Robust Lane Detection through Self Pre-training with Masked Sequential Autoencoders and Fine-tuning with Customized PolyLoss

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Publication date
2023

Document Version
Final published version

Citation (APA)
Dong, Y., Li, R., & Farah, H. (2023). *Robust Lane Detection through Self Pre-training with Masked Sequential Autoencoders and Fine-tuning with Customized PolyLoss*. 1. Poster session presented at 102nd Annual Meeting of the Transportation Research Board (TRB), Washington, District of Columbia, United States.

Robust Lane Detection through Self Pre-training with Masked Sequential Autoencoders and Fine-tuning with Customized PolyLoss

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Background & Aim

- ❖ Lane detection is crucial for Automated Vehicles and ADAS
- ❖ Available vision based methods usually use one image to do lane detection
- ❖ Traditional methods usually adopted cumbersome hand-crafted features
- ❖ Deep learning based methods in literature still can not make full use of spatial-temporal information and correlation
- ❖ Available methods can not handle challenging driving scenes well

The main aim of this study is:

- ➢ **To develop robust detection model handling challenging driving scenes**
- ➢ **To make full use of valuable features and aggregate contextual information**
- ➢ **To develop pre-training method for sequential vision based lane detection**

Figure 1. Examples of challenging driving scenes.

The framework of the proposed pipeline

- ➢ **End-to-end Encoder-decoder Structure**
- ➢ **Self Pre-training to Reconstruct Images**
  - ▪ Masked sequential autoencoders
- ➢ **Fine-tuning Segmentation**
  - ▪ Transfer pre-trained model weights to the segmentation model
- ➢ **Customized PolyLoss**
- ➢ **Post-processing with clustering & curve fitting**
- ➢ **Tested and verified on two data sets**
  - ▪ tvtLANE normal (TuSimple lane)
  - ▪ tvtLANE challenging (12 cases)

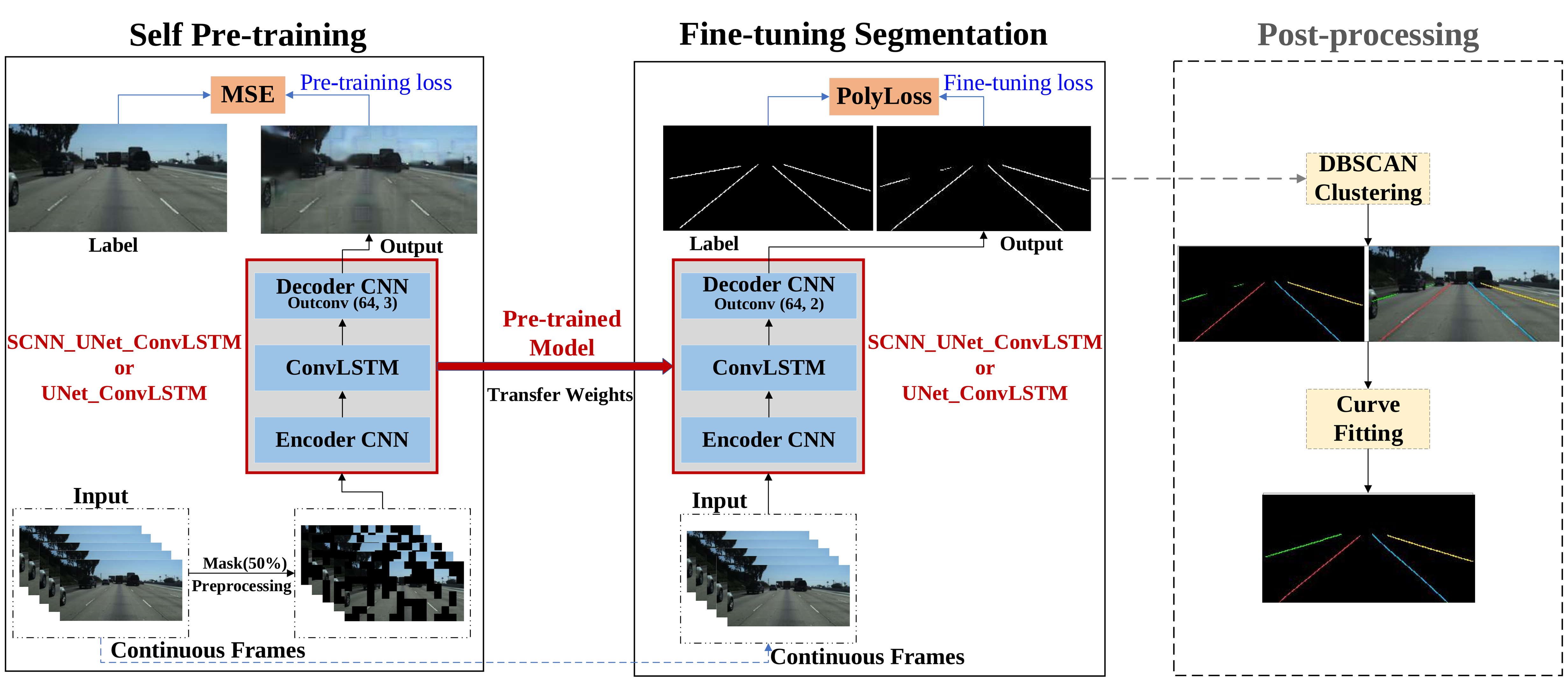

Figure 2. The framework of the proposed pipeline

Evaluation Metrics

- ➢ **Accuracy**
- ➢ **Precision**
- ➢ **Parameter Size**
- ➢ **F1-Meassure**
- ➢ **Recall**
- ➢ **MACs (Multiply-accumulate operations)**

Results

Models		Test_Acc (%)	Precision	Recall	F1-Measure	MACs (G)	Params (M)
Using single image		**Baseline Models**					
	SegNet	96.93	0.796	0.962	0.871	50.2	29.4
	UNet	96.54	0.790	**0.985**	0.877	15.5	13.4
	SCNN*	96.79	0.654	0.808	0.722	77.7	19.2
	LaneNet*	97.94	0.875	0.927	0.901	44.5	19.7
Using multi-continuous images	SegNet_ConvLSTM	97.92	0.874	0.931	0.901	217.0	67.2
	UNet_ConvLSTM	98.00	0.857	0.958	0.904	69.0	51.1
		Pre-trained Models					
	UNet_ConvLSTM_CE**	98.19	0.882	0.940	0.910	69.0	51.1
	UNet_ConvLSTM_PL**	98.34	0.921	0.909	0.915	69.0	51.1
		Baseline Models					
	SCNN_SegNet_ConvLSTM	98.07	0.893	0.928	0.910	223.0	67.3
	SCNN_UNet_ConvLSTM	98.19	0.889	0.950	0.918	93.0	51.3
		Pre-trained Models					
	SCNN_UNet_ConvLSTM_CE**	98.20	0.891	0.952	0.921	93.0	51.3
	SCNN_UNet_ConvLSTM_PL**	**98.38**	**0.929**	0.915	**0.922**	93.0	51.3

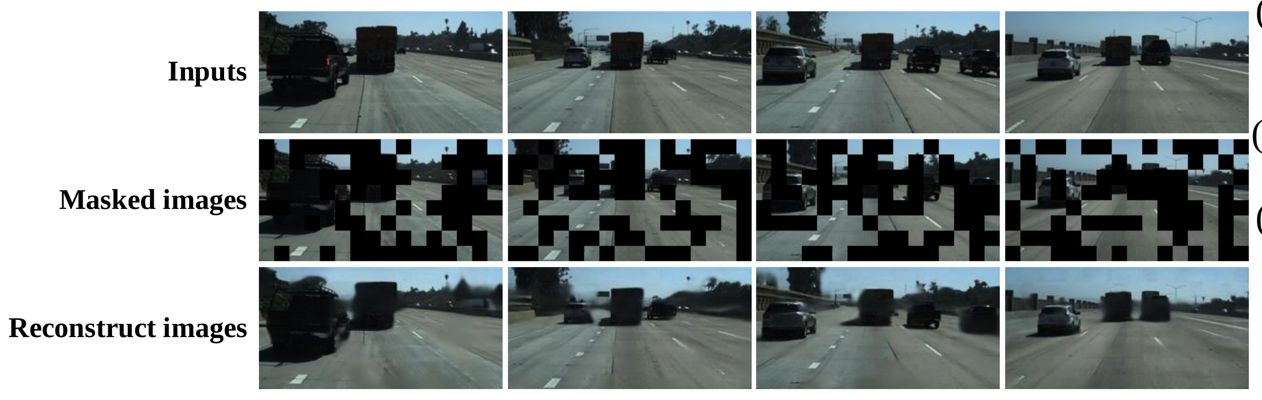

Figure 3. Visualization of the reconstructing results in the pre-training phase.

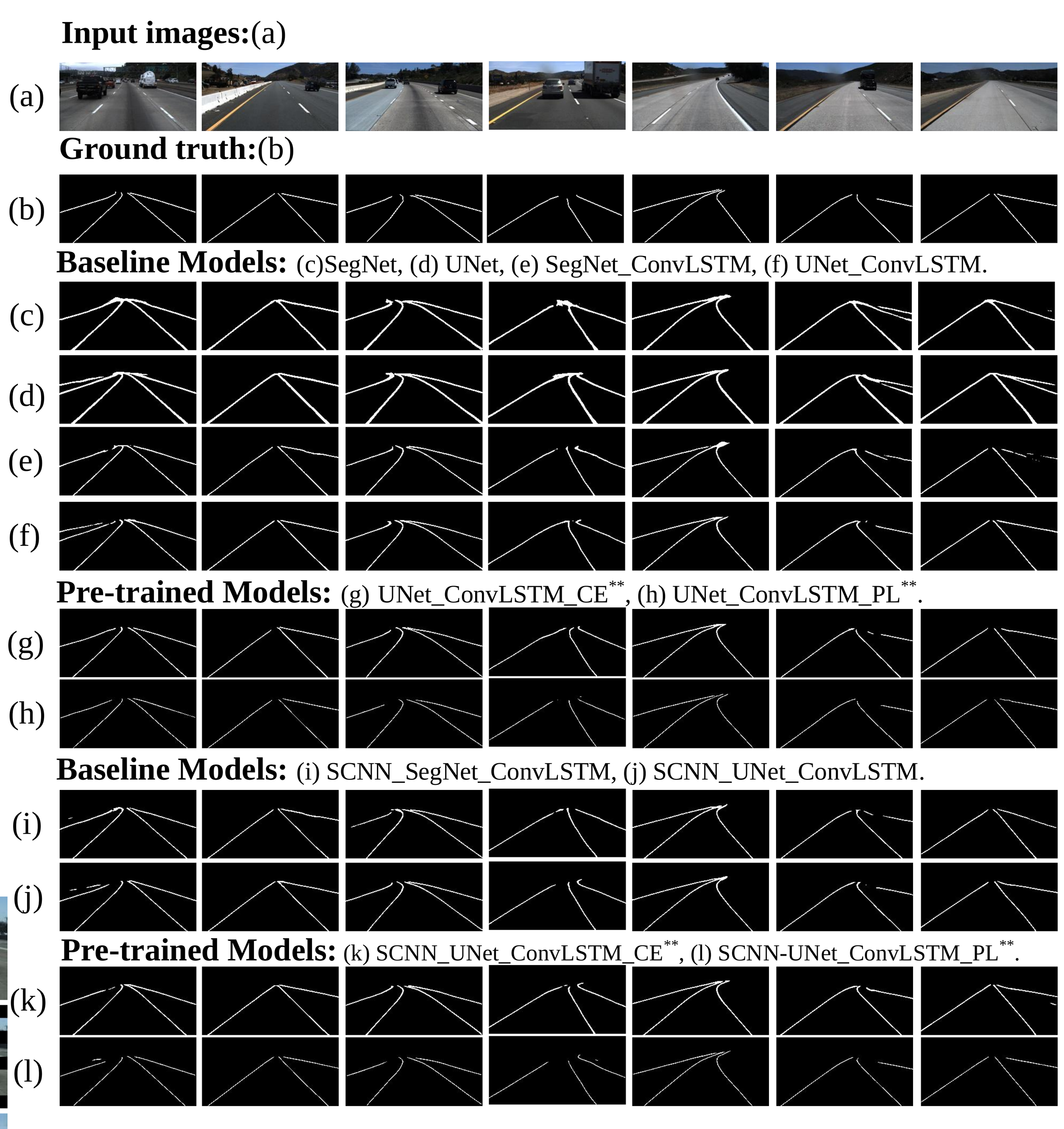

Figure 4. Visualization of lane-detection results on normal cases.

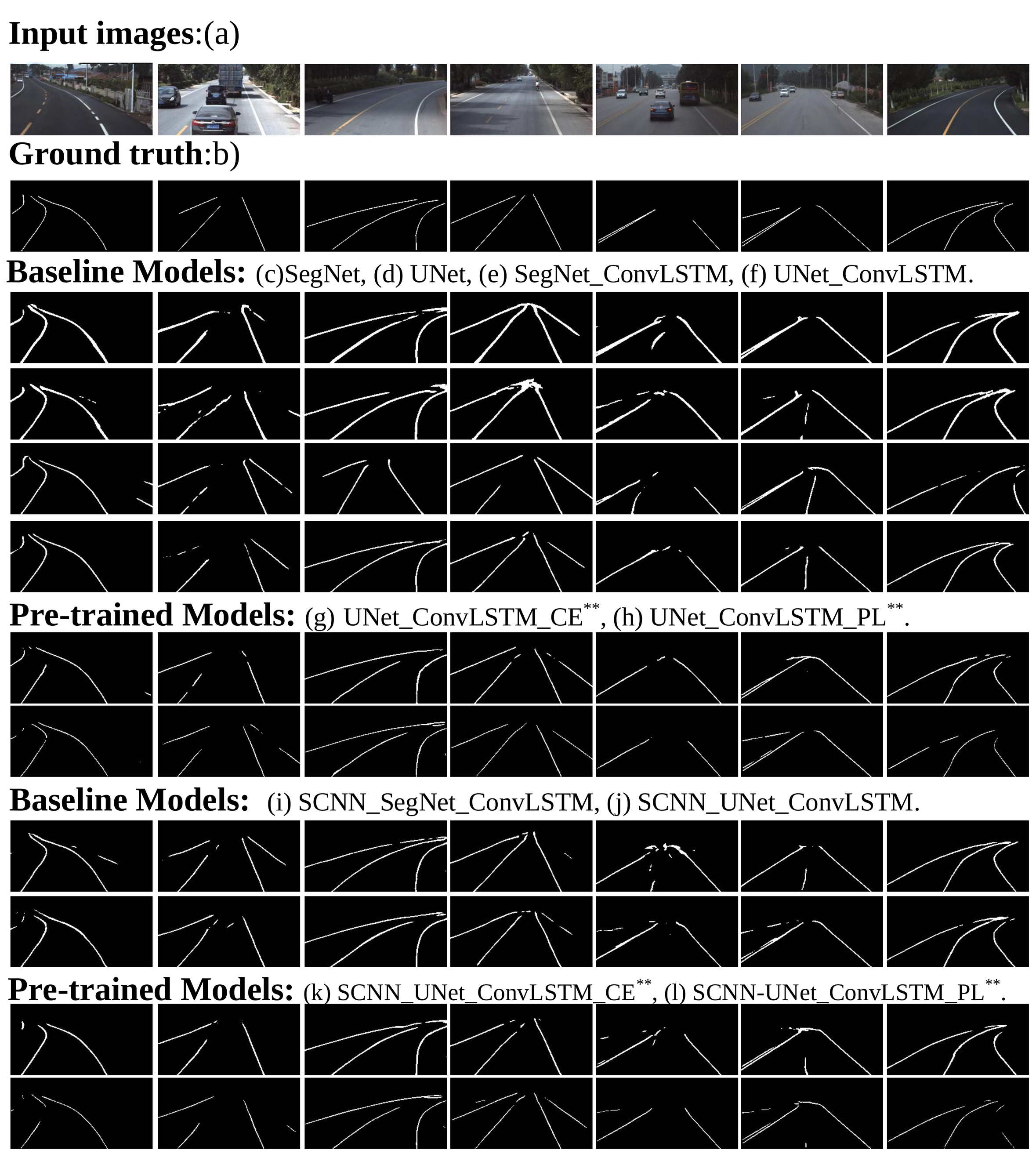

Figure 5. Visualization of lane-detection results on 7 challenging driving scenes.

Ablation Study

Testing different loss functions and models

Models \ Testing Datasets		Testset #1 (Normal Situations)				Testset #2 (Challenging Situations)			
	Loss Function	Test_Acc (%)	Precision	F1-Measure	Loss Function	Test_Acc (%)	Precision	F1-Measure	
UNet_ConvLSTM	CE	98.19	0.882	0.910	CE	98.13	0.7932	0.6537	
	PL	98.34	0.921	0.915	PL	**98.38**	0.8331	0.6284	
SCNN_UNet_ConvLSTM	CE	98.20	0.891	0.921	CE	98.03	0.8001	**0.7327**	
	PL	**98.38**	**0.929**	**0.922**	PL	98.36	**0.8444**	0.6711	

Conclusions

- ➢ **The proposed masked sequential autoencoder based pre-training and customized PolyLoss are useful**
- ➢ **The proposed pipeline is effective and robust which can improve the performances of SOTA models in both normal and challenging cases**

TRB Transportation Research Board of the National Academies | NWO Netherlands Organisation for Scientific Research | SAMEN Safe and Efficient Operation of Automated and Human Driven Vehicles in Mixed Traffic | Lab Traffic and Transportation Safety