Online Map Validation for Autonomous Driving

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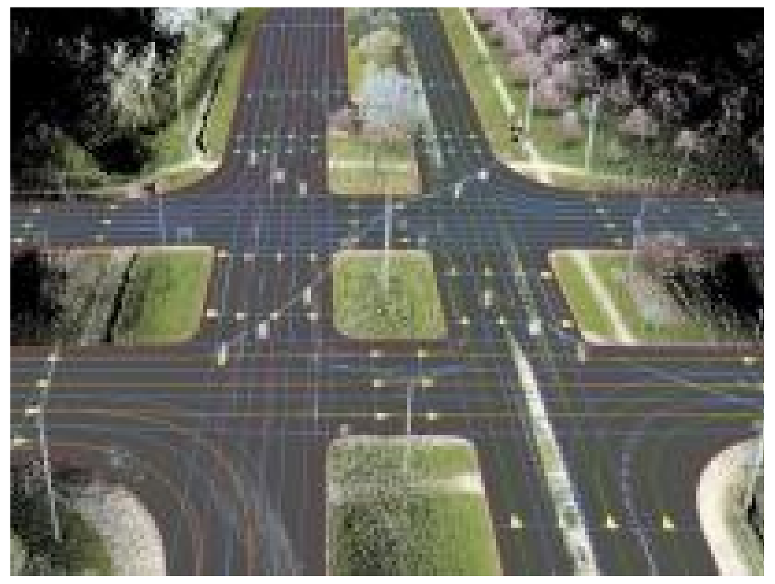
The need for map validation

Self-driving cars depend on high-definition (HD) maps containing semantic and geometric features. Data in HD maps, however, can be outdated and erroneous. It is therefore of critical importance to validate this information before it is used. In 2012, there have been 20.000 construction sites in Munich, Germany [2], which can lead to short or long term changes in the road structure.



Source: https://360.here.com

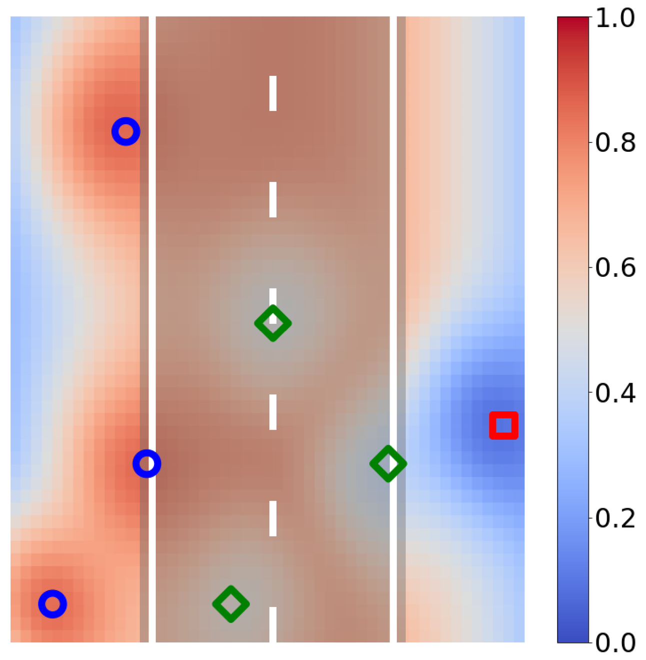
Map data can be considered as a sensor, whose field of view is not affected by traffic conditions, and that sends information with potentially unknown and extensive latency, e.g., maps can be days, or weeks old.

In order to perform the Validation of HD map data, two complementary approaches are developed. A model based approach is used to incorporate temporal and spatial correlation of point measurements in a cell based framework. The second approach utilizes Deep Neural Networks (DNN) to perform binary classification of the scene's map validity.

Model Based Approach

With this model based approach we focus on the validation of the semantincal aspects of HD maps, which lend themselves naturally to be explicitly modelled.

With the goal of extracting as much information as possible from the sparse data coming from sensors, both spatial and temporal correlations among measurements are explicitly handled in the model.



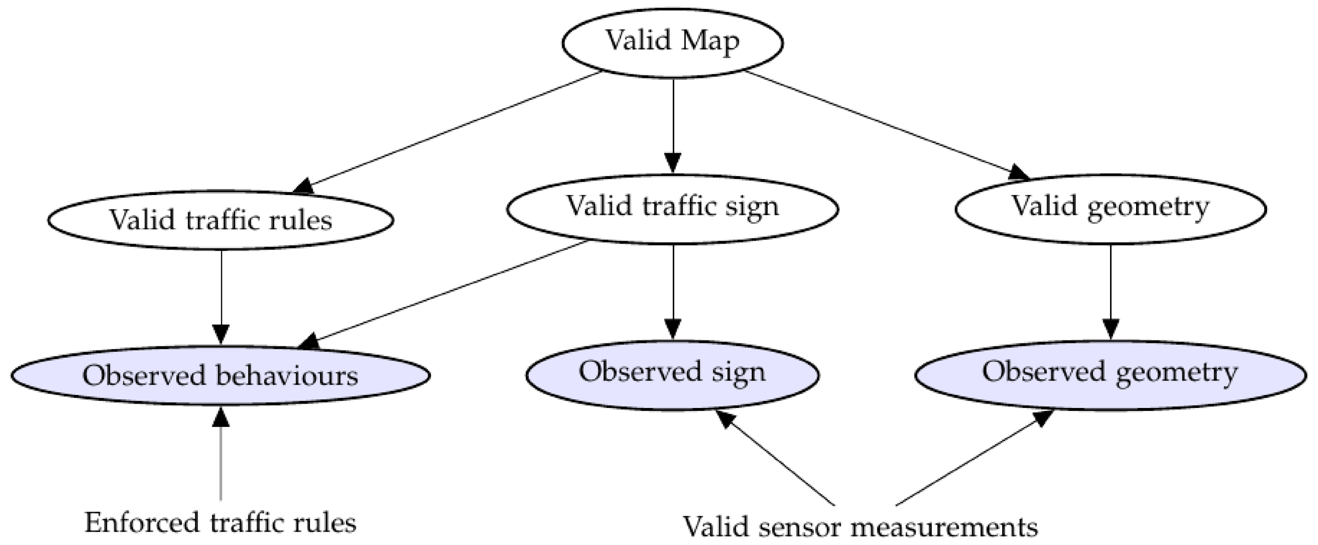
circles: valid data, squares: invalid data, diamond: unknown data.

The sensor measurements can be assume three different values:

- Valid
- Invalid
- Unknown

In the picture the color from blue to red represents the validity probability of the map.

Although flexible, the proposed approach is subject to the assumption of known correlation values among measurements. The latter can be obtained by the fusion among different sensors, performed by a Bayesian Network.

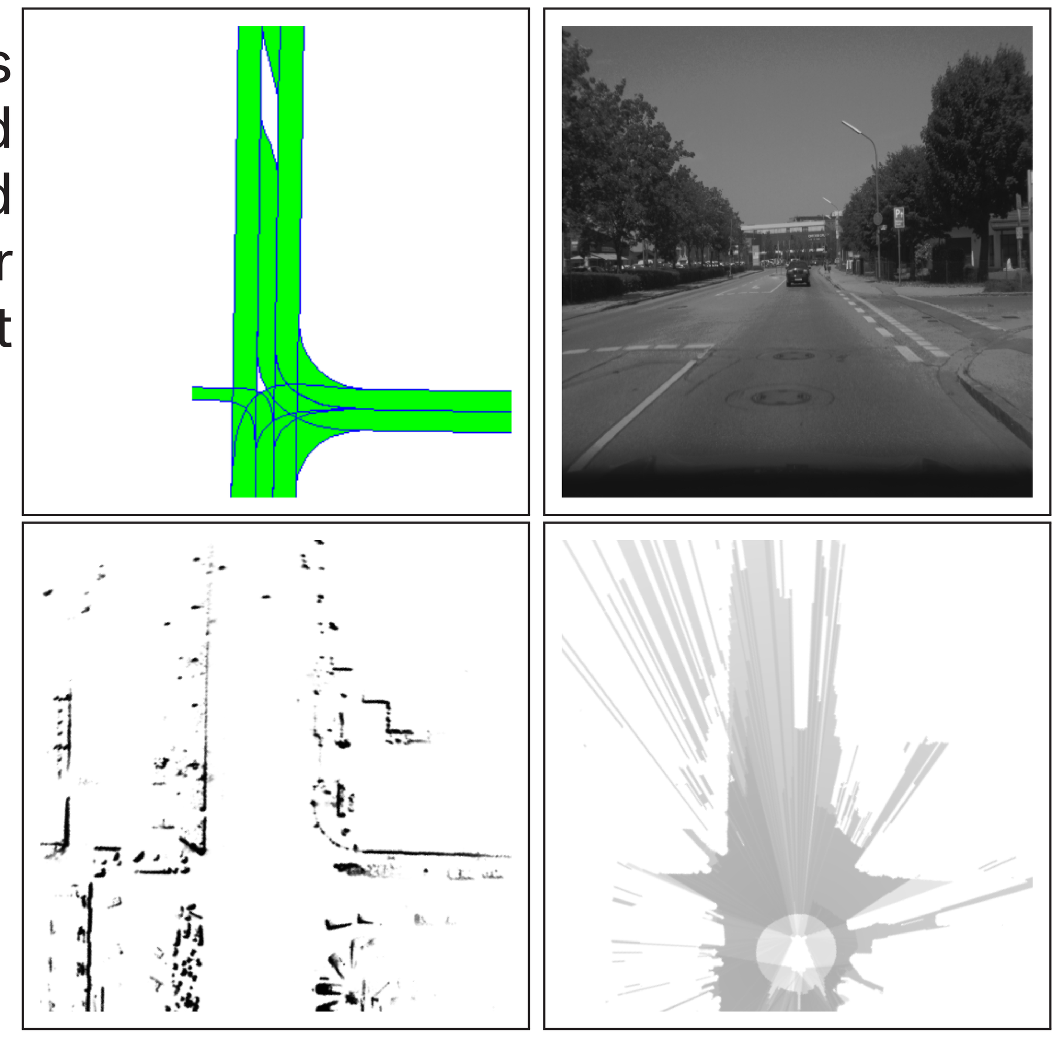


Deep Representation Learning

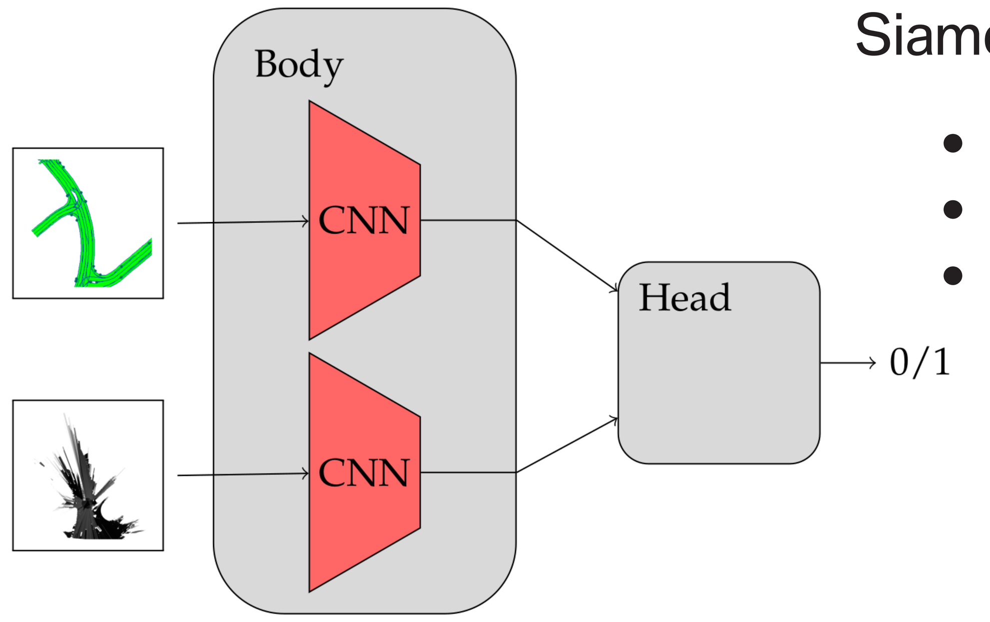
This data driven approach focuses on the validation of the geometrical aspects of HD maps, which are difficult to model explicitly such as complex road shapes.

For training the DNNs a dataset was created containing map and corresponding sensor data from different modalities:

- HD Map data (external)
- Gray-scale Image (Camera)
- Static Evidence (Radar, Lidar)
- Space Classification (Radar, Lidar)



Data pairs of the same recording time are labeled as valid samples. Invalid samples are created by matching images with different time stamps. The models are evaluated against a test set consisting of valid samples and construction sites.



Siamese Architecture [1]:

- Convolutional Body
- Fully Connected Head
- Cross-Entropy Loss

Concluding remarks

The model-based approach permits to define the relation between multiple sources of information but requires an high number of parameter. On the other side with a deep learning approach, complex comparisons among different data sources can be made, if enough training data is available at the expense of an higher computational costs on the vehicle's processing unit. Further work has to be conducted on localizing the concrete invalid part of the map so it can be detected when it does not affect the driving strategy, or missing information can be compensated by the vehicle's sensors.

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[1] Gregory R. Koch. Siamese neural networks for one-shot image recognition. 2015.

[2] Baureferat der Landeshauptstadt München. Jahresbericht 2012 2013, 2013.

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