Deep Polarization Reconstruction with PDAVIS Events (Supplementary Material)

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 Zürich and ETH Zürich, Zürich, Switzerland
haiyang.mei@outlook.com, {xinyang, xpwei}@dlut.edu.cn, {zuowen, tobi}@ini.uzh.ch

In this Supplementary Material, we present more results in support of the main manuscript. First, we provide visual evidence to demonstrate the effectiveness of our Rich Polarization Pattern Perception (**RPPP**) module and Cross-Modality Attention Enhancement (**CMAE**) module in Section 1. Then, in Section 2, we demonstrate the necessity of mixing synthetic with real events data for enabling sim-to-real generalization. Finally, we show more visual comparison results of our Events to Polarization (**E2P**) against the state of the art (**SOA**) event-to-polarization method Polarization FireNet [1] on both Events to Polarization Dataset (**E2PD**) synthetic and real testing data (Section 3 and the YouTube video at https://youtu.be/_8Xvu34oyWc).

1. Effectiveness of RPPP and CMAE

Our RPPP module can match five different polarization patterns in the feature extraction process, which can benefit robust measurement of polarization. As shown in Figure 1, the network equipped with our RPPP module produces more accurate DoLP for windshield regions than the one without the RPPP module.

Our CMAE module is designed to enhance features via a cross-modality attention mechanism for better polarization reconstruction. Figure 2 shows an example where CMAE helps to more accurately reconstruct DoLP in the complex region (pointed by a yellow circle). Figure 3 further visualizes the attention weights in the second CMAE module of E2P for the three modalities (*i.e.*, intensity, AoLP, and DoLP). It can be seen that the attention weights vary in different channels and positions, which indicates CMAE can guide the features where to emphasize or suppress for better polarization reconstruction.

2. Necessity of Mixing Synthetic with Real Events Data for Enabling Sim-to-Real Generalization

In certain scenarios, which include high dynamic range (**HDR**) or motion blur, PDAVIS produces low-quality polarization frames. A natural question is whether such PDAVIS data should be used for training the network. To answer this, we trained our E2P on simulated events only and observed that including PDAVIS data in the training has little impact to the accuracy on simulated testing set (Table 1) but is crucial for the polarization reconstruction on real PDAVIS testing data (Figure 4). This demonstrates that using the PDAVIS data for training can help the network achieve sim-to-real generalization.

3. Qualitative Comparison of Our E2P Against Polarization FireNet

We show more visual comparison results of our E2P against the SOA event-to-polarization method Polarization FireNet [1] on E2PD synthetic polarization event testing data in Figure 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14, and comparisons on E2PD real PDAVIS [1] polarization event testing data in Figure 15, 16, 17, and 18.

In addition, our E2P can reconstruct the high-speed polarization video, by taking as input the non-overlapping spatio-temporal polarization event windows ε_t with short time duration T. And examples are shown in the YouTube video at https://youtu.be/_8Xvu34oyWc.

References

[1] Viktor Gruev, Germain Haessig, Damien Joubert, Justin Haque, Yingkai Chen, Moritz Milde, and Tobi Delbruck. Division of focal plane asynchronous polarization imager. In *Polarization: Measurement, Analysis, and Remote Sensing XV*. SPIE, 2022.

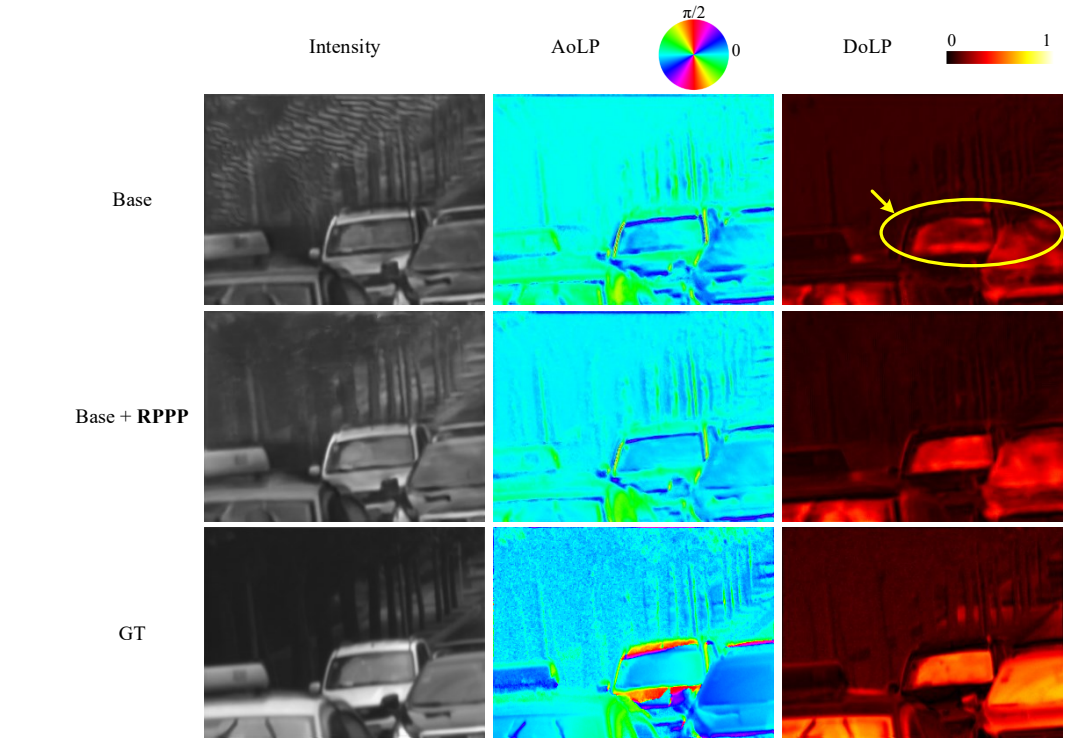

Figure 1. Effectiveness of RPPP module.

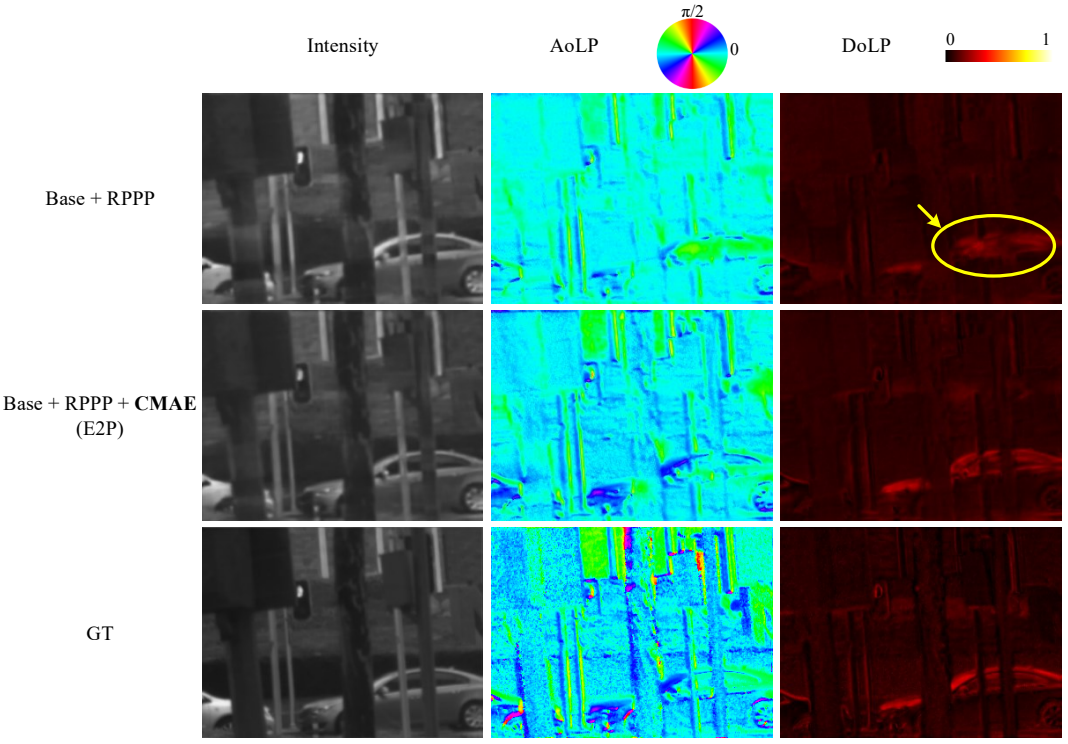

Figure 2. Effectiveness of CMAE module.

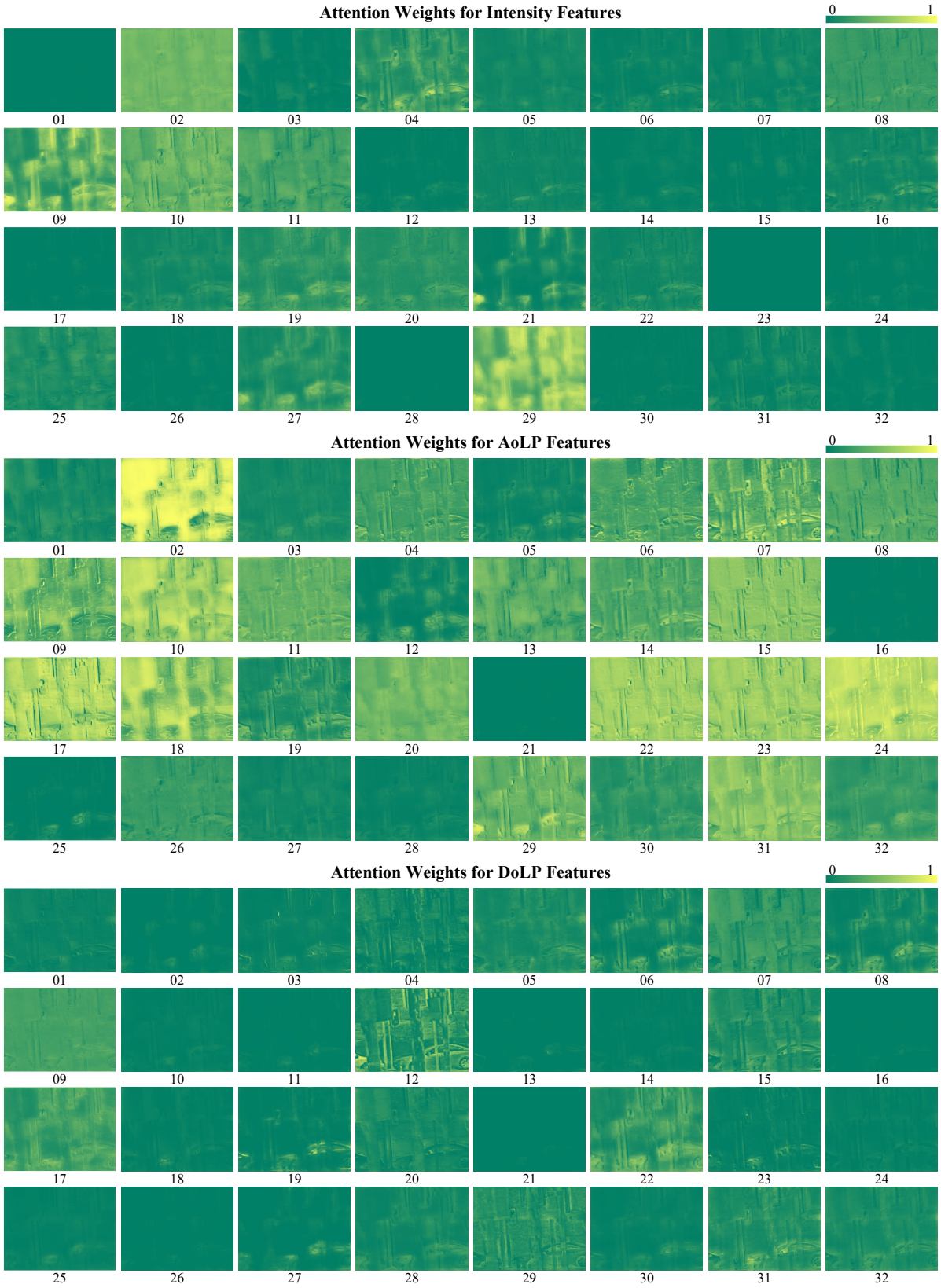

Figure 3. Attention weights in the second CMAE module of E2P for the three modalities (*i.e.*, intensity, AoLP, and DoLP).

Synthetic Testing Set	Intensity			AoLP			DoLP		
E2P trained on	MSE ↓	SSIM ↑	LPIPS ↓	MSE ↓	SSIM ↑	LPIPS ↓	MSE ↓	SSIM ↑	LPIPS ↓
synthetic events	.0117	.9099	**.2829**	**.0056**	**.8558**	.4276	**.0036**	**.8744**	**.3888**
synthetic + real events	**.0112**	**.9109**	.2862	.0058	.8513	**.4143**	.0044	.8624	.3908

Table 1. Including real PDAVIS data in training does not hurt performance on the synthetic testing set.

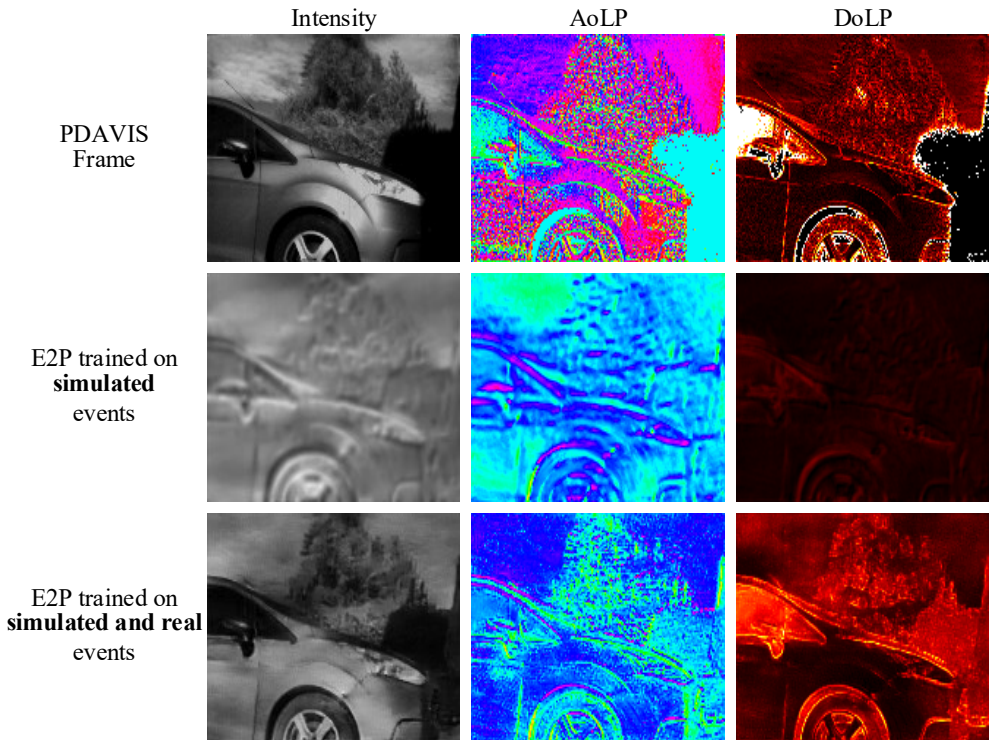

Figure 4. Including real PDAVIS data in training are crucial for achieving better sim-to-real generalization.

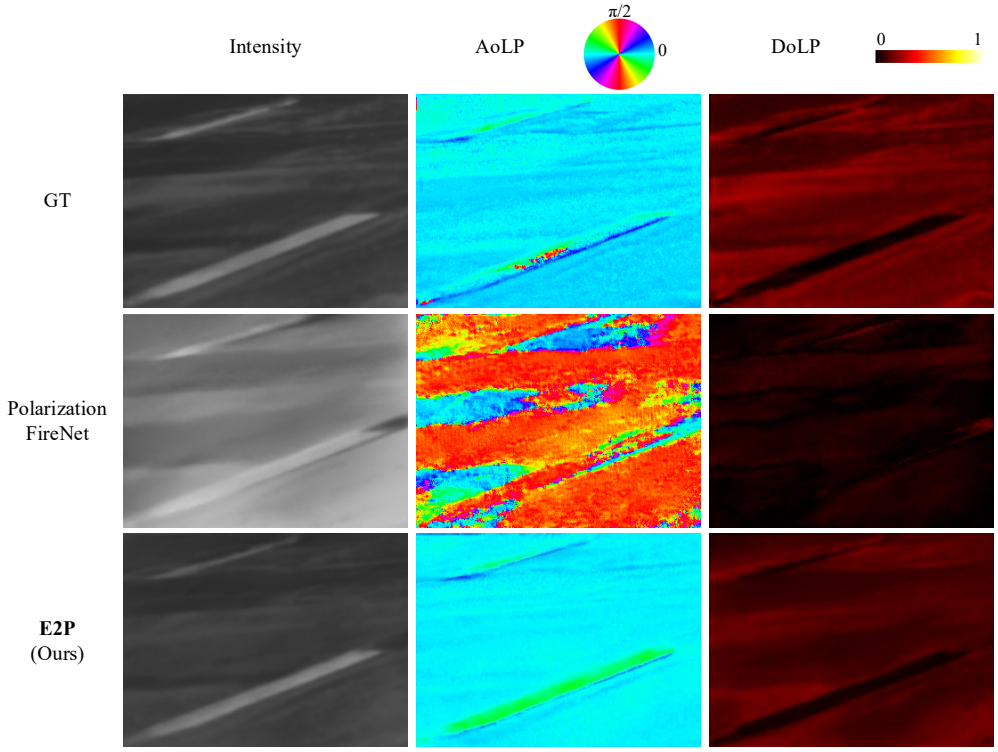

Figure 5. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

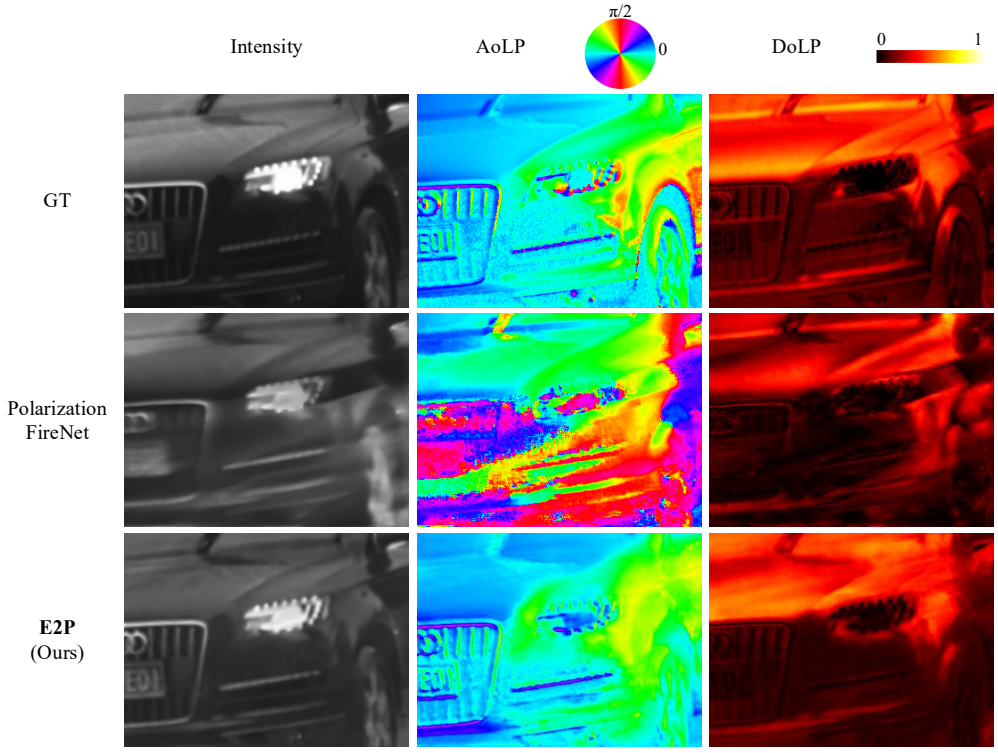

Figure 6. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

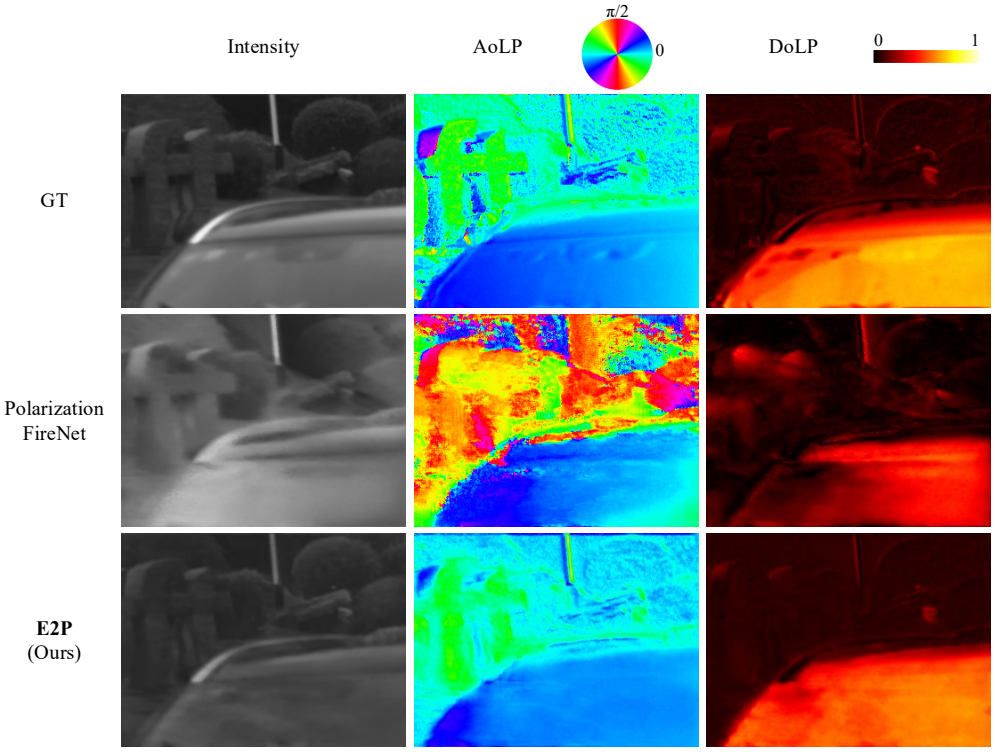

Figure 7. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

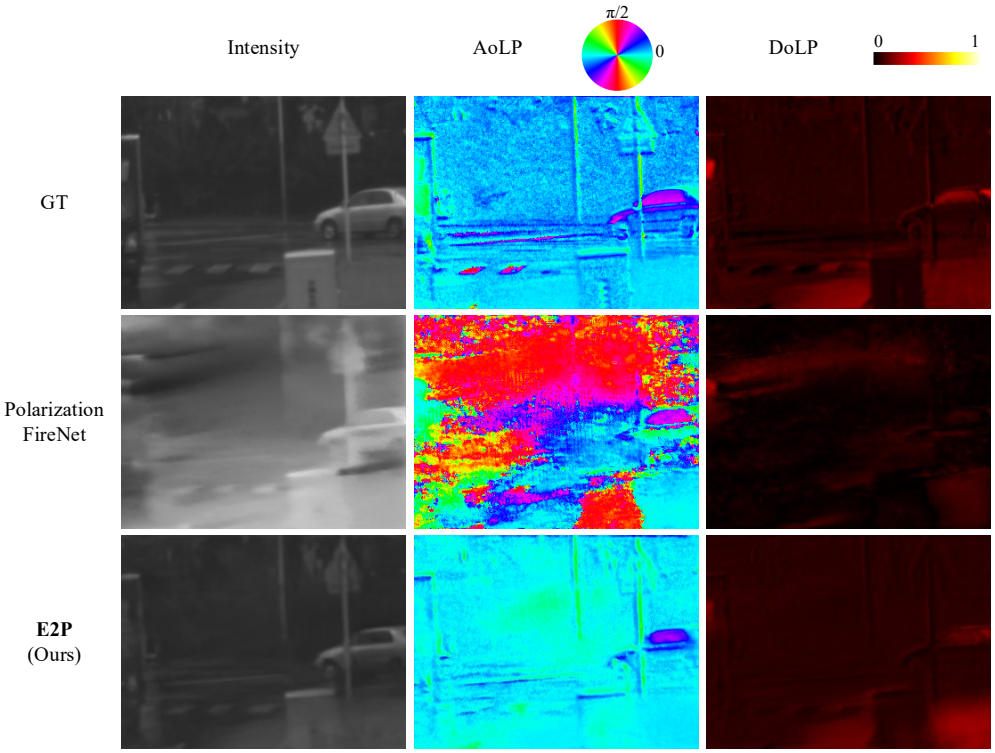

Figure 8. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

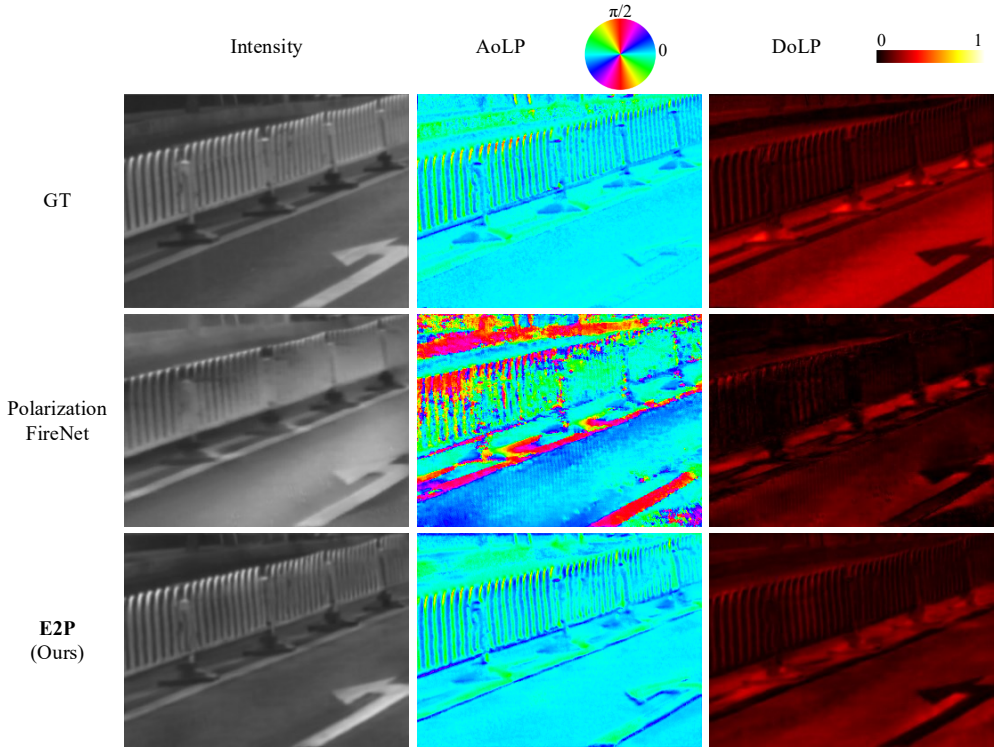

Figure 9. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

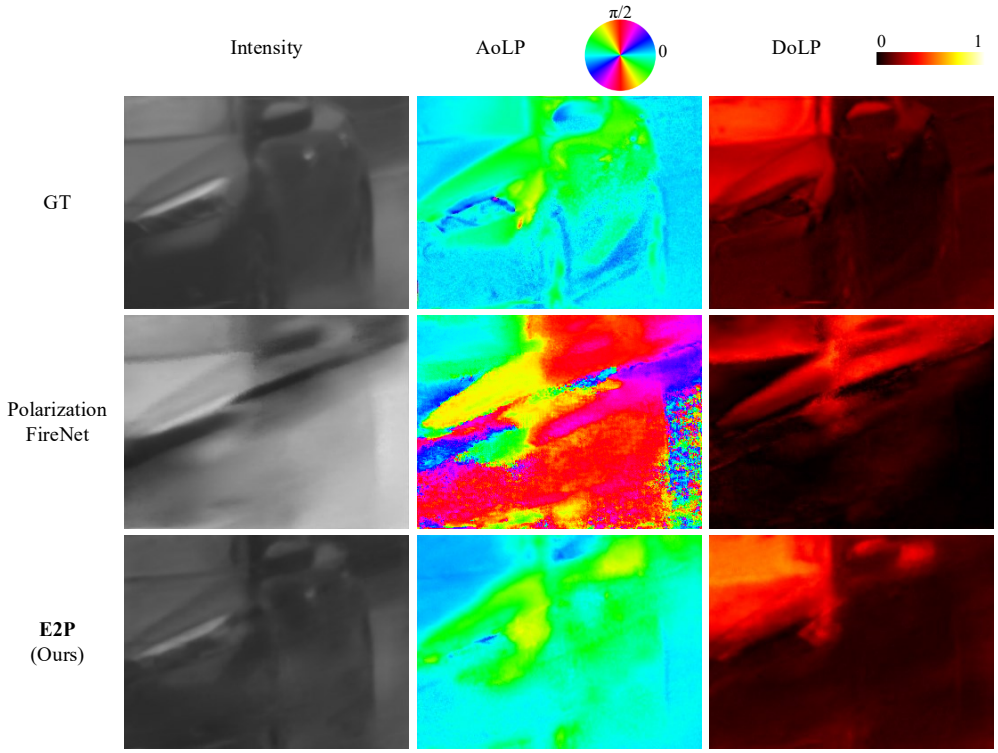

Figure 10. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

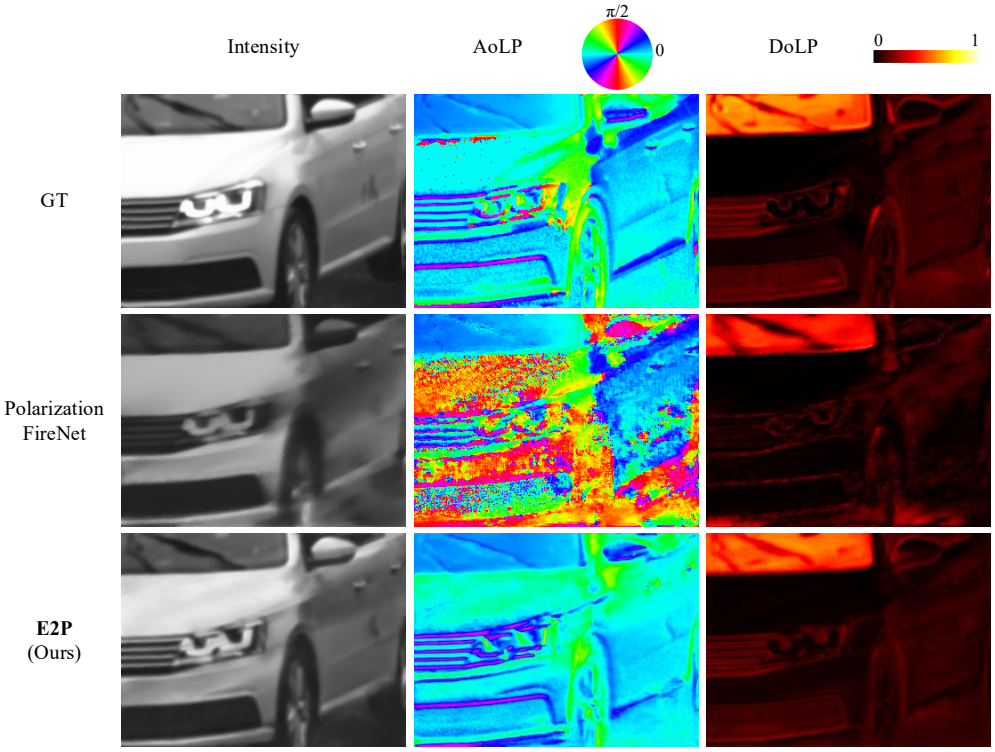

Figure 11. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

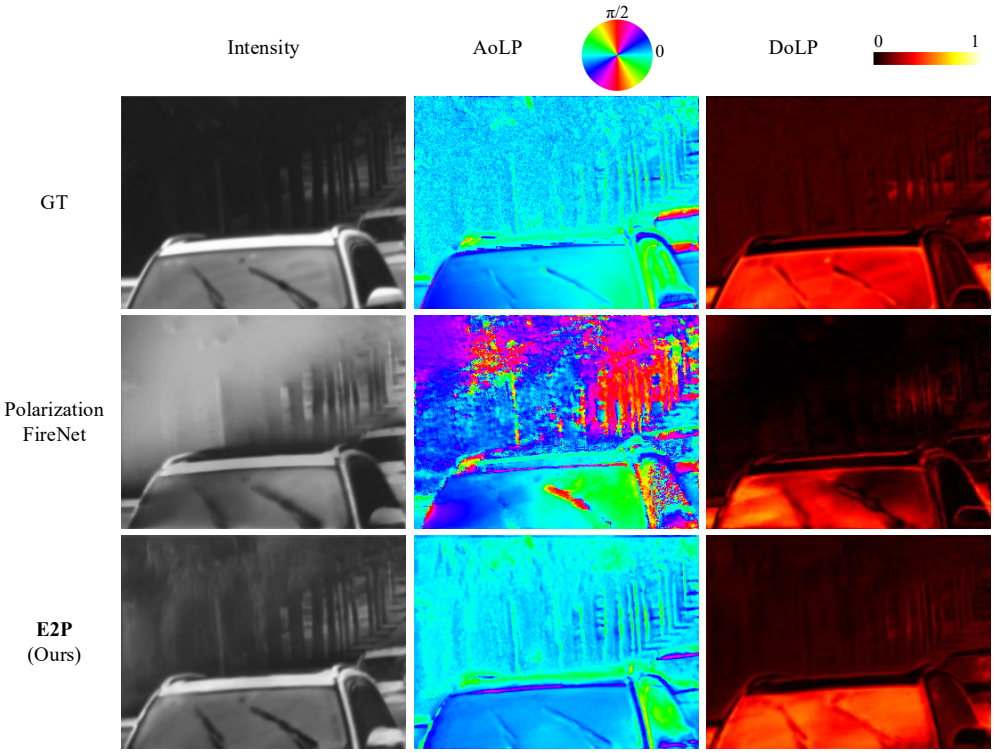

Figure 12. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

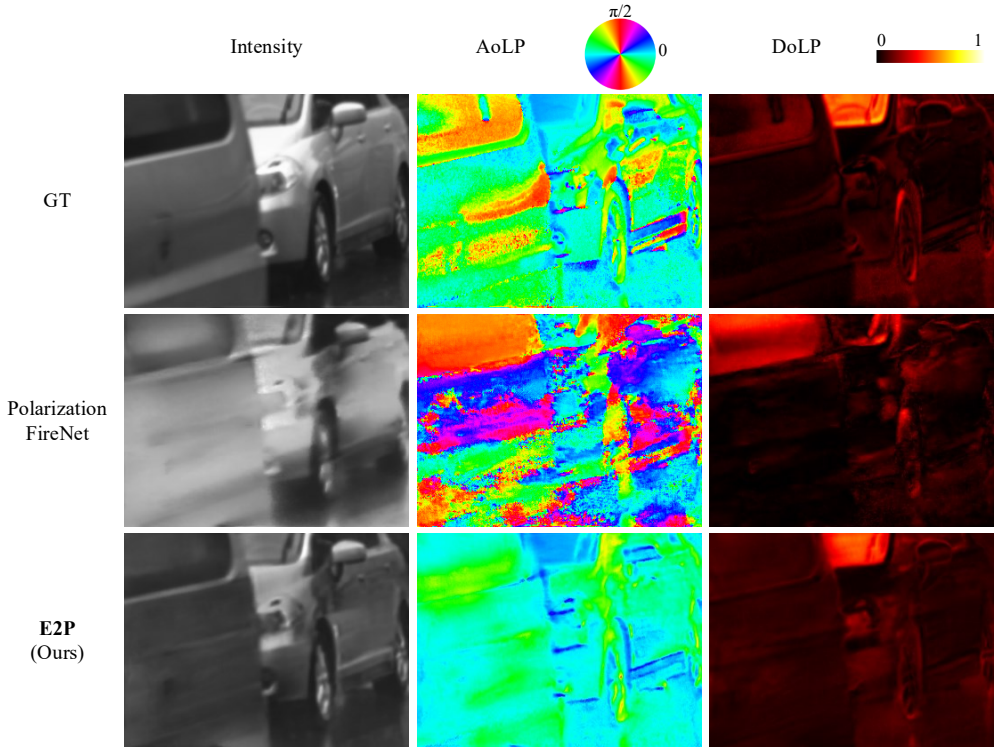

Figure 13. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

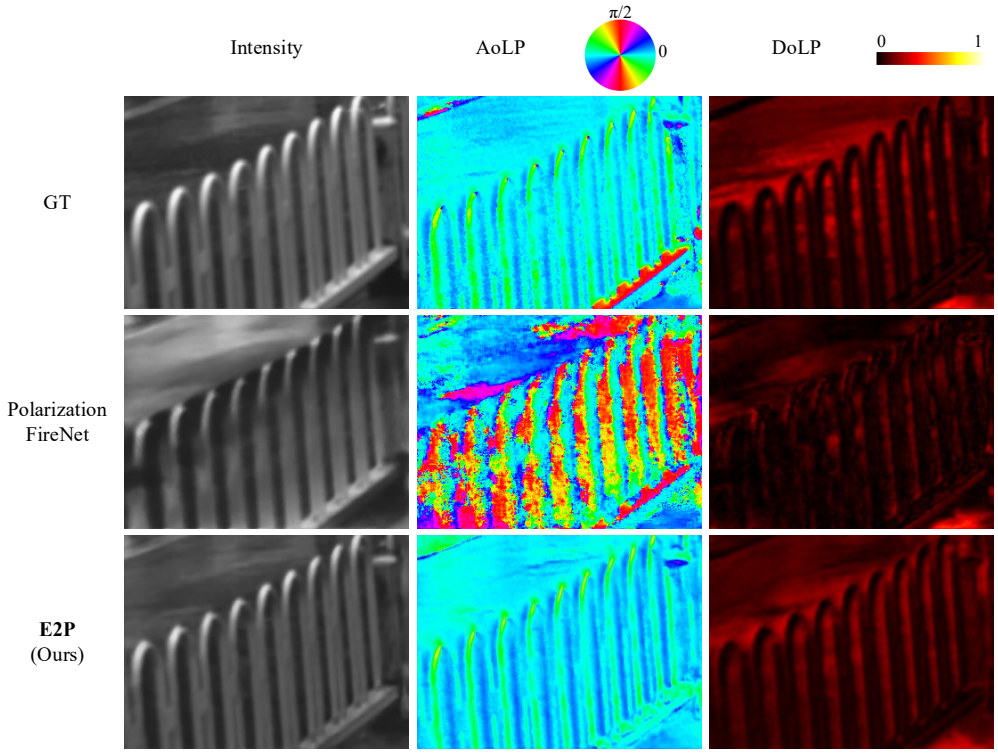

Figure 14. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD synthetic testing data.

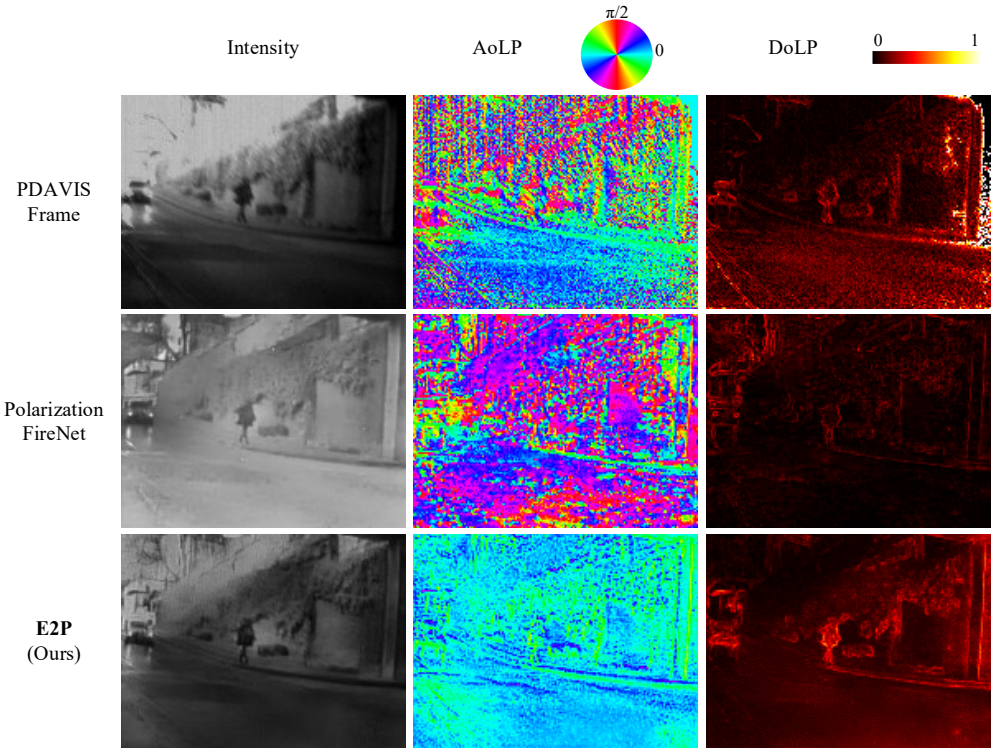

Figure 15. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD real testing data.

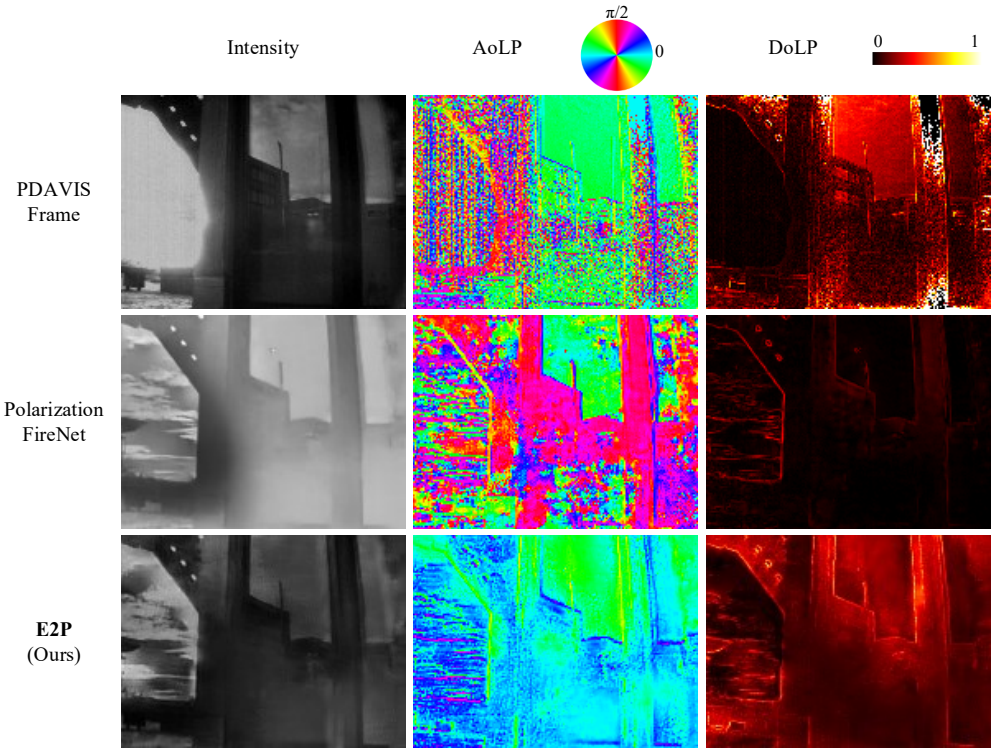

Figure 16. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD real testing data.

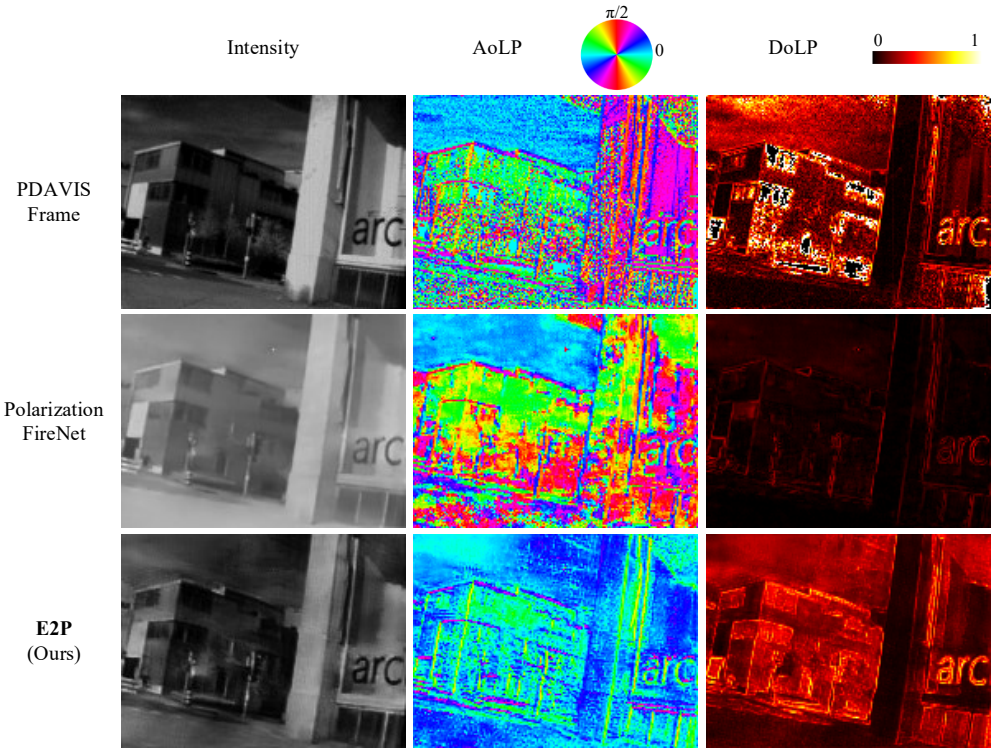

Figure 17. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD real testing data.

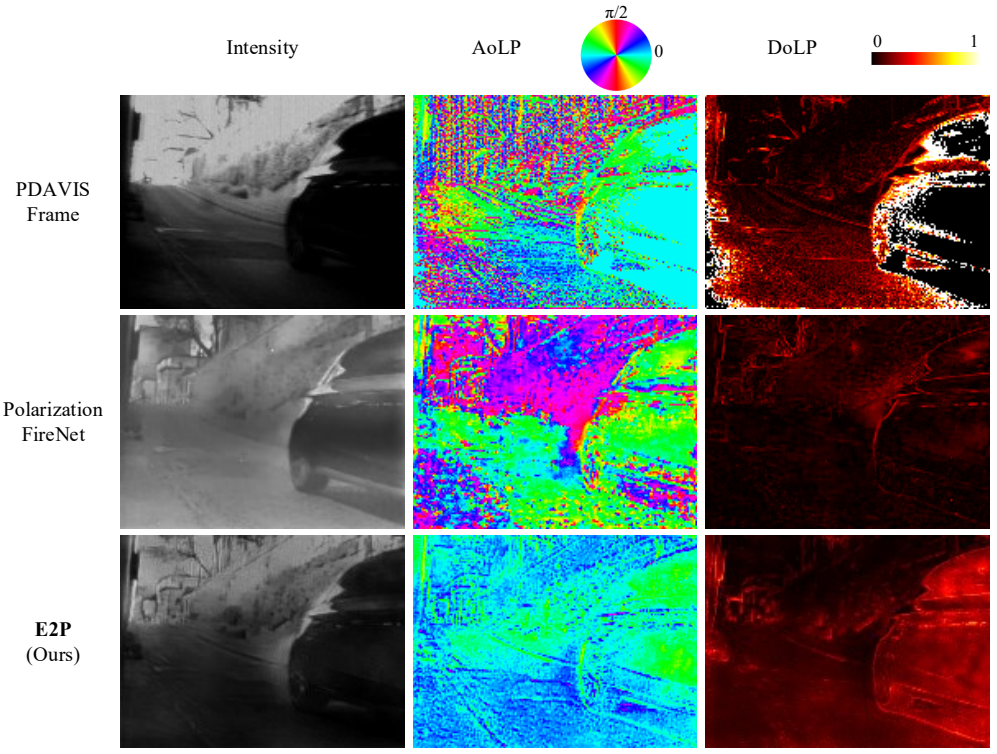

Figure 18. Qualitative comparison of our E2P against SOA event-to-polarization method [1] on the E2PD real testing data.