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Event-based Vision meets Deep Learning on Steering Prediction for Self-Driving Cars

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Event-based Vision

Deep Learning

POLITÉCNICA

Motivation:

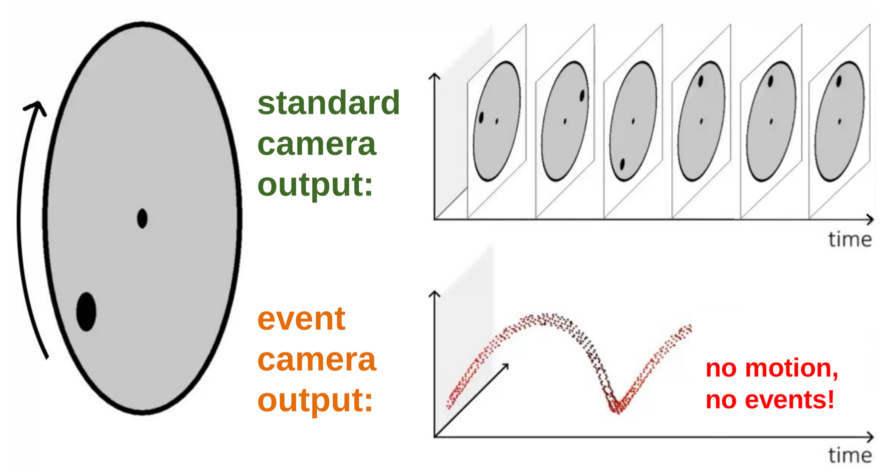
Steering angle prediction with standard cameras is not robust to scenes characterized by **high dynamic range (HDR), motion blur, and low light**.

Goal:

By using an event camera, we achieve **steering angle prediction** with **unprecedented performance in HDR and even at night**, outperforming standard cameras.

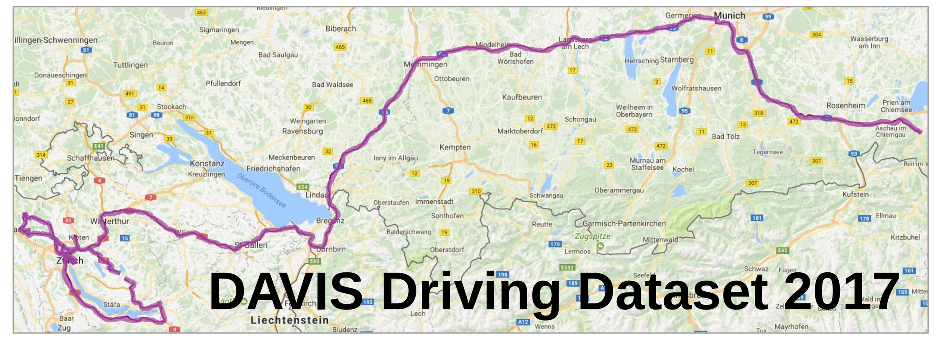
Why event cameras?

- They **naturally respond to motion** in the scene.
- Advantages over standard cameras: **low latency, high temporal resolution, and HDR.**



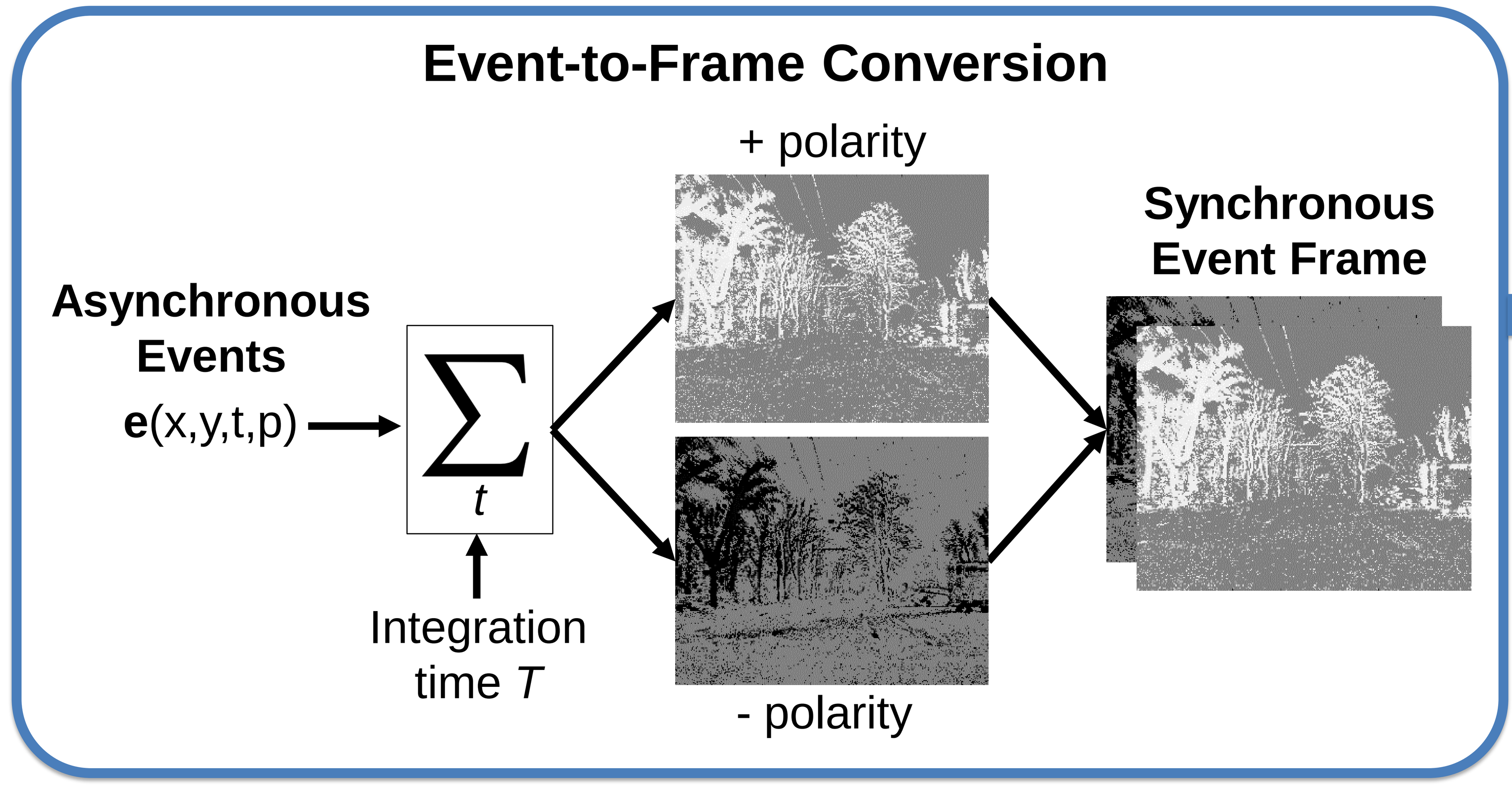
Large-scale dataset

≈ 12 h. of annotated driving recordings, including async. events and sync. grayscale frames.

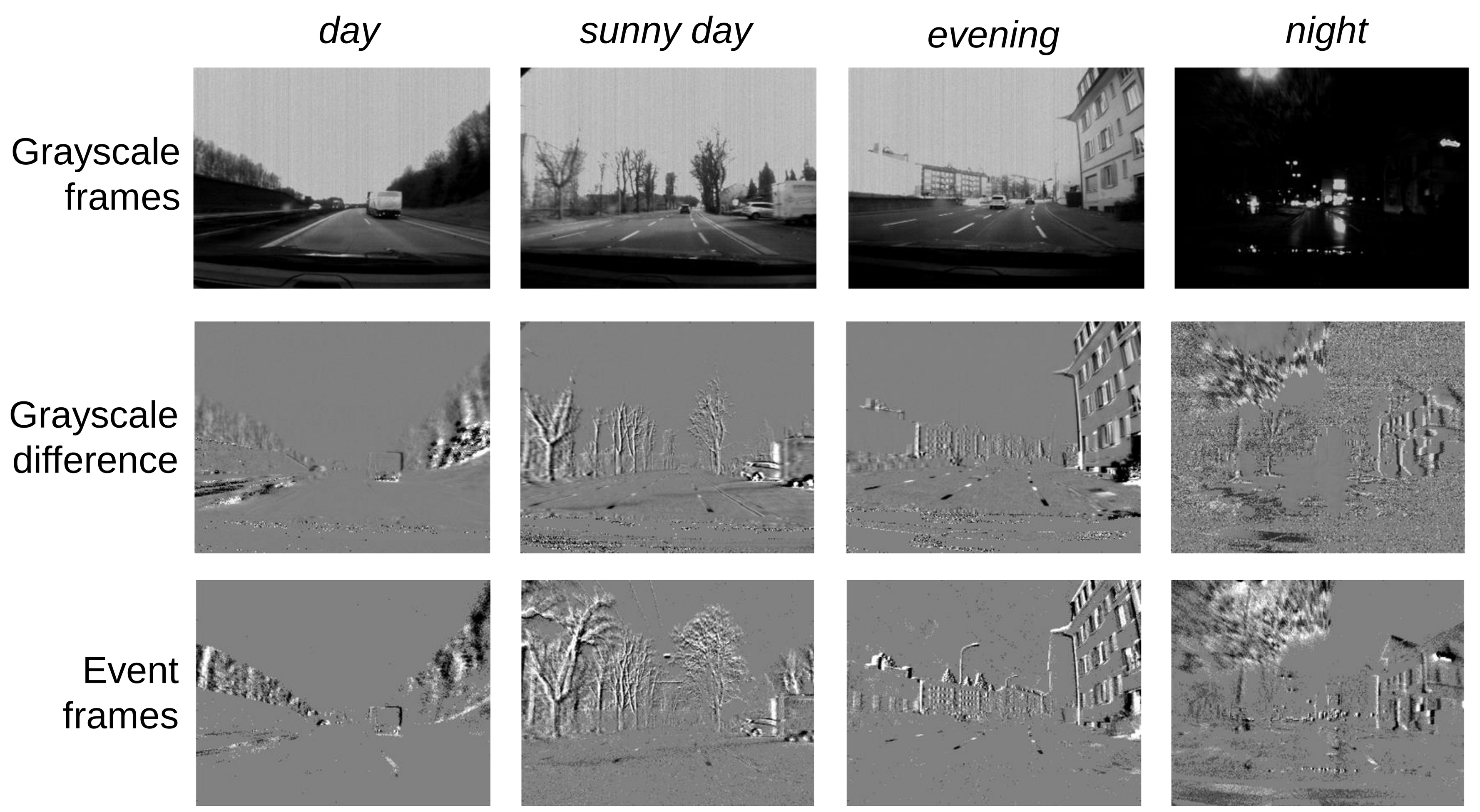


Input data

- Asynchronous event: change in pixel brightness.
- Conversion to synchronous event frames.

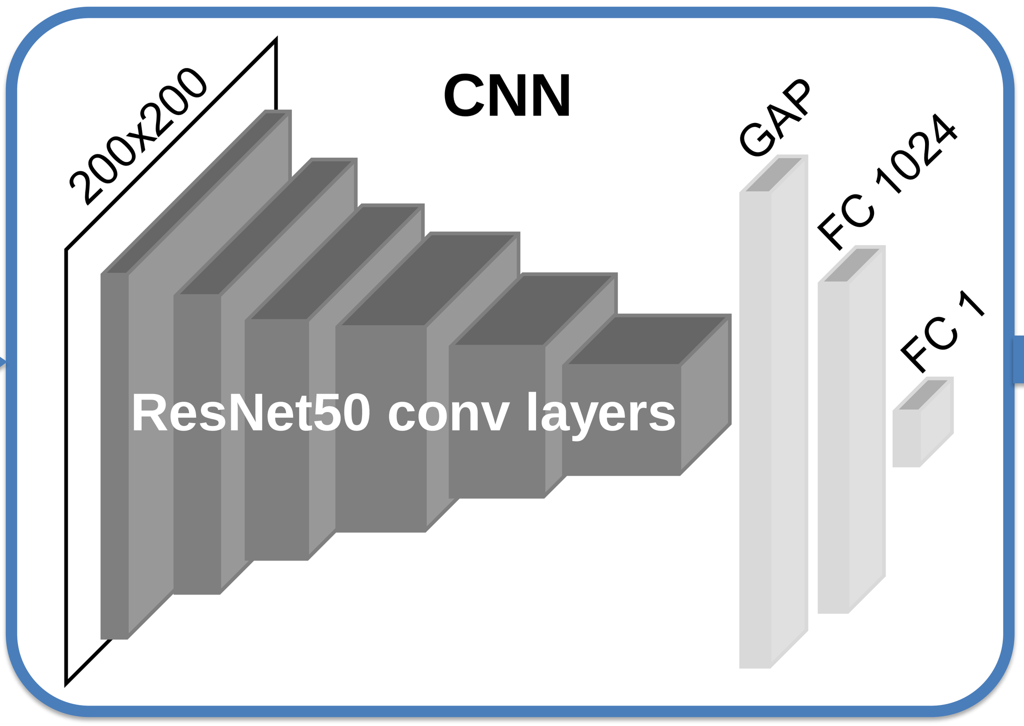


- Comparison with grayscale frames and difference of grayscale frames under different conditions:

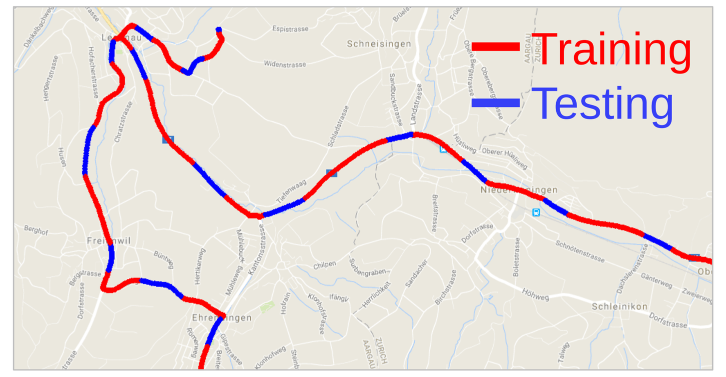


Learning process

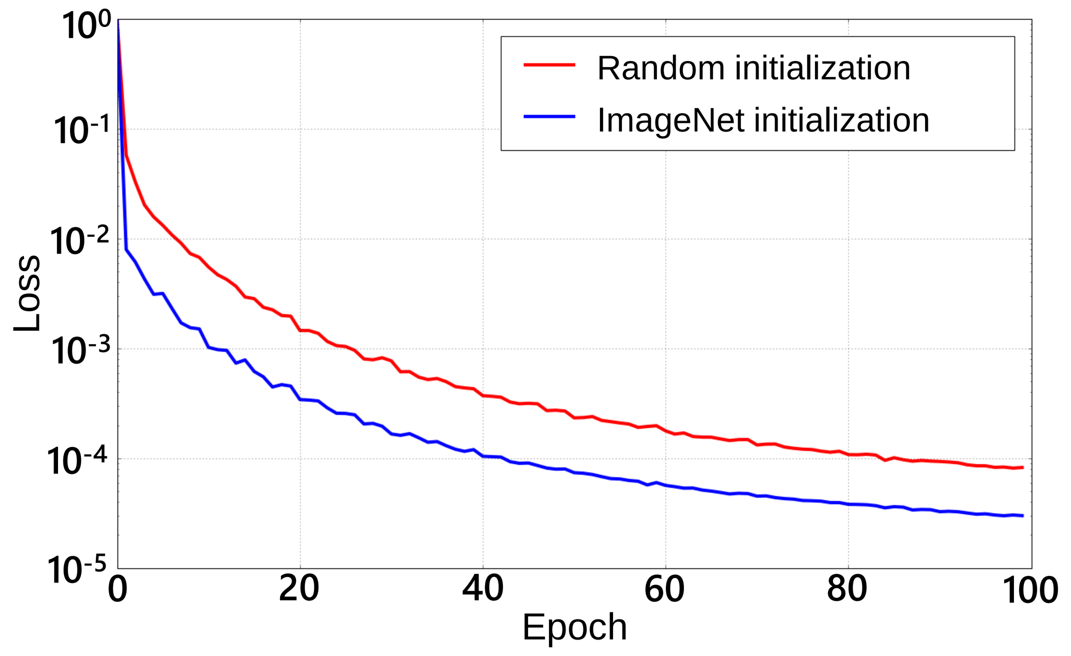
- Steering angle regression through a Convolutional Neural Network.



- Alternate sequences of 40 sec for training, and 20 sec for testing.



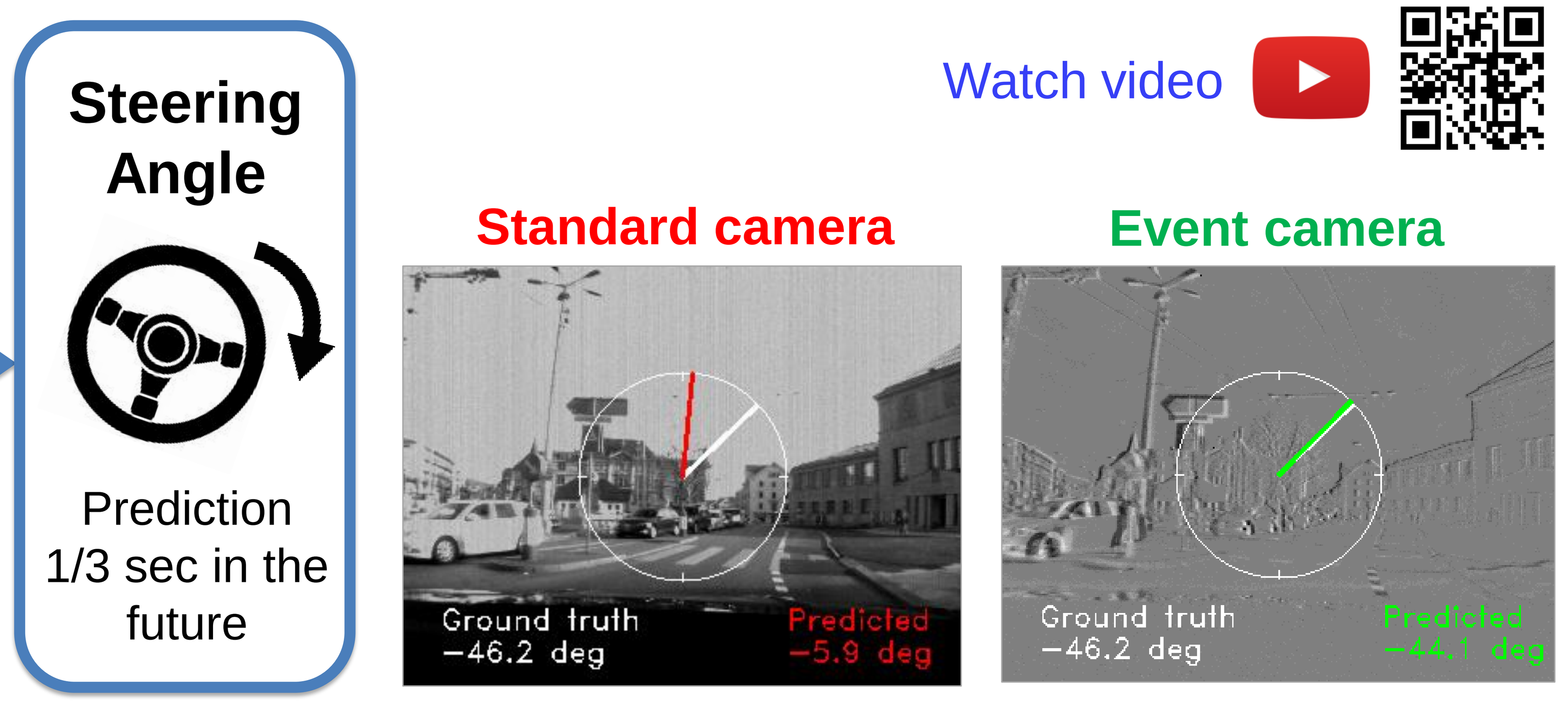
- Transfer learning from RGB images to event frames:

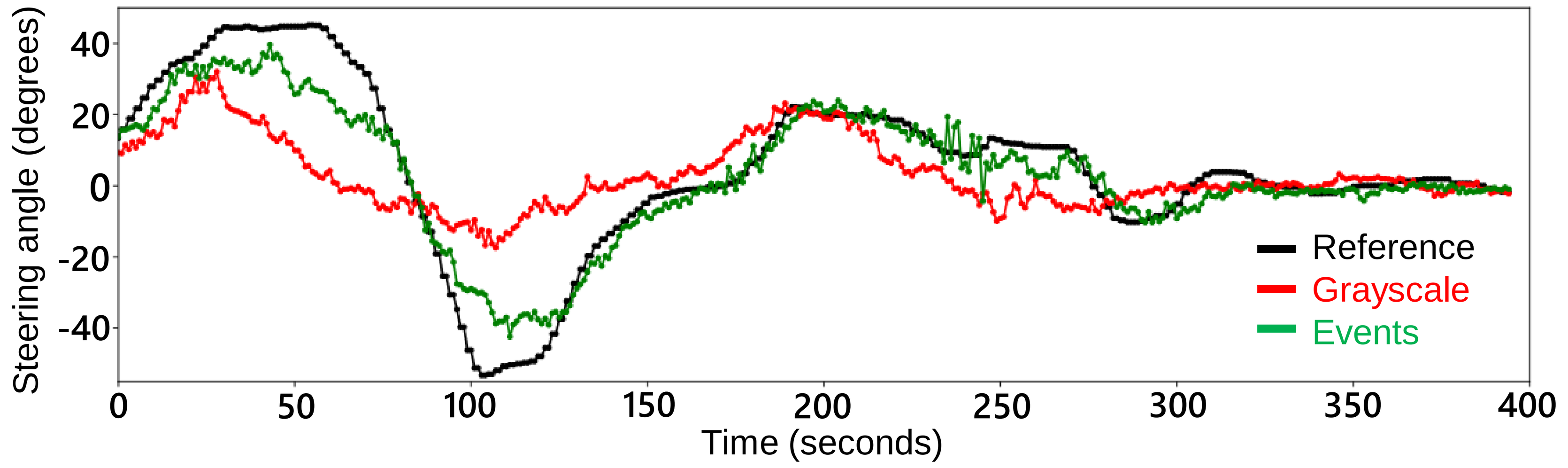


Results

- The same CNN can predict a vehicle's steering angle on a very wide range of scenarios.

Watch video





- The proposed network improves results w.r.t. the state-of-the-art based on standard cameras by 50-55%.

Architecture	EVA	RMSE	Input
Bojarski et al. [1] (NVIDIA 2016)	0.161	9.02º	Grayscale
CNN-LSTM [2] (CVPR 2017)	0.300	8.19º	Grayscale
ResNet18	0.738	4.58º	Events
ResNet50 (random init.)	0.800	4.40º	Events
ResNet50 (ImageNet init.)	**0.826**	**4.10º**	**Events**

[1] Bojarski *et al.*, "End to end learning for self-driving cars", *arXiv*, April 2016.
[2] Xu *et al.*, "End-to-end learning of driving models from large-scale video datasets", *IEEE Int. Conf. Comp. Vis. Pattern Recog. (CVPR)*, July 2017.