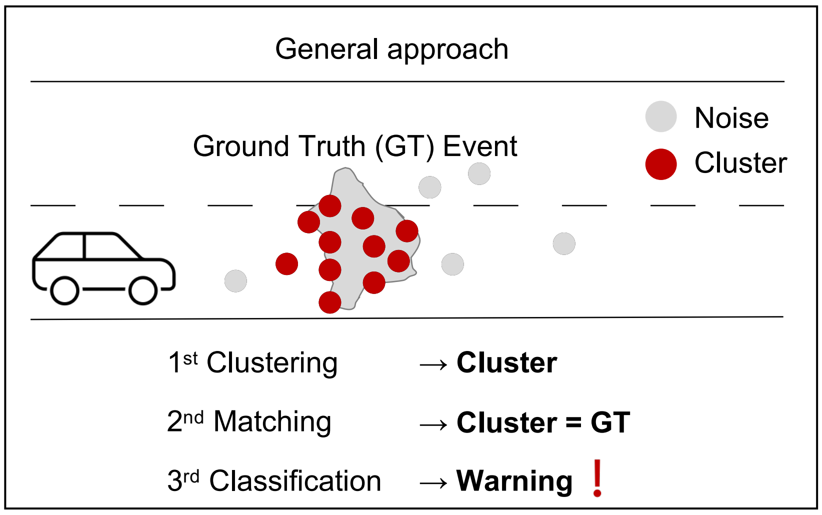
Learning rough road conditions from the fleet sensor data

Master‘s Thesis of Felix Lattemann

Mentoring:
Dr.-Ing. Lisa Kessler
Dr.-Ing. Matthias Spangler

External Mentoring:
Dr.-Ing. Maxim Sidorov (BMW Group)
M.Sc. Burkard Rendenbach (BMW Group)

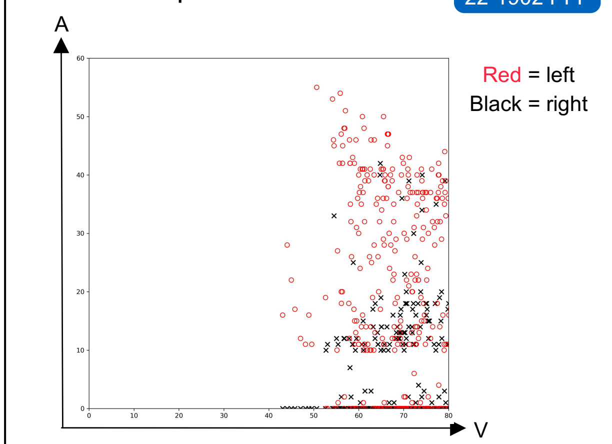


Introduction

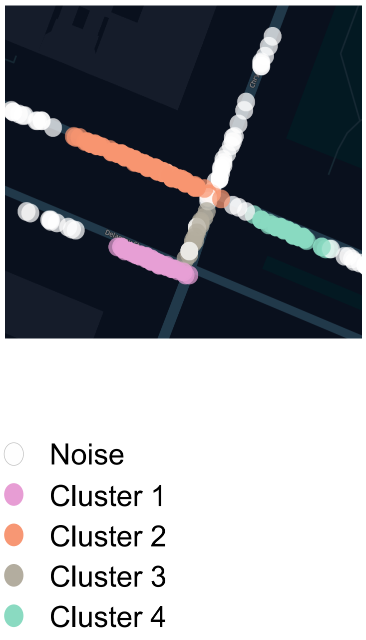
Knowledge of road conditions is critical for almost all stakeholders involved in traffic scenarios, as it not only reduces costs for the customer, the manufacturer, and communities but also has a significant impact on driver safety. To use fleet data to create a map that includes events such as potholes or speed bumps, there are three main steps. First, the data must be clustered to form a subset that is likely to have been caused by the same event. Second, the found subset must be associated with a known event (GT) to perform supervised learning which requires labels against which the prediction is compared. This step is called matching. Finally, the data from each cluster and the corresponding label is used as input for a classifier to learn complex decision rules. The objective is to develop an algorithm that decides whether a driver should receive a warning because of upcoming disturbances or not.

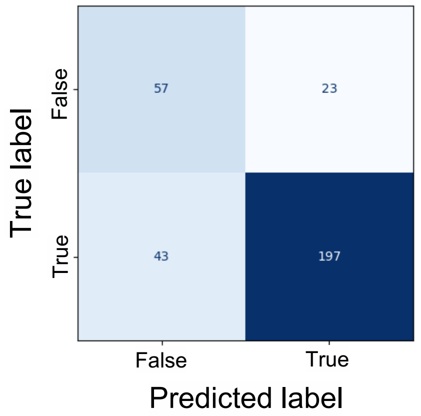
Methodology

The data consists of many recordings by the fleet of BMW within the US. Thus, it is noisy which is why the first clustering step must be able to distinguish those measurements from the rest of the data accurately. Furthermore, the data includes all states of the US and therefore varies in density. Moreover, the road network in which the data is recorded includes constraints such as driving directions or architectural limitations. This work introduces a new way of including those constraints while using a batch-approach that is scalable to large regions based on the NSDBSCAN [1] (BMW Patent 22-1725 PFF). In terms of the classification a pretrained deep Convolutional Neural Network (CNN) is used. However, even if CNNs could prove their performance in many studies, they usually require an image. To adapt the problem to this, the data of each cluster was plotted in a way that contains the necessary information to develop a valid classification rule (BMW Patent 22-1902 PFF). For the base-network, the Xception [2] architecture was chosen which had been trained on ImageNet. Using a pretrained network is especially beneficial due to the small amount of GT data. Even the literature suggests that when using transfer learning the tasks have to be sufficiently similar, the model could become adapted to the task of learning the impression of a human on different road condition just by observing the scatterplots of the amplitude at the suspension on the back of the vehicle.



The dates denote the amplitude at both sides of the vehicle





F_1 = 87.9* **+30%****
Accuracy = 81.9* **+25%****

* On existing clustering. The performance of the whole pipeline is F_1= 89.1, Acc = 83.4
** Compared to the benchmark

Results

For evaluating the results, different analyses were performed. This is especially important because defining quality in clustering is rather complicated. In consequence, the modified NSDBSCAN was validated mainly qualitatively. The same applies to the matching algorithm, since there is no known quality criteria. However, it can be said that the algorithm fulfills the requirements defined in the beginning which consider network constraints and work with geospatial data of large areas. The classification methodology could achieve very good results, especially when thinking of the impact future works could have when combining the creative usage of image processing algorithms with well known classifiers. Finally, not only the classification but the complete pipeline (clustering, matching, classification) was tested to ensure that cross effects will not influence the overall performance negatively. This increased the accuracy even more.

[1] WANG, TIANFU; CHANG REN; YUN LUO; JING TIAN (2019). “NS-DBSCAN: A density-based clustering algorithm in network space”. DOI: 10.3390/ijgi8050218.

[2] CHOLLET, FRANCOIS (2017). “Xception : Deep Learning with Depthwise Separable Convolutions”. DOI: 10.1109/CVPR.2017.195.