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RGB-Event Fusion for Robust Lane Detection

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Introduction

Our task

Exploiting image and event data for robust lane detection in challenging scenarios.

Key words

Event Camera, Multimodal, Lane Detection, Autonomous Dataset.

Lack of synchronized image-event lane detection dataset

Dataset	Year	Modality	E-I Pair	MI	MS	ML	MM	Real	Annotations	Scale	Resolution
Caltech Lanes [2]	2008	RGB	✗	✗	✗	✗	✗	✓	Key point coordinates	1,225	640×480
Tusimple [49]	2017	RGB	✗	✗	✗	✗	✗	✓	Key point coordinates	6,498	1280×720
CULane [39]	2017	RGB	✗	✗	✗	✗	✓	✓	Key point coordinates	133,235	1640×590
VPGNet [22]	2017	RGB	✗	✗	✗	✓	✓	✓	Key point coordinates	21,097	346×260
LLAMAS [4]	2019	RGB	✗	✗	✗	✓	✓	✓	Pixel level	100,442	128×128
CurveLanes [61]	2020	RGB	✗	✓	✓	✓	✓	✓	Key point coordinates	150,000	1280×800
DET [9]	2020	Event	✗	✓	✓	✓	✗	✓	Pixel level	5,424	1280×800
DSEC-Lane	2025	RGB+Event	✓	✓	✓	✓	✓	✓	Key point coordinates	11,862	640×480

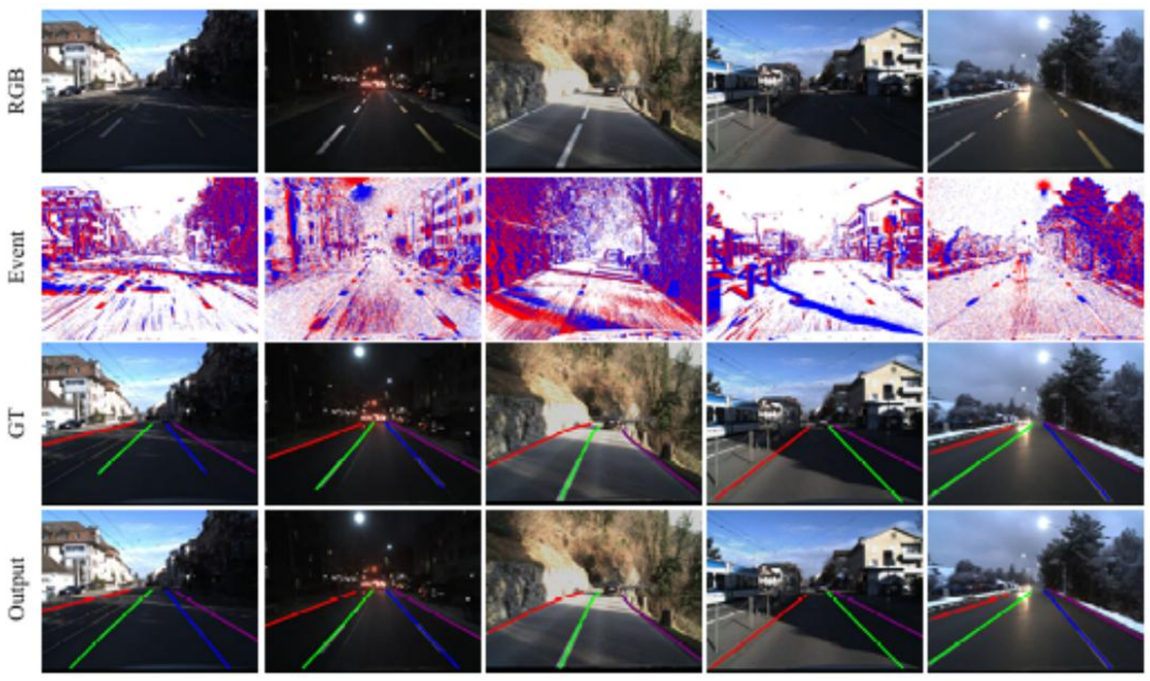
Definitions: E-I Pair (Event-Image Pairing), MI (Multi-Illumination), MS (Multi-Scenes), ML (Multi-Line Type), MM(Multiple Moments).

-**Collecting a** large-scale, high-quality real-world event-image lane detection dataset represents a challenge.

Lanes	One	Two	Three	Four	Total
Count	566	4033	4232	3031	11862
Percent (%)	4.77	34.00	35.68	25.55	100

Distribution of lane annotation counts per image in our dataset.

-The dataset contains manually annotated lane line instance point sets, with points sampled at consistent height intervals.



Examples of our DSEC-Lane dataset

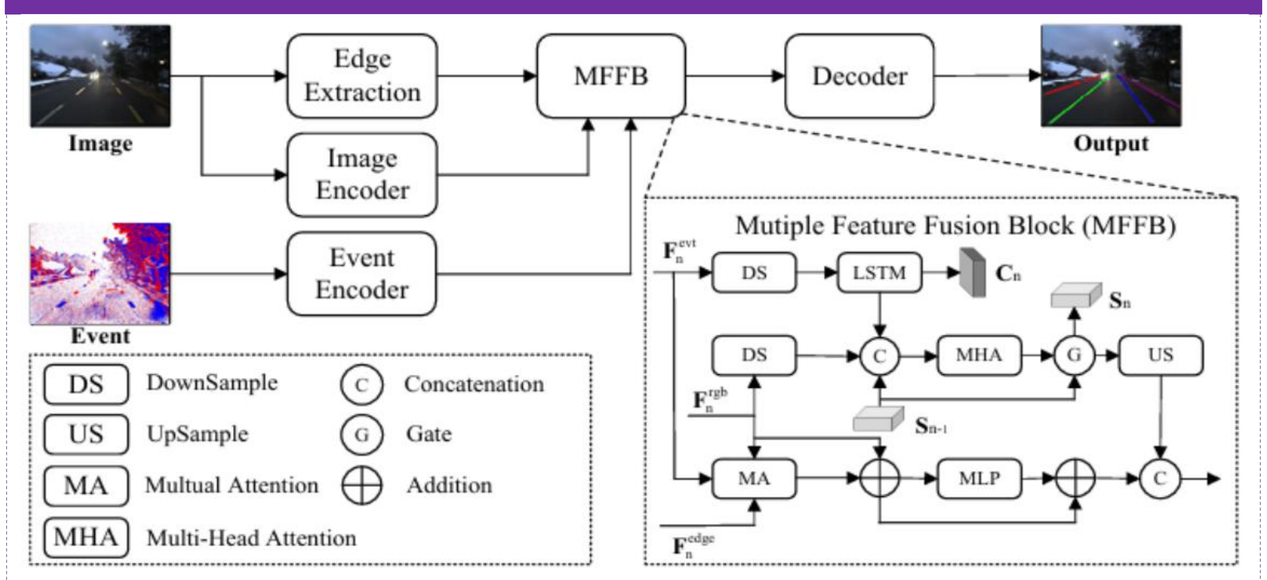
Ensure spatial and temporal sync of image and event data

$$P_{event,rgb} = K_{event} * R_{rgb} * R_{event,rgb} * R_{event}^{T} * K_{rgb}^{-1}$$

-We apply a homography transformation to map the scene from the RGB frame to the event camera frame, followed by annotating the lane lines on the transformed RGB image.

-We compress the raw event stream along the time dimension with Δt=50ms,which corresponds to the frame rate of an standard camera,allowing for better alignment.

Method



Contributions

- We introduce DSEC-Lane, a dataset with 11,862 samples for lane detection.
- We propose MFFB, fusing RGB frames and event streams using time-aware self-attention for robust lane detection.
- We establish the first RGB-Event fusion benchmark for lane detection, achieving state-of-the-art results on DSEC-Lane.

Results

Method	Overall		Normal		Overexposure		Underexposure	
	Acc.(%)↑	F1(%)↑	Acc.(%)↑	F1(%)↑	Acc.(%)↑	F1(%)↑	Acc.(%)↑	F1(%)↑
LaneATT [46]	84.80	73.42	85.48	70.04	83.16	73.11	85.05	74.21
CLRNet [66]	86.48	79.97	86.32	79.95	87.97	78.51	85.82	81.28
ADNet [60]	86.38	79.41	86.02	79.42	87.73	77.36	86.75	81.16
SRLane [6]	86.39	79.74	86.52	80.51	87.94	77.20	84.42	78.61
CLRKDNet [41]	86.62	79.32	86.48	79.70	87.86	77.07	86.10	79.69
Ours-S	86.92	81.41	86.67	81.48	87.99	**79.07**	86.10	**82.80**
Ours-B	**87.32**	**81.57**	**87.35**	**82.14**	**88.05**	78.03	**86.73**	82.21

Lane-detection results on the DSEC-Lane dataset. **Ours-S** and **Ours-B** represent the small and base versions of our proposed method.

Method	Acc. (%)↑	F1 (%)↑
Add	86.30	80.44
Concat	86.81	80.34
CBAM [57]	86.58	80.38
ECANet [54]	86.24	80.79
CMT [55]	86.54	80.70
Ours	**87.32**	**81.57**

Guidance	Operator	Acc. (%)↑	F1 (%)↑
w/o edge	-	86.00	80.49
w/ edge	Canny	86.45	80.91
	Sobel	**87.32**	**81.57**

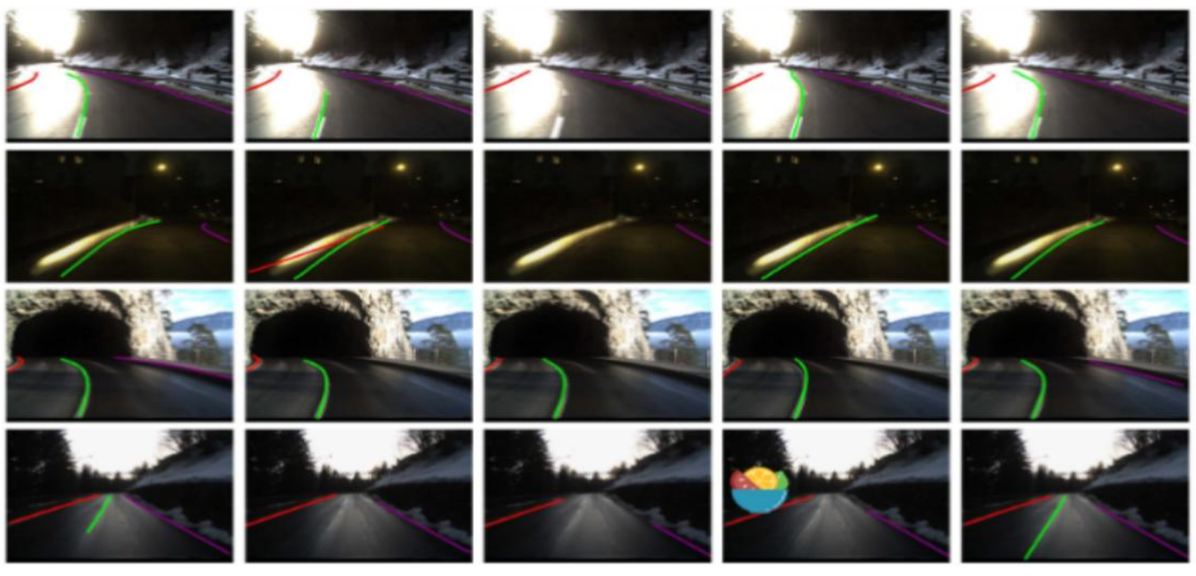
Ablation study on edge guidance and different Event and Image fusion methods.

Representation	Acc. (%)↑	F1 (%)↑
Voxel(bin=3)	86.01	80.38
Voxel(bin=6)	86.31	80.60
Ours(Timestamp)	**87.32**	**81.57**

Ablation study on different event representations.

Baseline	Time	Edge	Acc.(%)↑	F1(%)↑
✓	✗	✗	86.81	80.34
✓	✓	✗	86.70	81.27
✓	✗	✓	87.22	81.00
✓	✓	✓	**87.32**	**81.57**

Ablation study on model components.



GT LaneATT CLRNet CLRKDNet Ours