MULi-Ev: Maintaining Unperturbed Event-LiDAR Calibration

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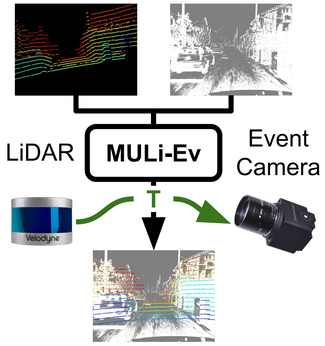
Introduction

Problem

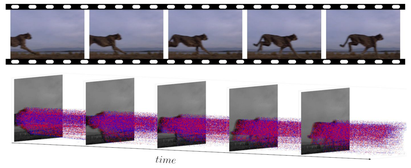
Event camera + LiDAR pairing is more and more common in autonomous driving but there is no online calibration method yet.

Solution

We propose a first ML-based online method for this setup, inspired by works on other sensors [1, 2].



What is an Event Camera?



- Asynchronous stream of events
- Event = pixel brightness change
- Advantages:
  - high temporal resolution
  - low latency, no motion blur
  - high dynamic range
  - low power consumption

Challenges

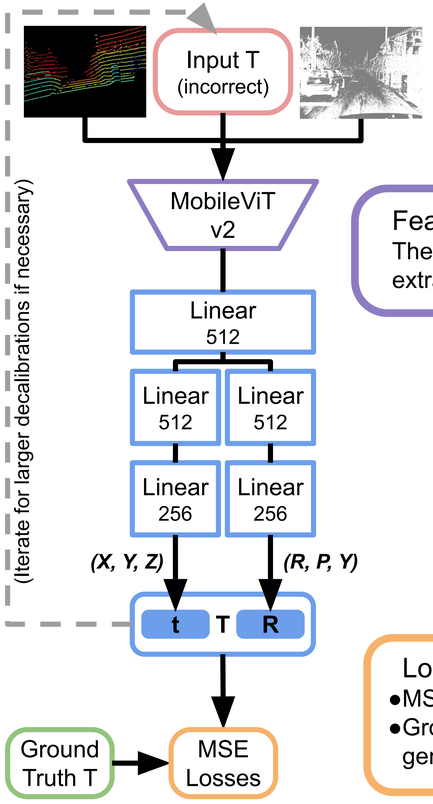
Event representation

Representation	MAE_{trans} (cm)	MAE_{rot} (deg)
Event Frame	0.81	0.10
Voxel Grid	0.88	0.11
Time Surface	1.17	0.23

Environment Variabilty

Location	MAE_{trans} (cm)	MAE_{rot} (deg)
Interlaken	1.07	0.12
Thun	0.59	0.08
Zurich City	0.40	0.08

Method Overview



Input preprocessing:
- Events synced to LiDAR
- Events → events frame

Feature extraction:
The MobileViTv2 backbone jointly extracts features from both inputs.

Regression head:
- first layer is common
- following layers split:
  - translation (t)
  - rotation (R)
- outputs transformation T

Loss:
- MSE losses on R and t
- Ground truth is a known artificially generated decalibration

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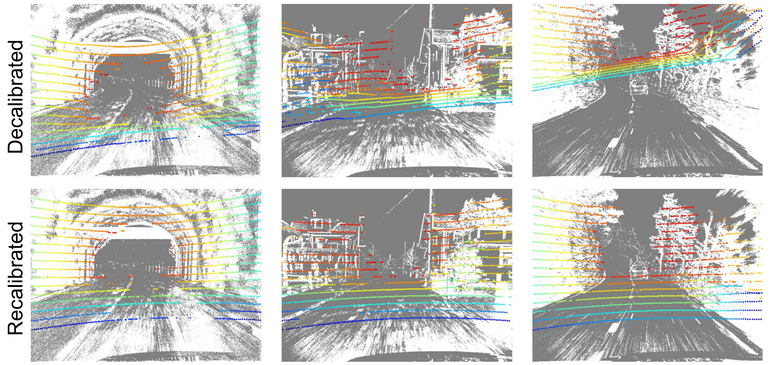
Results

Method	MAE_{trans} (cm)	MAE_{rot} (deg)	Online	Execution Time (s)
L2E [3]	N/A	N/A	No	134
LCE-Calib [4]	1.5	0.3	No	N/A
MULi-Ev (ours)	**0.81**	**0.1**	**Yes**	**< 0.1**

- 1st online method
- Fast
- Accurate
- Targetless

$$\mathrm{MAE}_{\mathrm{trans}} = \frac{1}{N}\sum_{i=1}^{N} \|\mathbf{t}_{\mathrm{pred},i} - \mathbf{t}_{\mathrm{gt},i}\|_2 \qquad \mathrm{MAE}_{\mathrm{rot}} = \frac{1}{N}\sum_{i=1}^{N} \|\mathrm{Euler}(\mathbf{R}_{\mathrm{rel},i})\|$$



References

[1] Mathieu Cocheteux et al. "PseudoCal: Towards Initialisation-Free Deep Learning-Based Camera-LiDAR Self-Calibration". British Machine Vision Conference (BMVC), 2023.

[2] Nick Schneider et al. "RegNet: Multimodal Sensor Registration Using Deep Neural Networks." 2017 IEEE Intelligent Vehicles Symposium (IV). 2017.

[3] Kevin Ta et al. "L2E: Lasers to Events for 6-DoF Extrinsic Calibration of LiDARS and Event Cameras." 2023 IEEE International Conference on Robotics and Automation (ICRA). 2023.

[4] Jianhao Jiao et al. "LCE-Calib: Automatic LiDAR-frame/Event Camera Extrinsic Calibration with a Globally Optimal Solution." IEEE/ASME Transactions on Mechatronics. 2023.