Street-Map Based Validation of Semantic Segmentation in Autonomous Driving

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Research question

Can predicted semantic segmentation masks be validated with a-priori knowledge from street maps?

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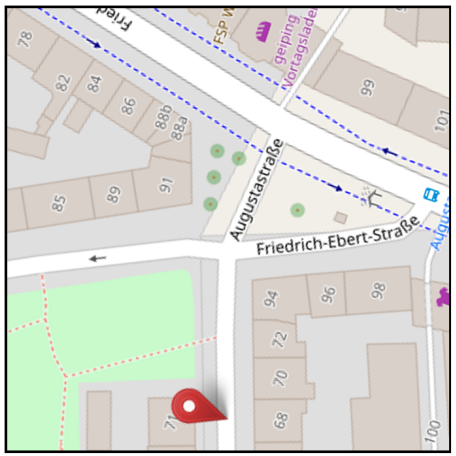
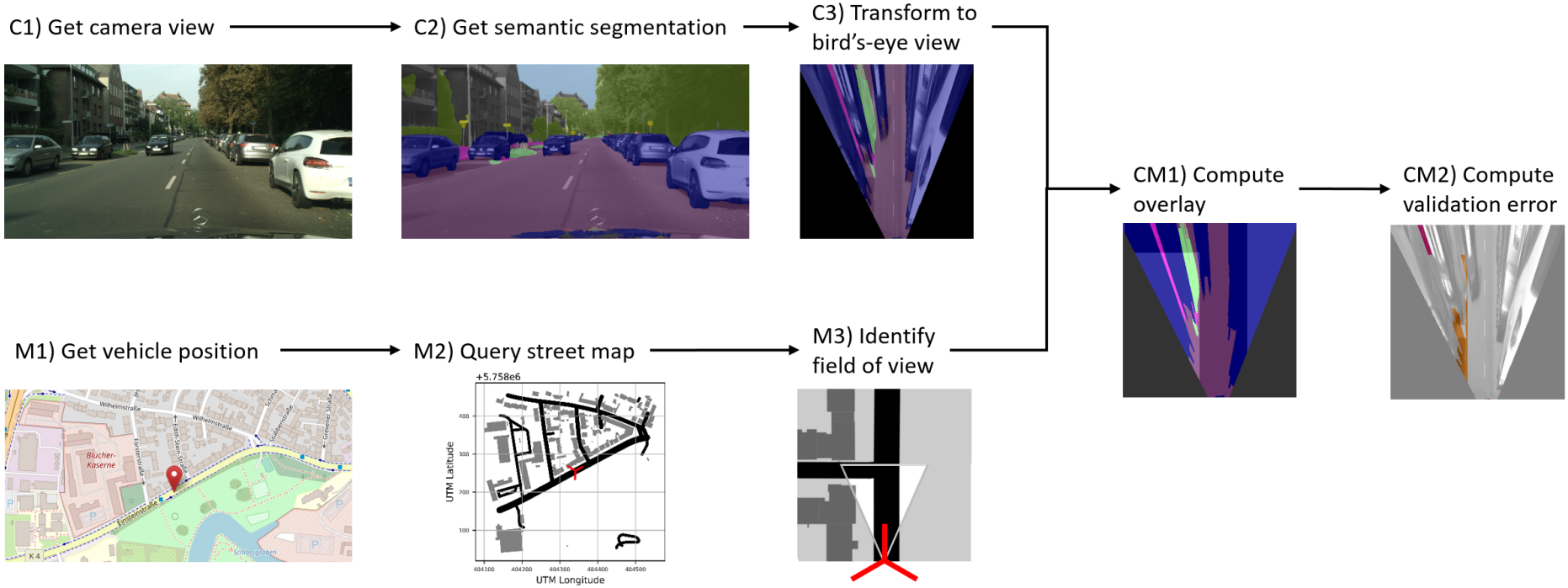


Robust artificial intelligence is important for safe autonomous driving!

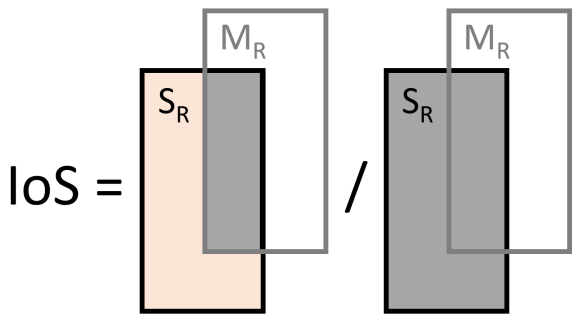
Approach

Compute overlay of segmentation mask and street map in order to identify validation errors in the road segments

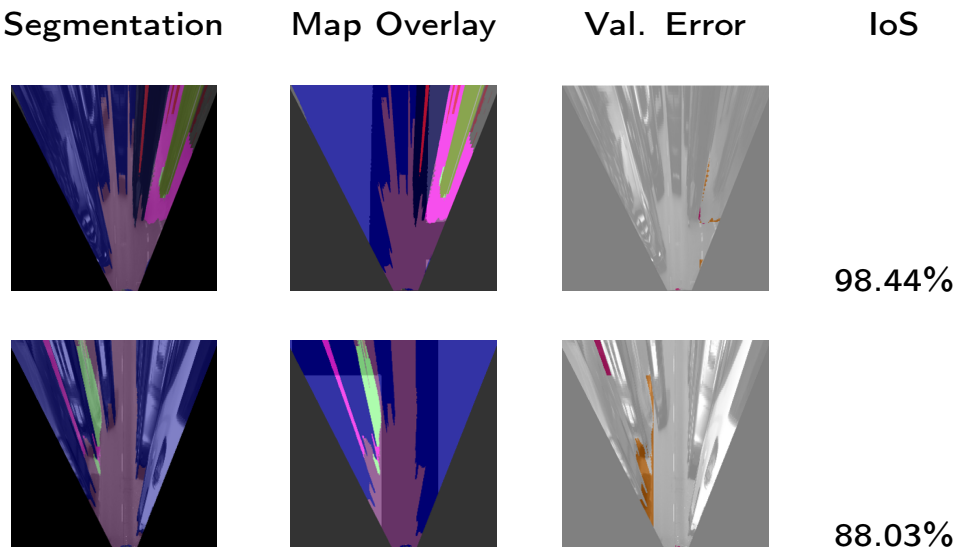


Validation metrics

The share of the semantic road segment that is covered by the map can be quantified by the *Intersection over Segment (IoS)*



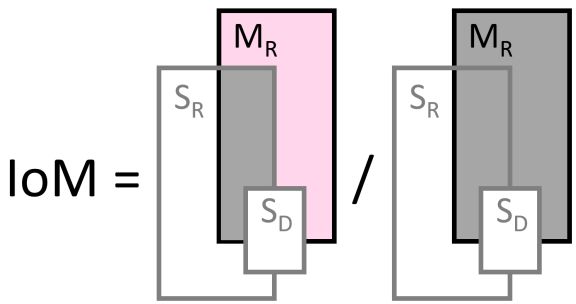
$$IoS = \frac{S_R \cap M_R}{S_R} = \frac{TP}{TP + FP}$$



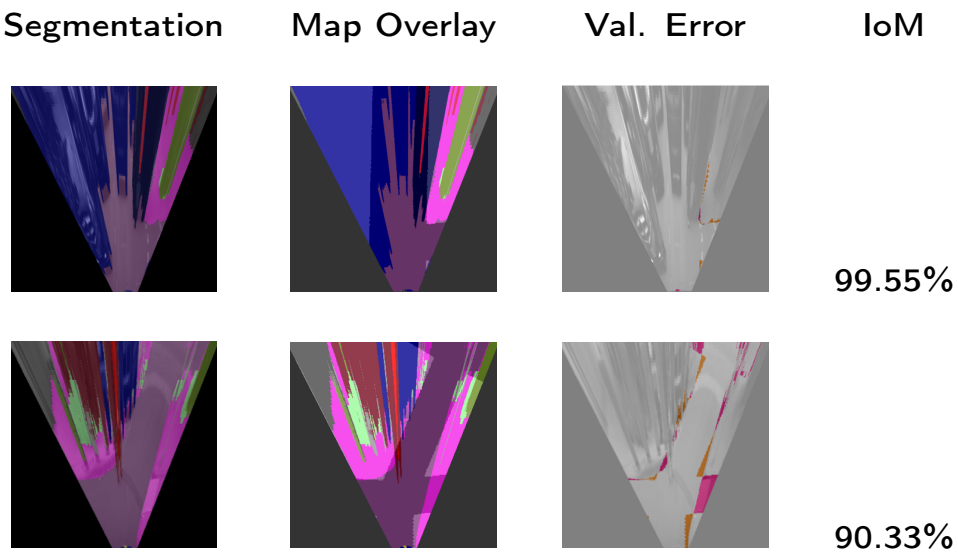
⇒ The lower the *IoS*, the more *False Positive* road segments in the prediction

Validation metrics

The share of the road in the map that is covered by the semantic segment can be quantified by the *Intersection over Map (IoM)*



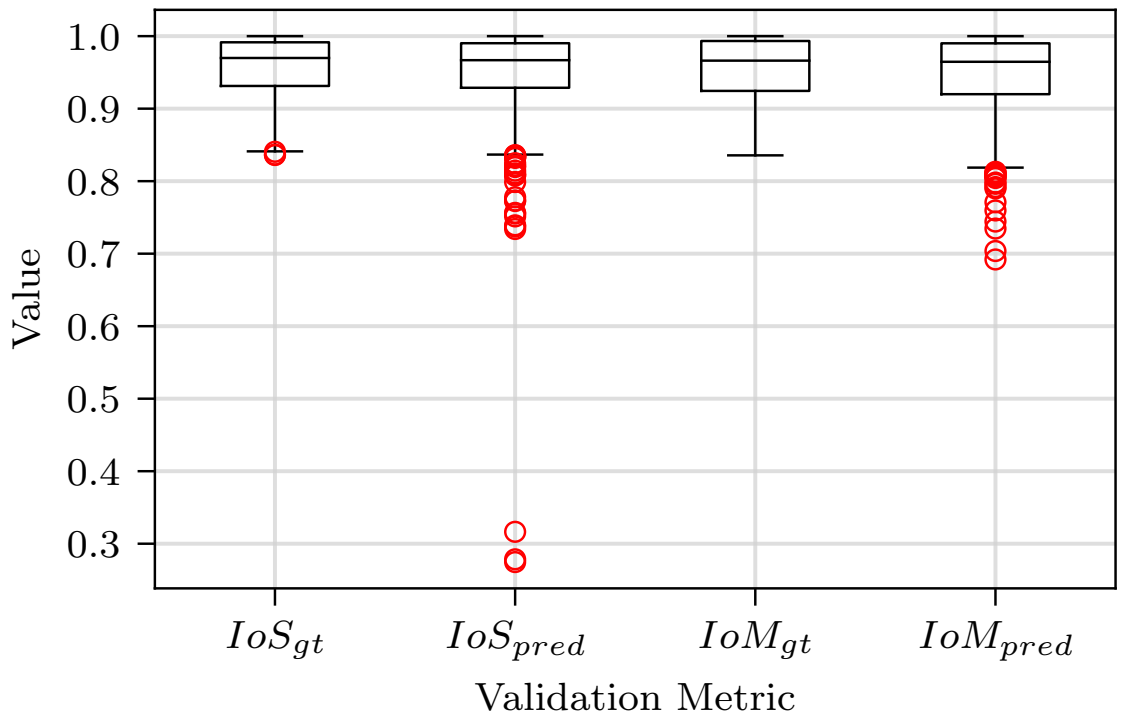
$$IoM = \frac{S_R \cap M_R}{M_R - (M_R \cap S_D)} = \frac{TP}{TP + FN}$$



$\Rightarrow$ The lower the *IoM*, the more *False Negative* road segments in the prediction

Results for Cityscapes Dataset

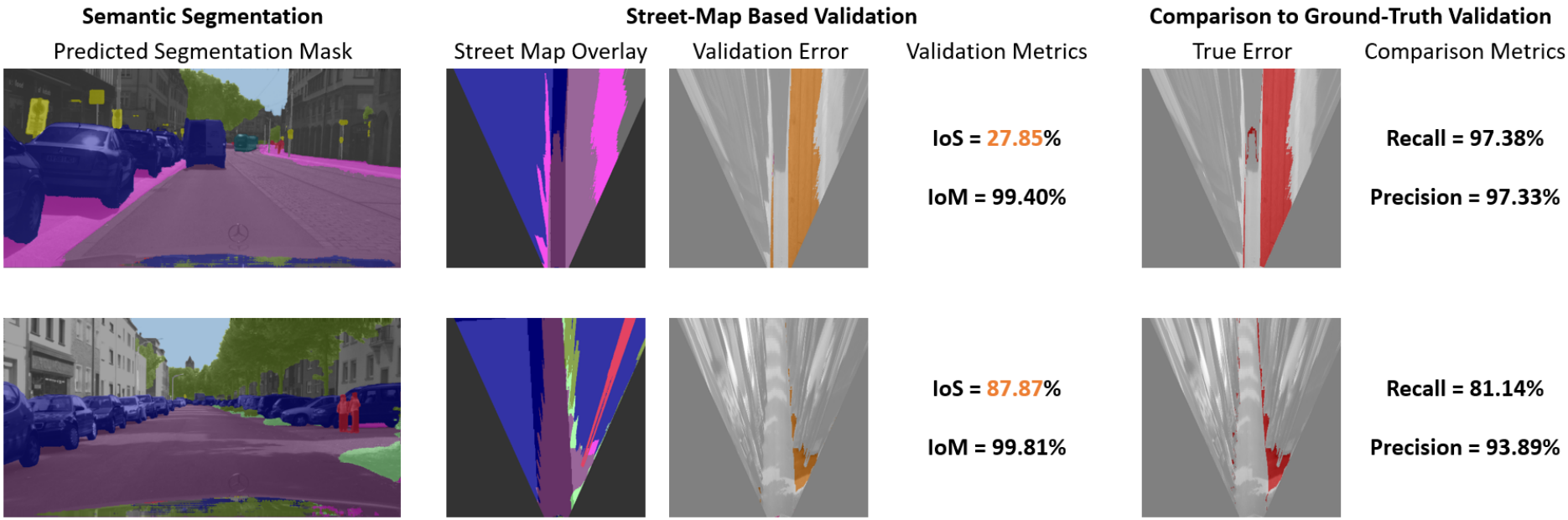
The validation metrics *IoS* and *IoM* contain outliers for the predicted segmentation masks and thus help to identify potential errors



Comparison to Ground-Truth Validation

The street-map based validation can detect similar prediction errors as using ground truth

Examples for *False Positive* road segments:



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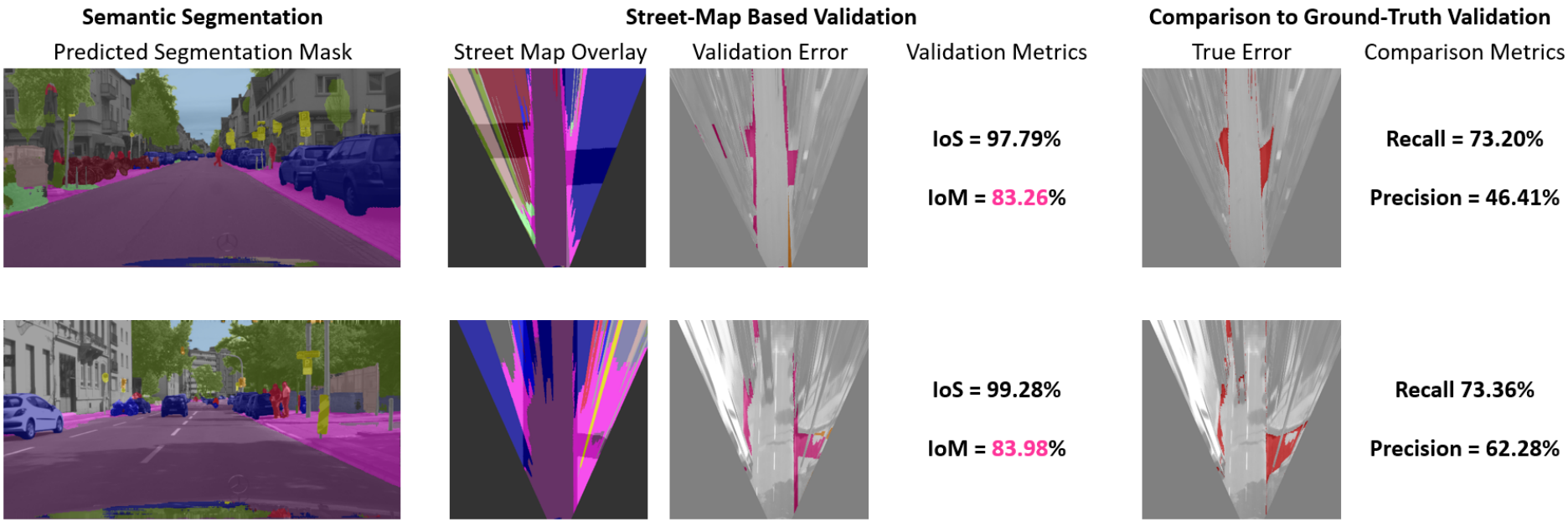
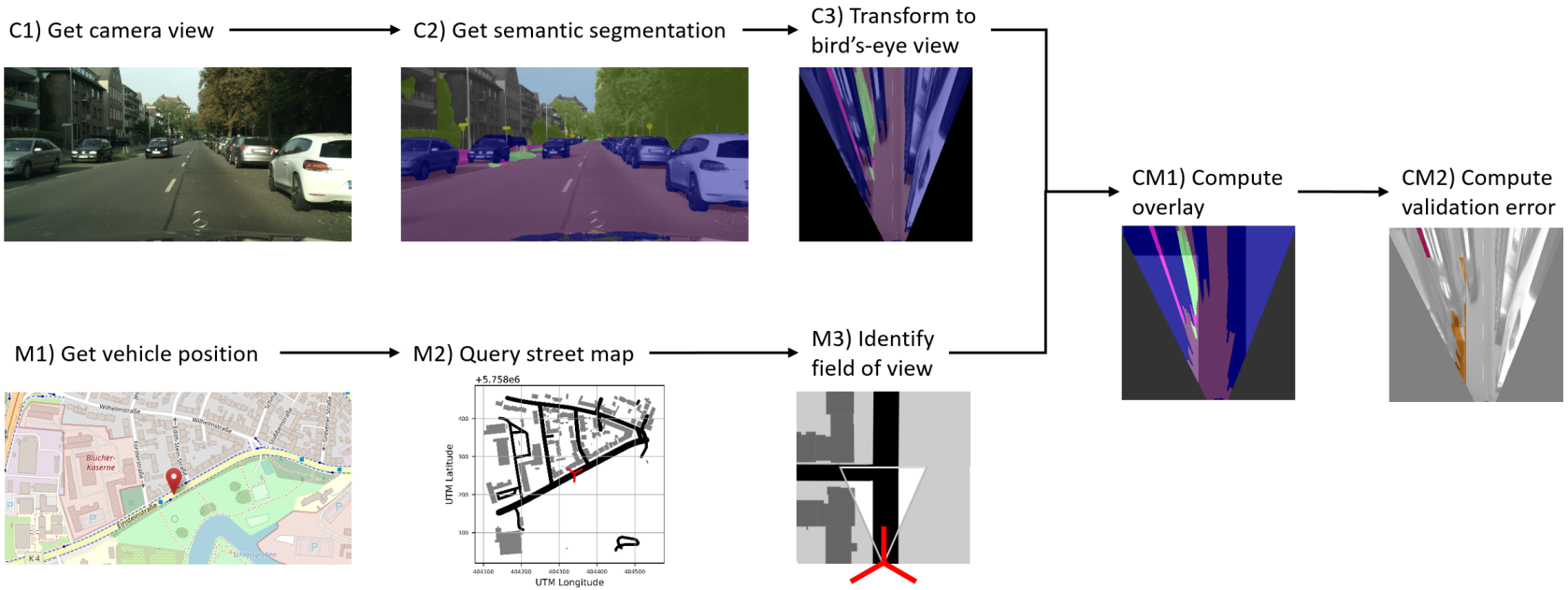


Conclusion

The roads in semantic segmentation masks can be validated with a-priori knowledge from street maps



Further details you can find in our paper:

L. von Rueden, T. Wirtz, F. Hueger, J. D. Schneider, N. Piatkowski, and C. Bauckhage.
Street-Map Based Validation of Semantic Segmentation in Autonomous Driving.
In Proceedings of the 25th International Conference on Pattern Recognition (ICPR), 2020.

References

[1] M. Cordts, M. Omran, S. Ramos, T. Rehfeld, M. Enzweiler, R. Benenson, U. Franke, S. Roth, and B. Schiele. The cityscapes dataset for semantic urban scene understanding. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2016.

[2] OpenStreetMap. `https://www.openstreetmap.org`.

[3] E. Romera, J. M. Alvarez, L. M. Bergasa, and R. Arroyo. Erfnet: Efficient residual factorized convnet for real-time semantic segmentation. *IEEE Transactions on Intelligent Transportation Systems*, 19(1), 2017.

[4] L. von Rueden, S. Mayer, K. Beckh, B. Georgiev, S. Giesselbach, R. Heese, B. Kirsch, J. Pfrommer, A. Pick, R. Ramamurthy, M. Walczak, J. Garcke, C. Bauckhage, and J. Schuecker. Informed machine learning - a taxonomy and survey of integrating knowledge into learning systems. *arXiv:1903.12394v2*, 2020.