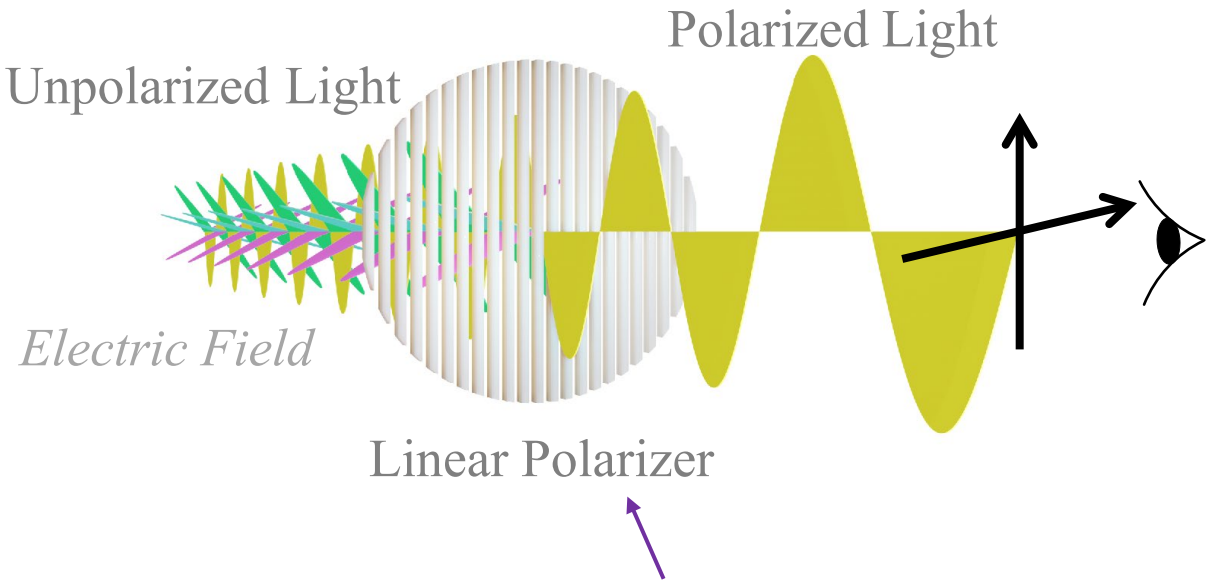


[1] Cronin, Thomas W., et al. "Visual ecology." Visual Ecology. Princeton University Press, 2014.

1. Background --- *Polarization*

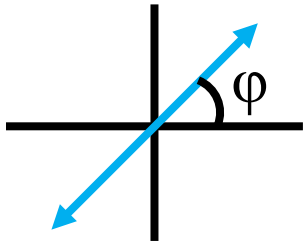
University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics

Visual information is encoded in light by intensity, color, and polarization[1]

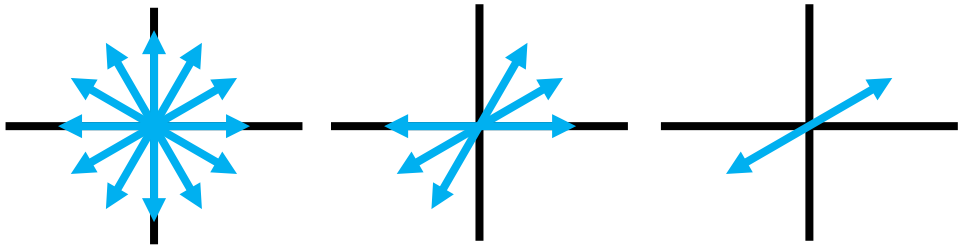


related to the nature of object materials

Angle of Linear Polarization
AoLP



Degree of Linear Polarization
DoLP

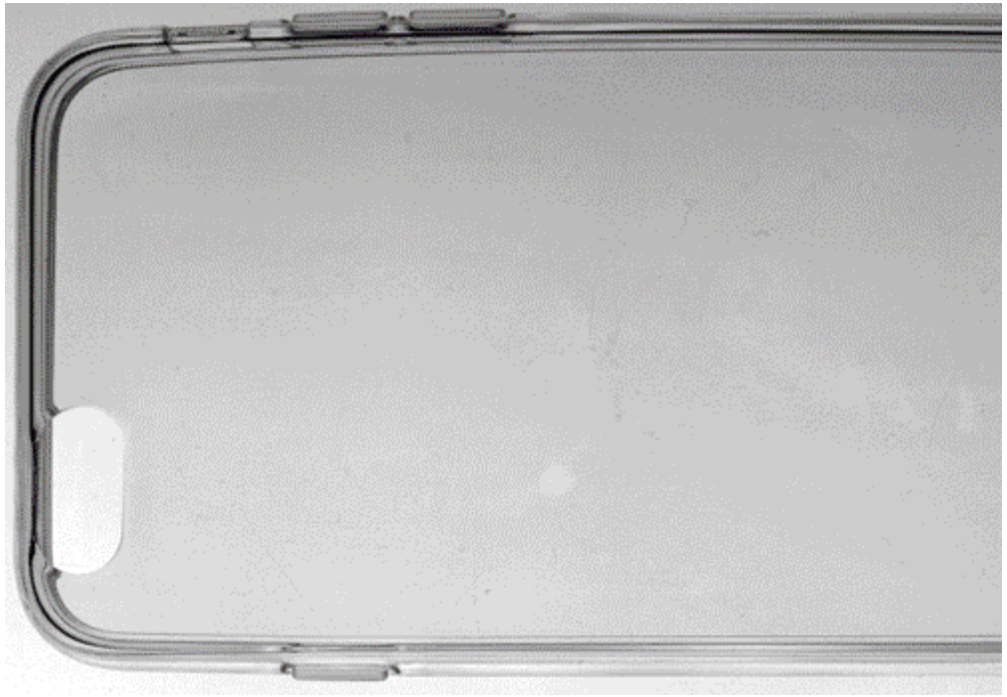


[1] Cronin, Thomas W., et al. "Visual ecology." Visual Ecology. Princeton University Press, 2014.

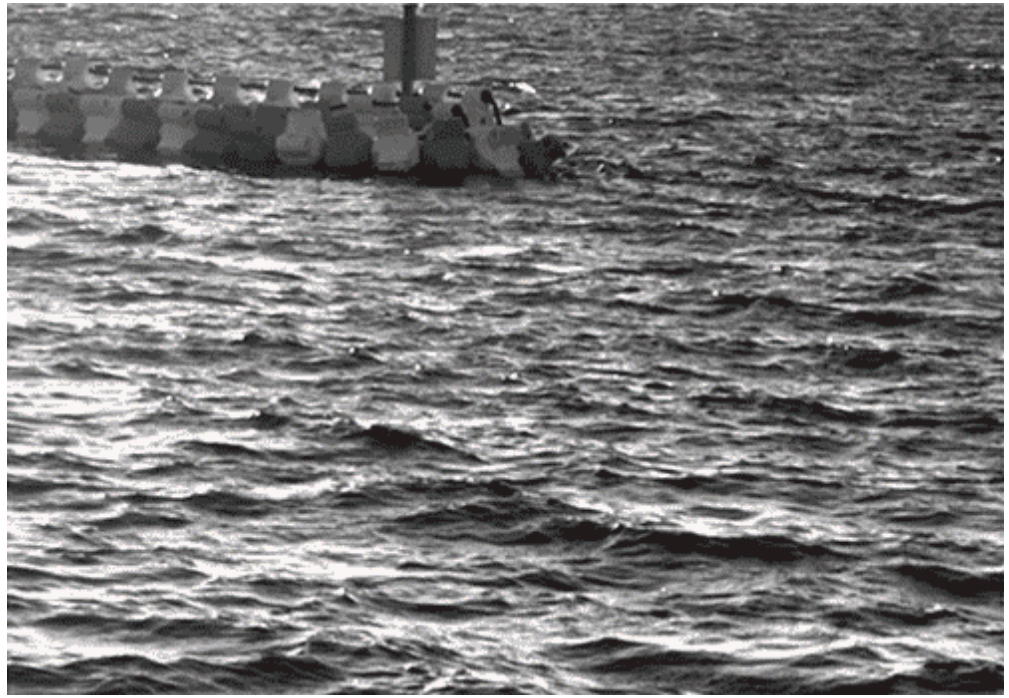
1. Background --- *Polarization*

University of Zurich[UZH]
ETH zürich
Institute of Neuroinformatics

Polarization can reveal intrinsic physical properties of the object.



Defects Inspection



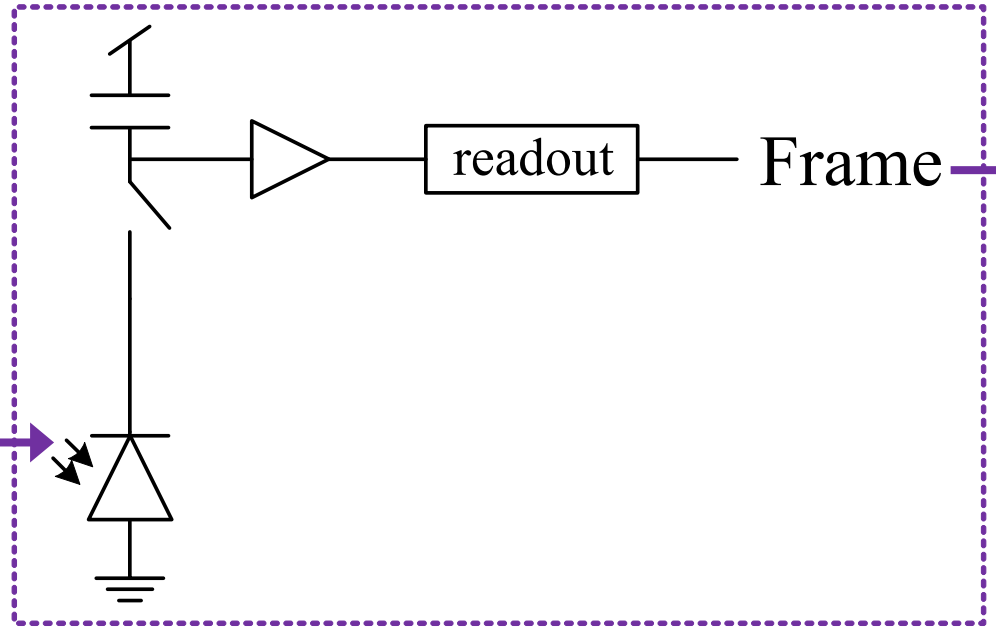
Concealed Object Detection

1. Background --- *Polarization Camera*

University of Zurich[UZH] | ETH zürich

Institute of Neuroinformatics

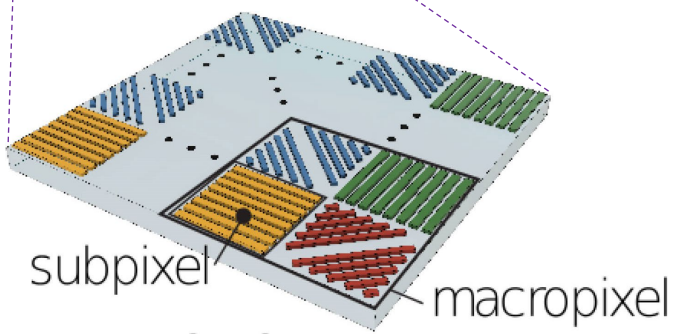
Subpixel Circuit



$I_{90°}$ $I_{45°}$

$I_{135°}$ $I_{0°}$

Polarizer Array



$$S_0 = I_{0°} + I_{90°}$$

$$S_1 = I_{0°} - I_{90°}$$

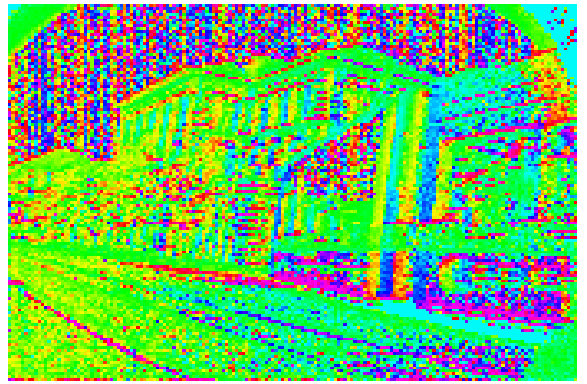
$$S_2 = I_{45°} - I_{135°}$$

$$Intensity = \frac{S0}{2}$$

$$AoLP = \frac{1}{2}\arctan\left(\frac{S_2}{S_1}\right)$$

$$DoLP = \frac{\sqrt{S_1^2 + S_2^2}}{S_0}$$

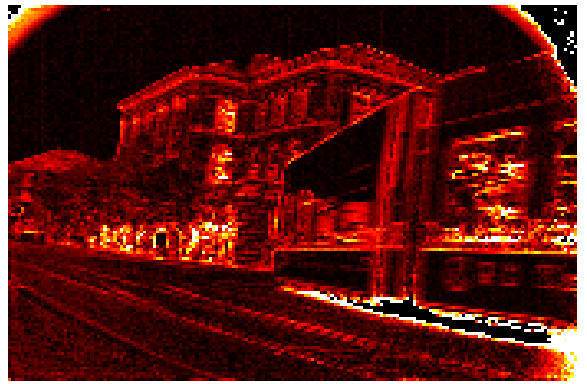
Intensity



AoLP

π/2

0



DoLP

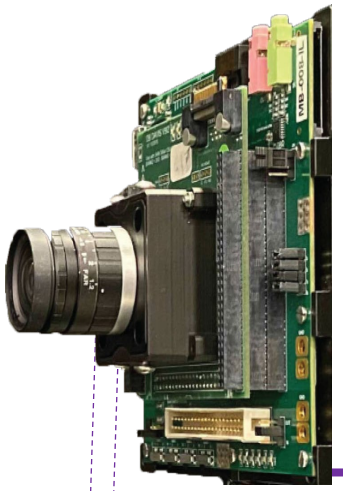
0 1

1. Background --- *Polarization Event Camera*

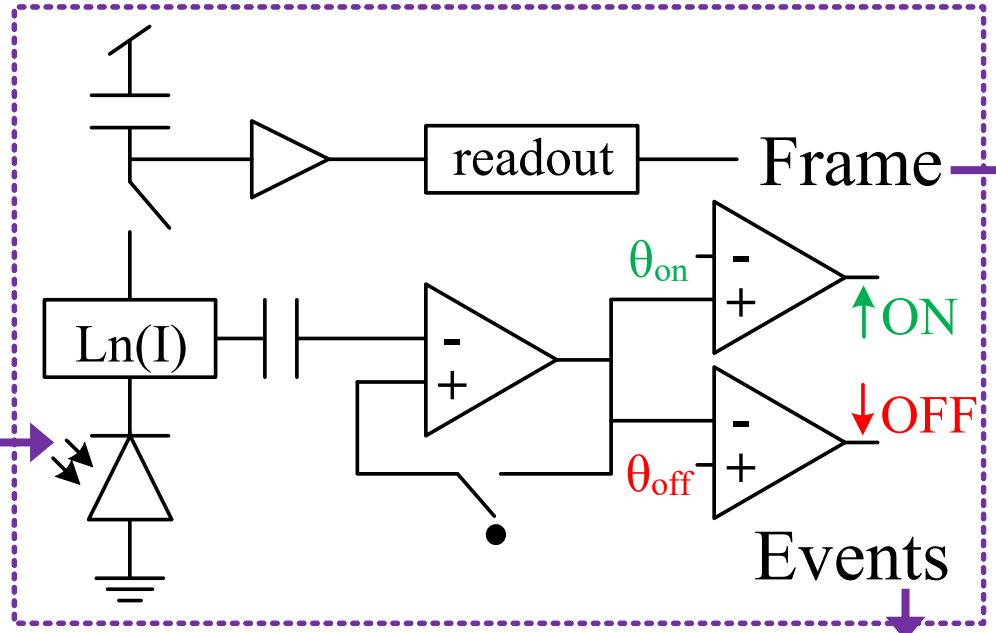
University of Zurich[UZH] | ETH zürich

Institute of Neuroinformatics

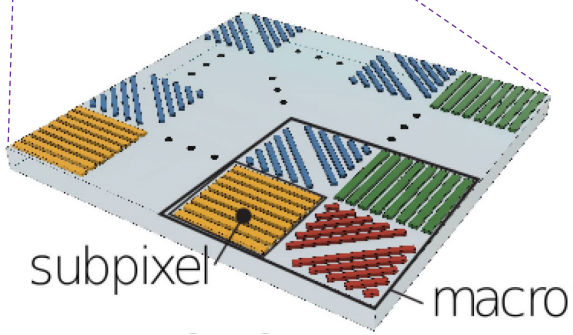
PDAVIS

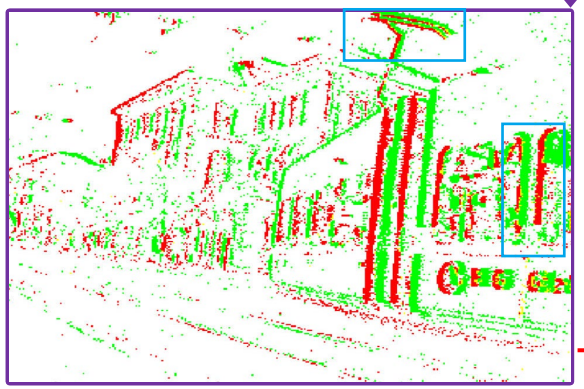


Subpixel Circuit



Polarizer Array

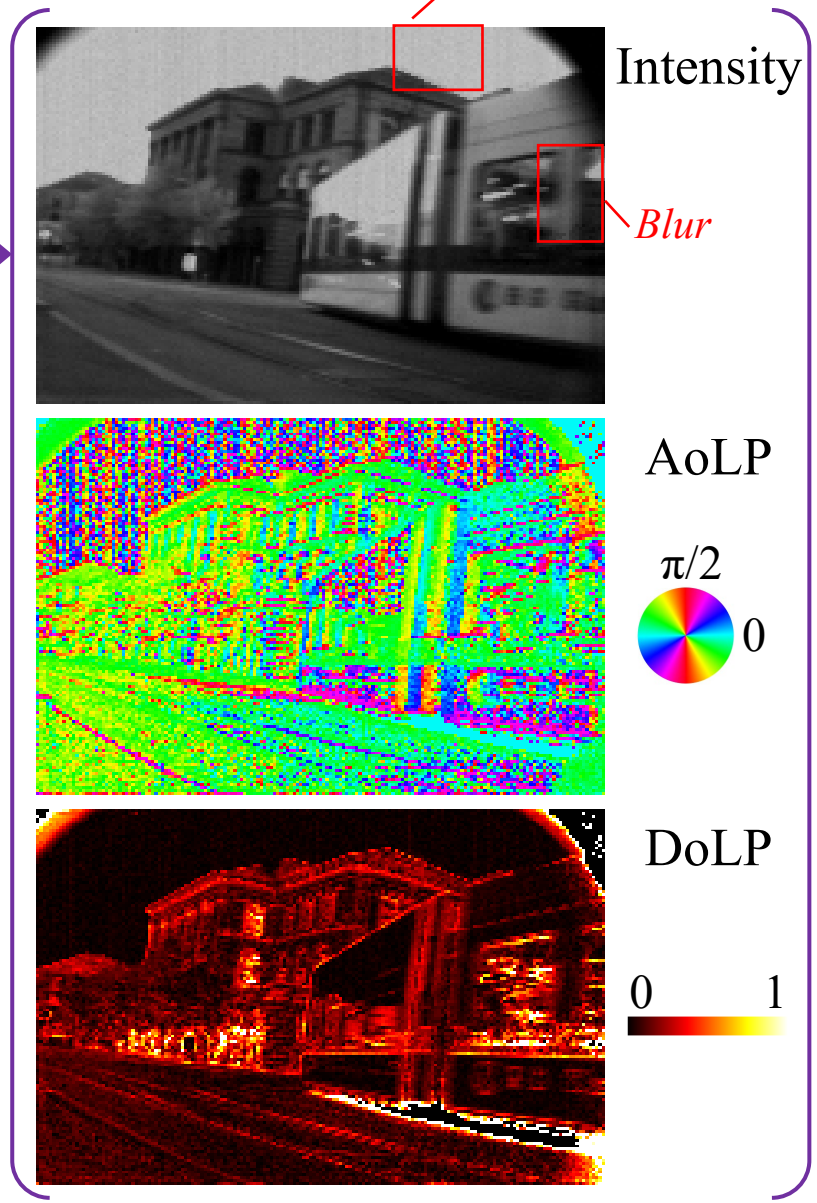




High Dynamic Range, Low Latency.

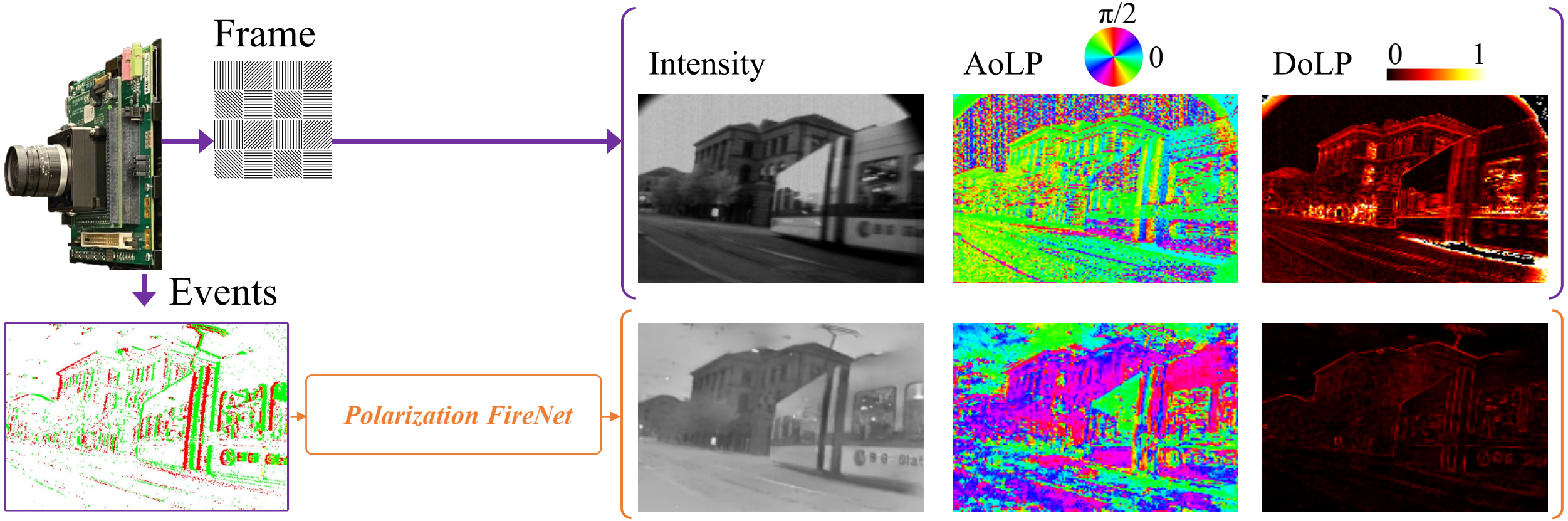
Not friendly to observation and traditional computer vision.

better ?



2. Polarization Video Reconstruction

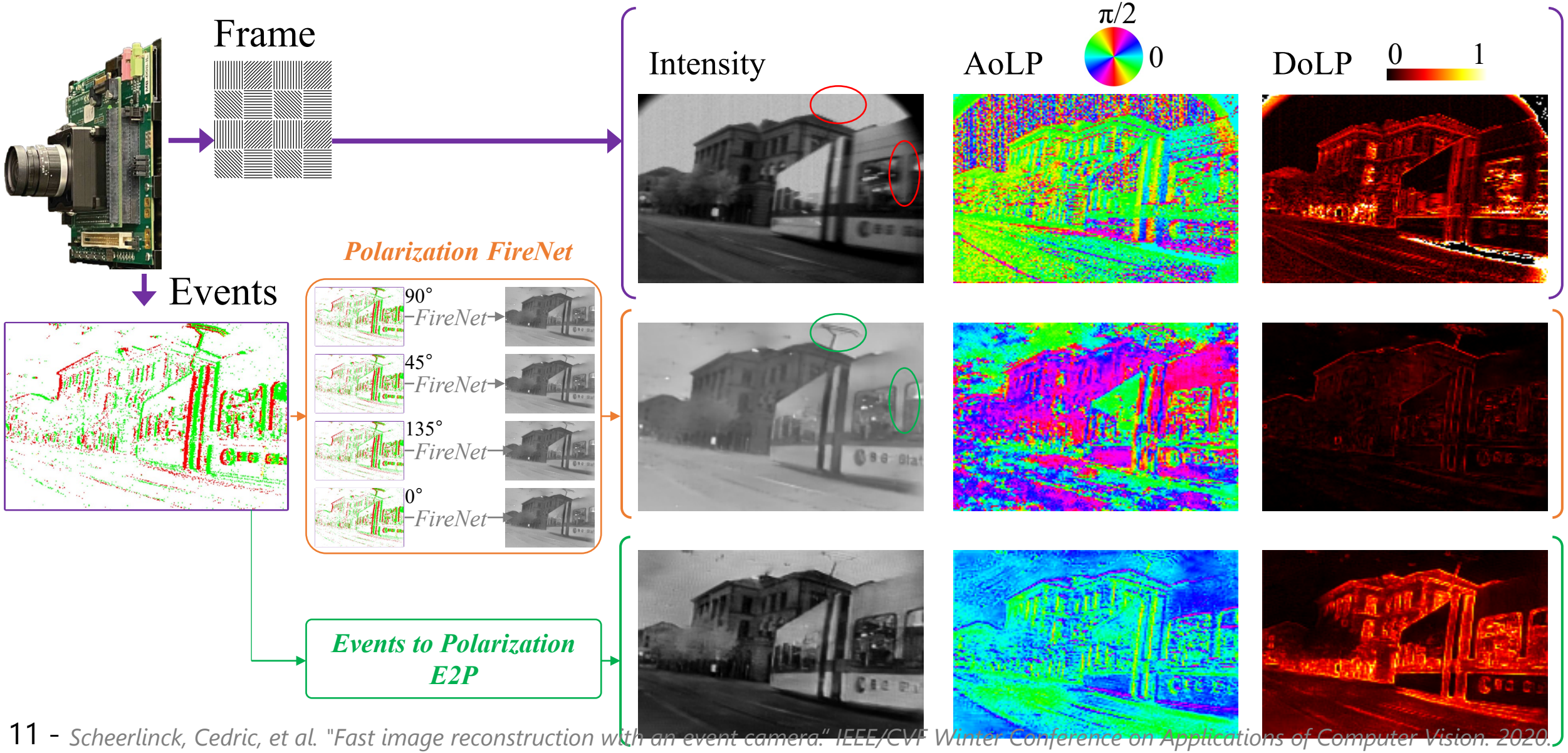
University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics



Scheerlinck, Cedric, et al. "Fast image reconstruction with an event camera." IEEE/CVF Winter Conference on Applications of Computer Vision. 2020.

2. Polarization Video Reconstruction

University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics



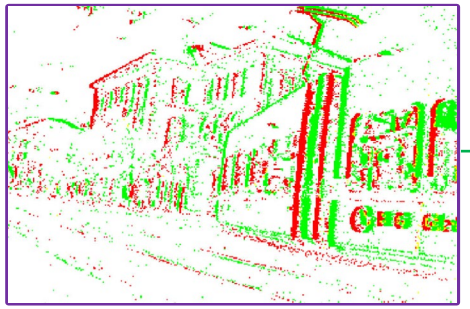
Scheerlinck, Cedric, et al. "Fast image reconstruction with an event camera." IEEE/CVF Winter Conference on Applications of Computer Vision. 2020.

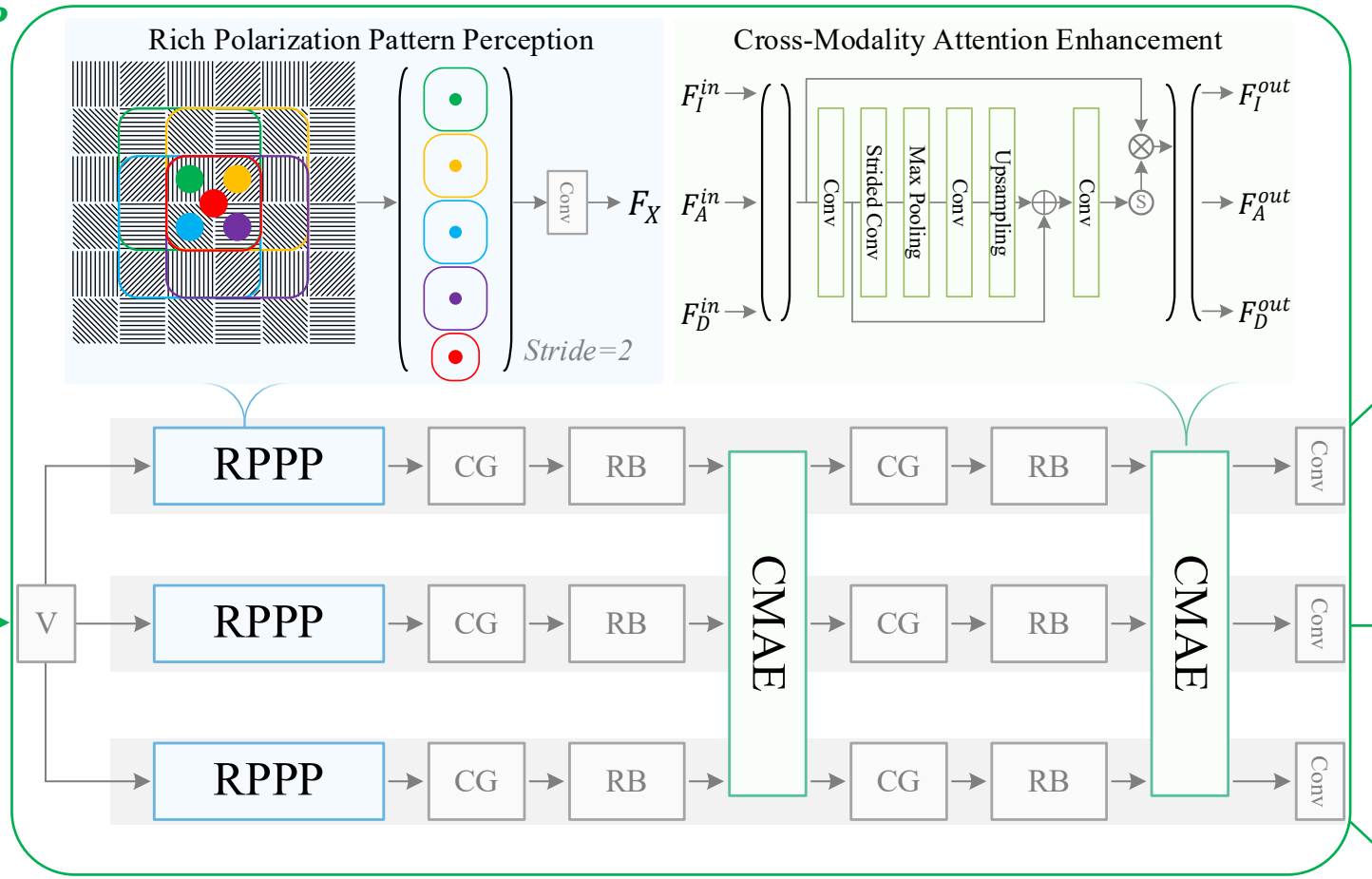
2. Polarization Video Reconstruction

University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics

Events to Polarization
E2P

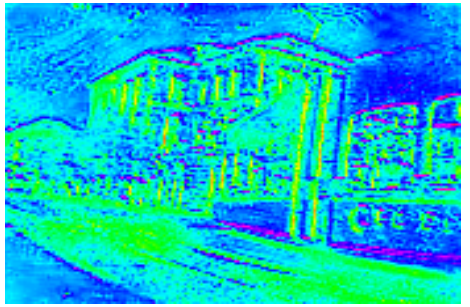
Events



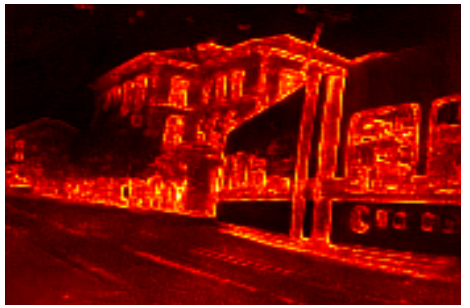


Intensity

AoLP



DoLP



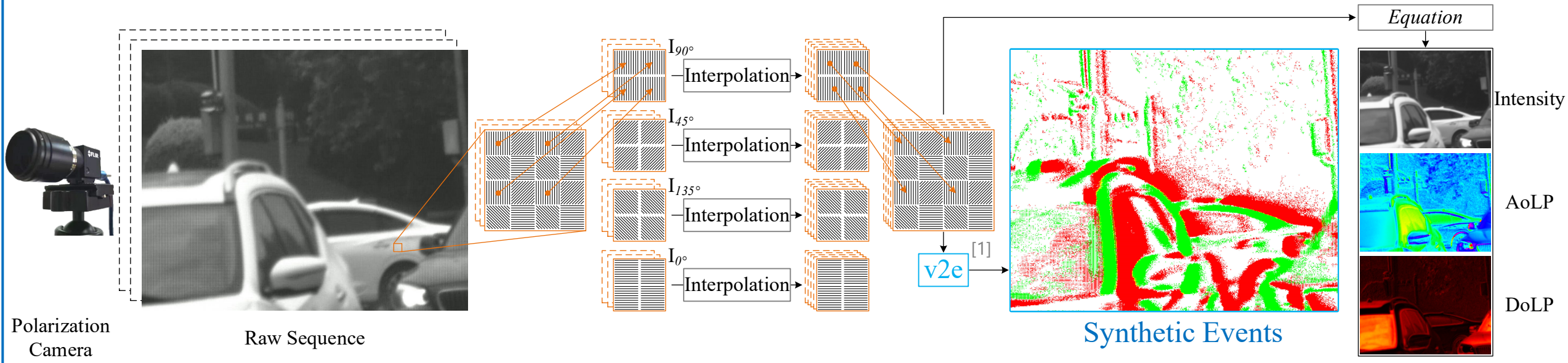
V Voxelization CG ConvGRU RB Residual Block

2. Polarization Video Reconstruction

-- Dataset

University of Zurich[UZH] | ETH zürich

Institute of Neuroinformatics



[1] Hu, Yuhuang, Shih-Chii Liu, and Tobi Delbruck. "v2e: From video frames to realistic DVS events." CVPRW. 2021.

2. Polarization Video Reconstruction

-- Dataset

University of Zurich[UZH]

ETH zürich

Institute of Neuroinformatics

Synthetic / Real	Videos	Frames (K)	Events (M)
Train	92 / 56	91 / 9	3019 / 680
Test	29 / 23	29 / 4	1087 / 308
Total	121 / 79	120 / 13	4107 / 988

Number statistics of our event-to-polarization dataset **E2PD**

3. Experimental Results

University of Zurich[UZH]

ETH zürich

Institute of Neuroinformatics

01 Polarization Reconstruction Results on Synthetic Polarization Events

Quantitative Comparison Sequence #1 Sequence #2

02 Polarization Reconstruction Results on Real Polarization Events

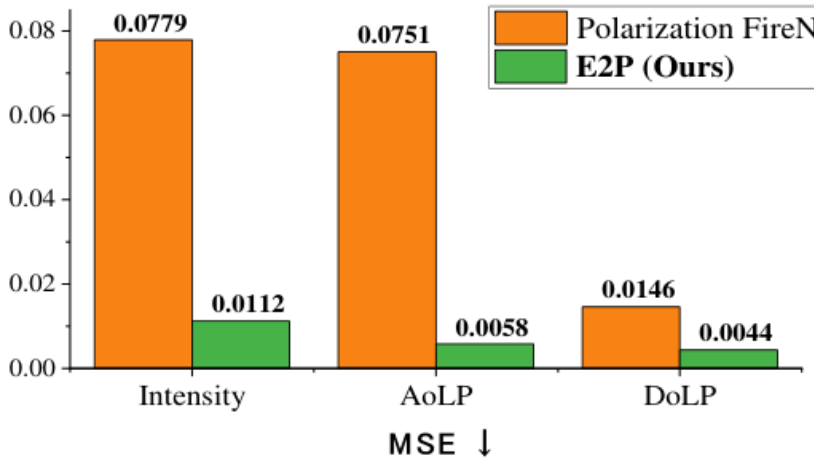
Sequence #3 Sequence #4

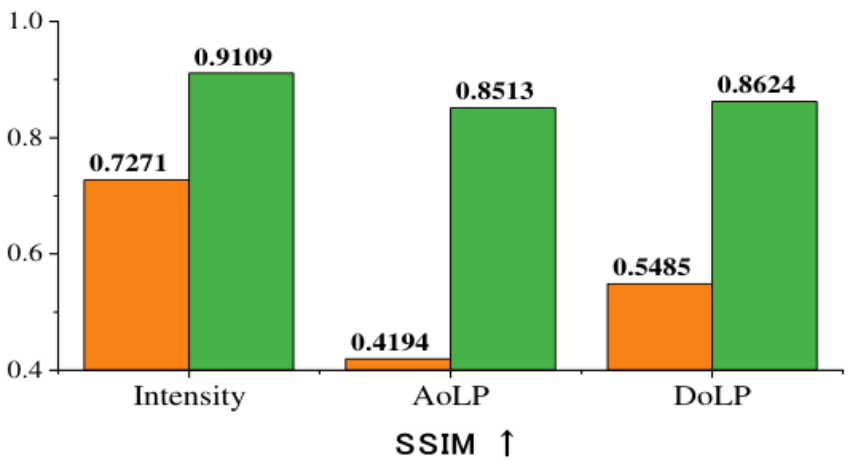
03 Polarization Reconstruction Live Demo

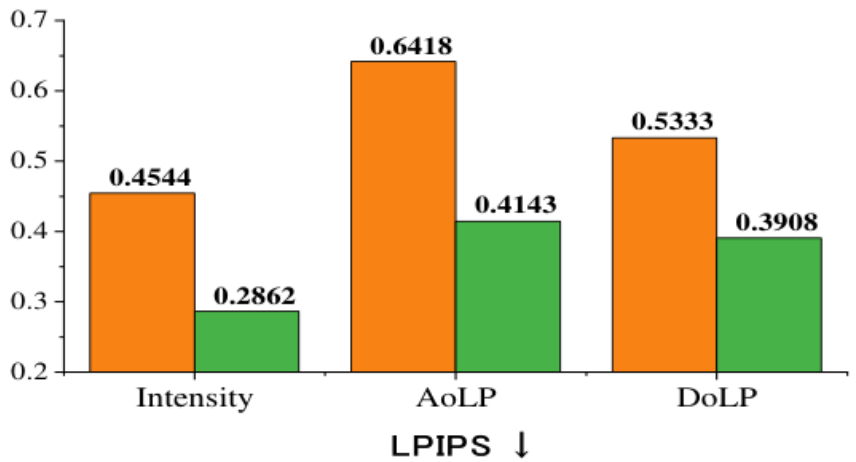
Live Demo #5 Live Demo #6

3. Experimental Results

University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics







mean squared error *structural similarity index measure* *perceptual similarity*

Sequence #1

Synthetic Polarization Events

Display Speed: 10 FPS

Intensity

AoLP

π/2

0

DoLP

0 1

Ground Truth

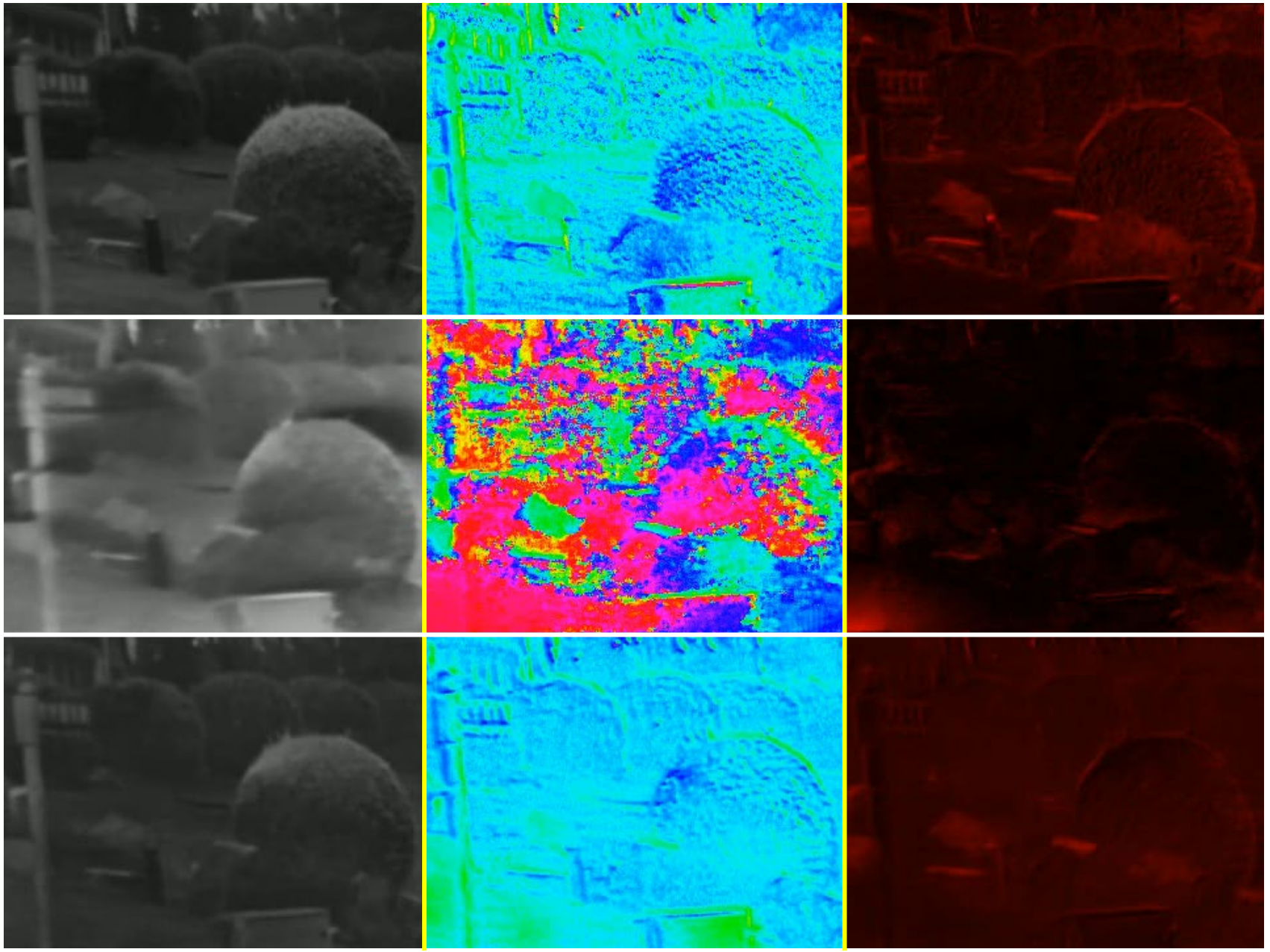
Frame Rate: 200 Hz

Polarization FireNet

Frame Rate: 200 Hz

E2P (Ours)

Frame Rate: 200 Hz



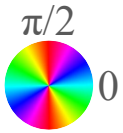
Sequence #2

Synthetic Polarization Events

Display Speed: 10 FPS

Intensity

AoLP



DoLP

Ground Truth

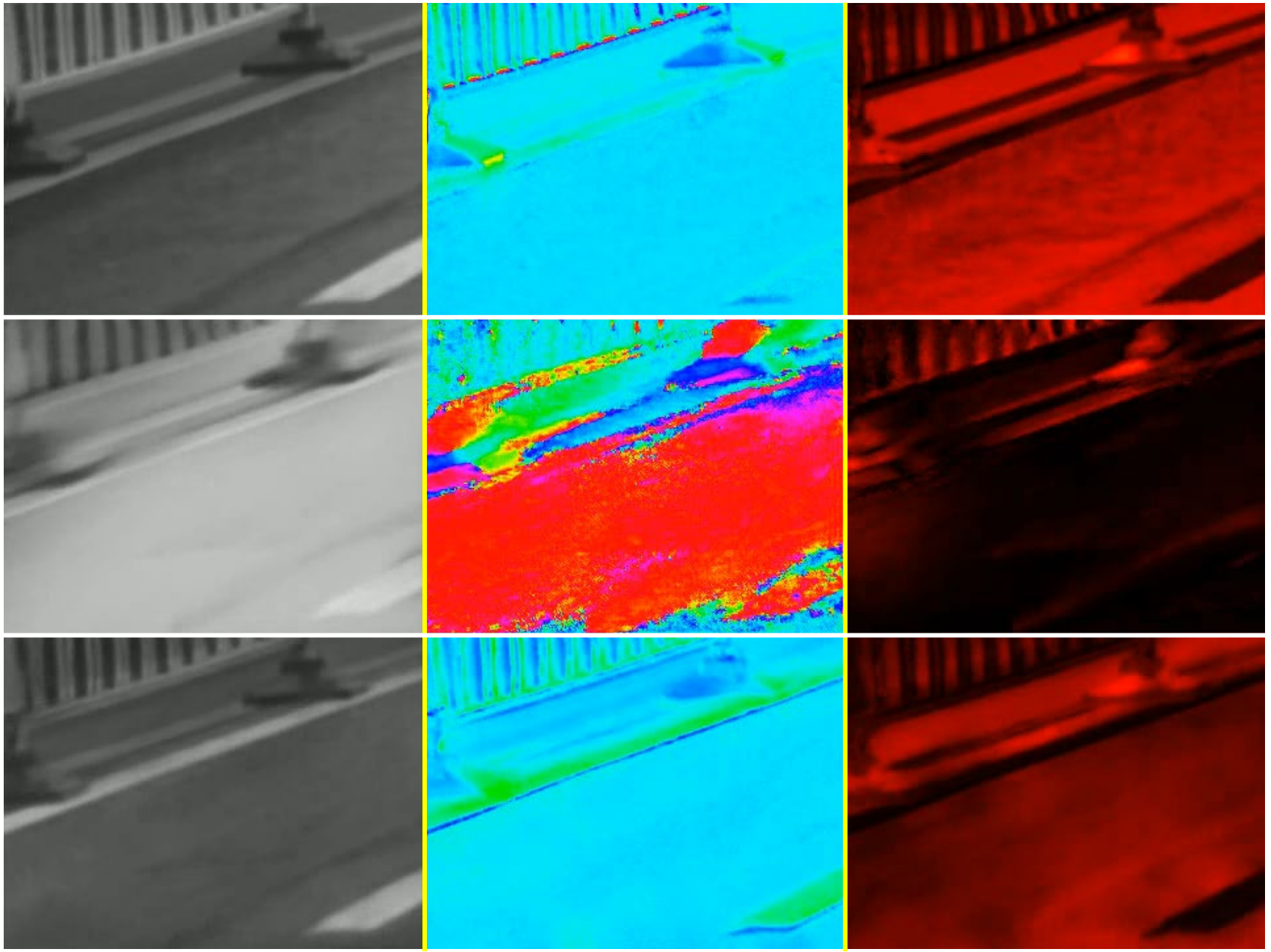
Frame Rate: 200 Hz

Polarization FireNet

Frame Rate: 200 Hz

E2P (Ours)

Frame Rate: 200 Hz



Sequence #3

Real Polarization Events

Display Speed: 10 FPS

PDAVIS Frame

Frame Rate: 20 Hz

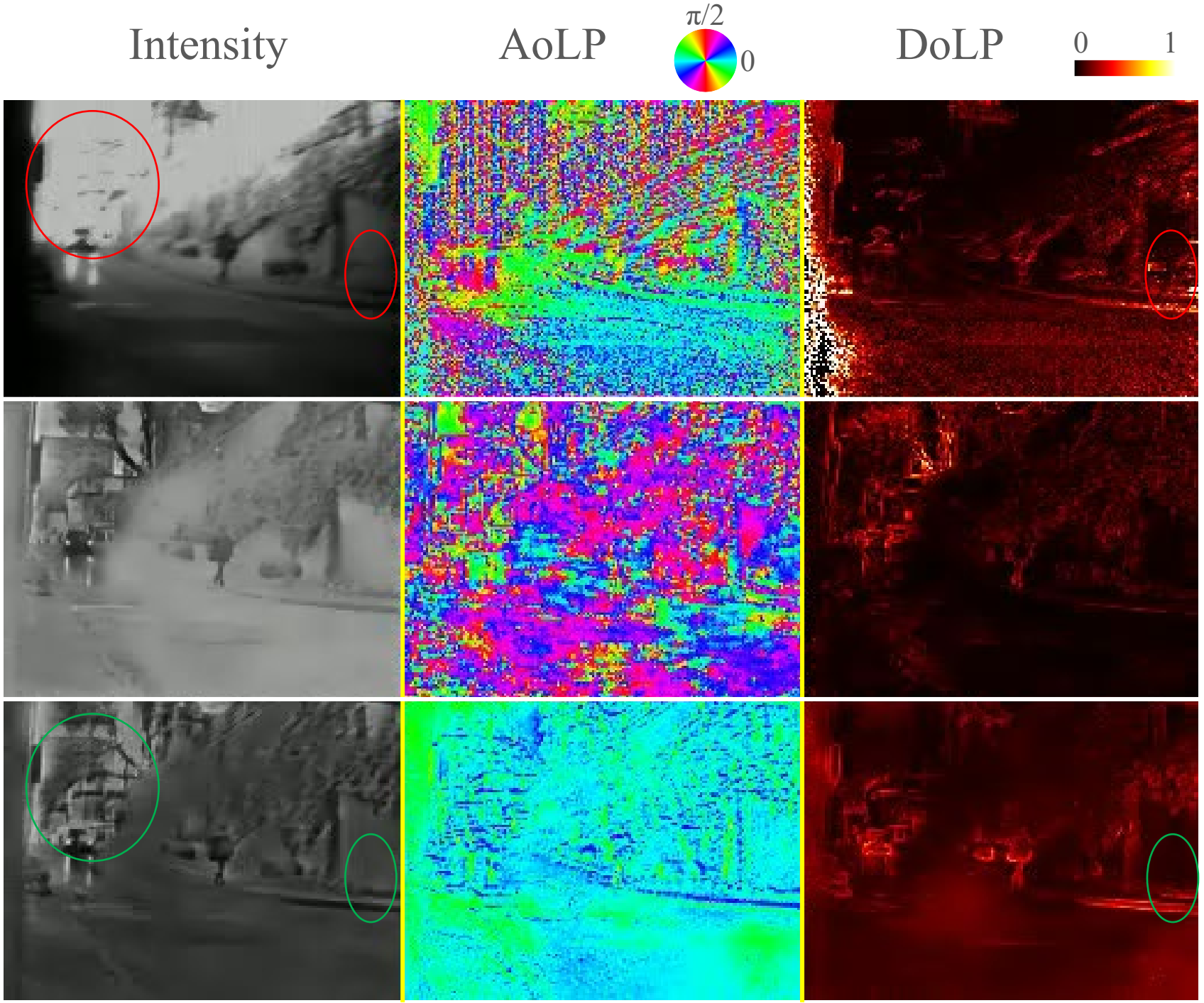
Polarization FireNet

Frame Rate: 20 Hz

E2P (Ours)

Frame Rate: 20 Hz

High Dynamic Range



Sequence #4

Real Polarization Events

Display Speed: 10 FPS

PDAVIS Frame

Frame Rate: 20 Hz

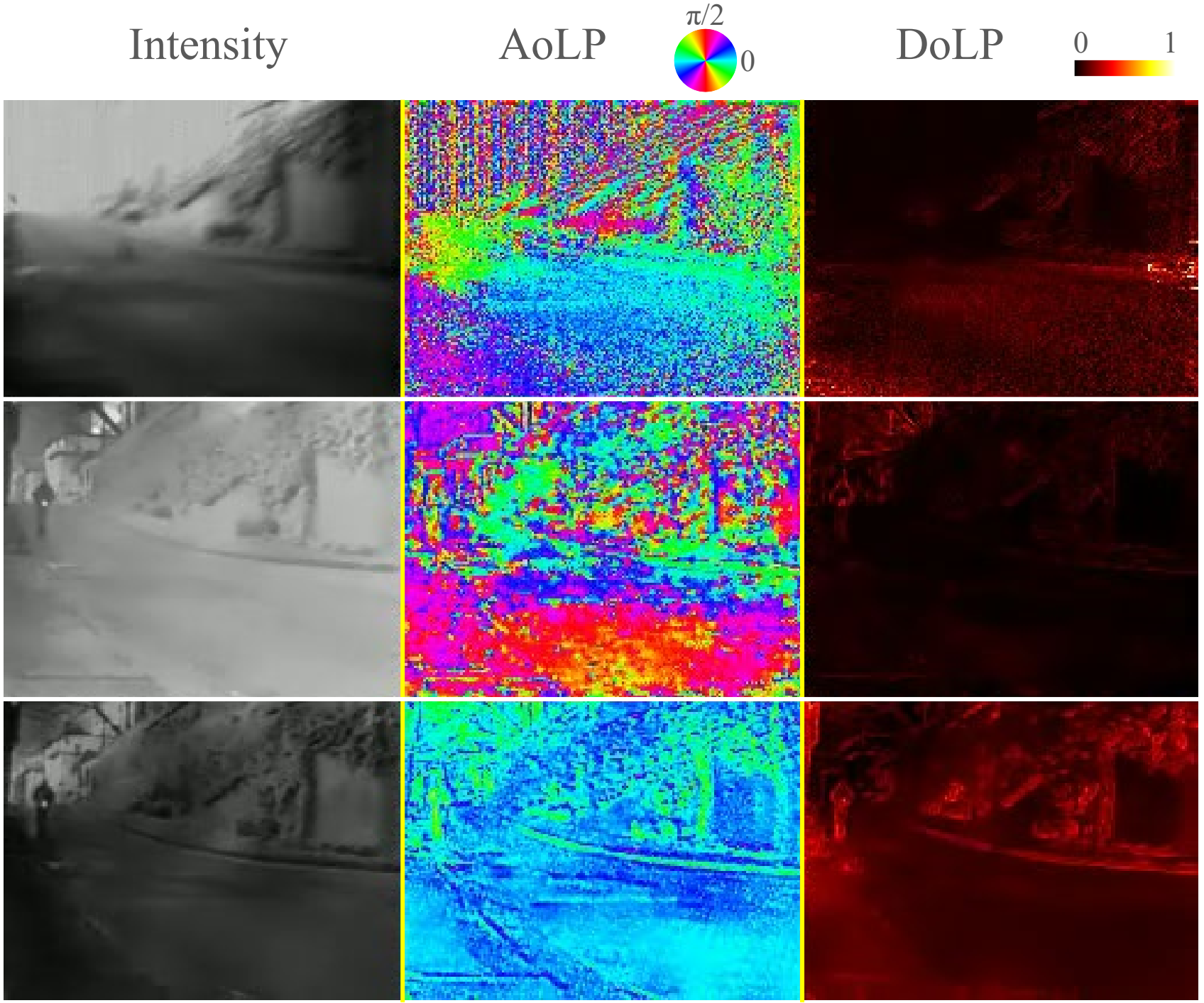
Polarization FireNet

Frame Rate: 100 Hz

E2P (Ours)

Frame Rate: 100 Hz

High Speed



3. Experimental Results

University of Zurich[UZH]

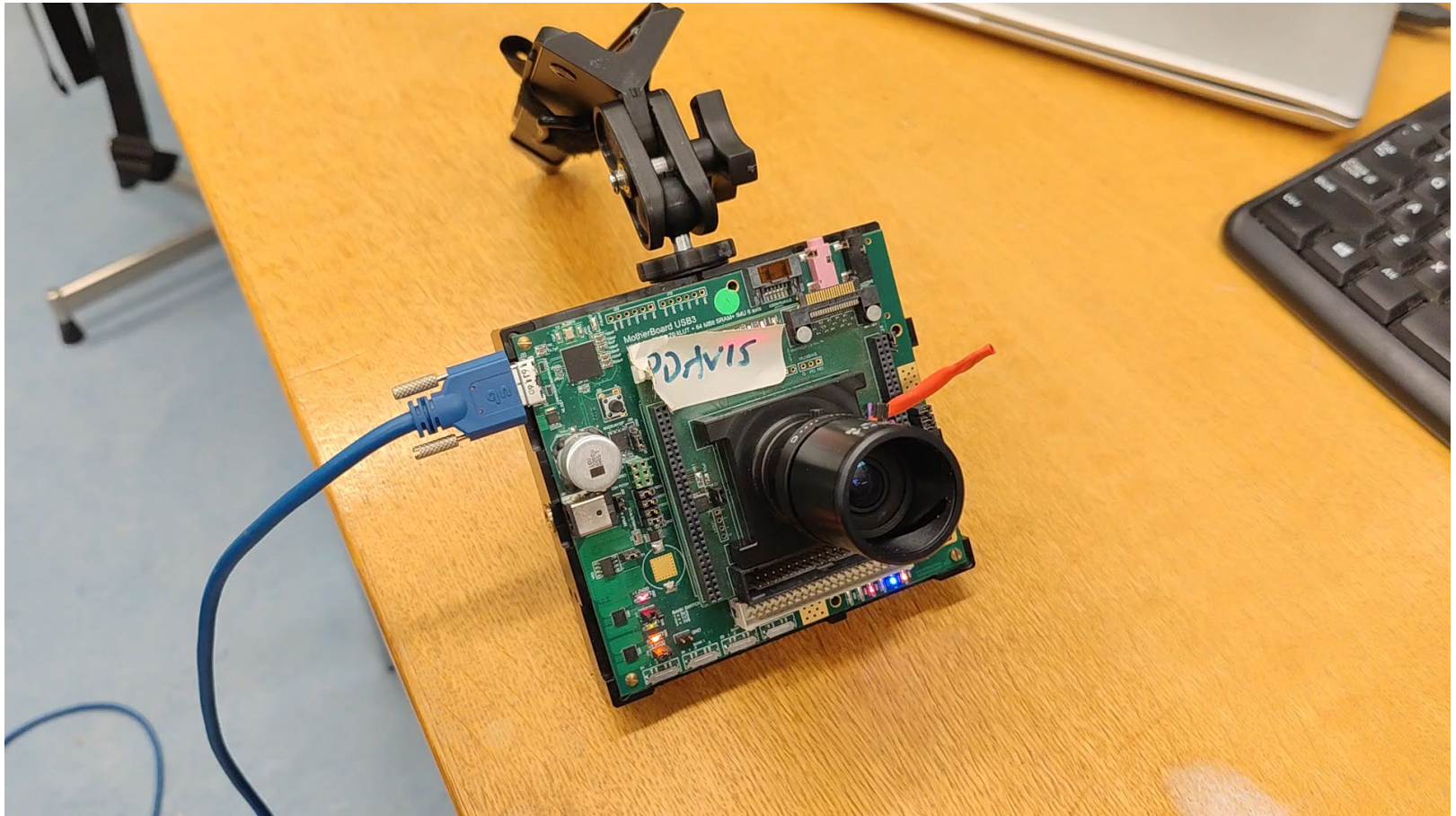
ETH zürich

Institute of Neuroinformatics

Computational Efficiency

Methods	FLOPs (G)	Inference Time (ms)
Polarization FireNet	46.4	5.3
E2P (Ours)	**36.4**	**5.1**

Live Demo #5



4. Conclusion and Outlook

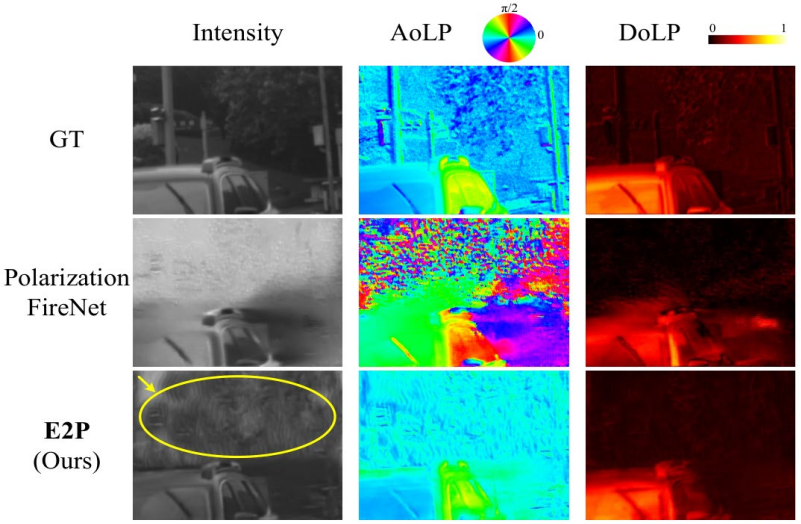
University of Zurich[UZH] | ETH zürich
Institute of Neuroinformatics

Conclusion

We achieve
high-speed and high dynamic range
polarization reconstruction with PDAVIS events.

Outlook

More Robust



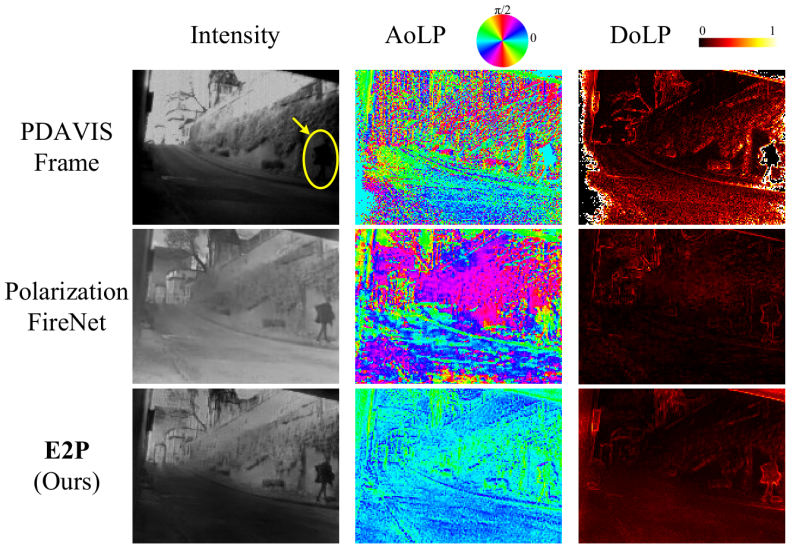
- Adaptive integration of frames and events

More Accurate/Efficient

Our E2P is with
simple CNN architecture

- Powerful Transformer
- Biologically inspired spiking neural networks

Downstream Applications



- Car/Pedestrian detection in challenging scenes

JUNE 18-22, 2023
CVPR
VANCOUVER, CANADA

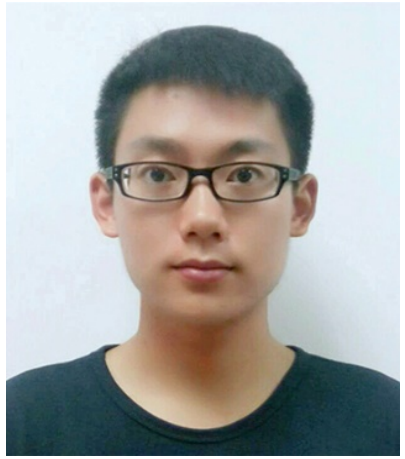
THU-PM-147

Project Page

University of Zurich[UZH]
ETH zürich
Institute of Neuroinformatics

Thank you for your attention!

Deep Polarization Reconstruction with PDAVIS Events



Haiyang Mei

Zuowen Wang

Xin Yang

Xiaopeng Wei

Tobi Delbruck