SAFIR: Kundengerechte Erprobungssystematik für pilotiertes Fahren

Vorhaben: Sicherheit für Alle – Forschungs- und Innovationspartnerschaft in der Region für globale Fahrzeugsicherheit
Impulsprojekt 2; Förderkennzeichen (FKZ): 03FH7I02IA

BayWISS-Kolleg
Mobilität & Verkehr

Motivation

- Field tests during the development phase ensure that
  - The system performs according to the intended specifications
  - Unexpected reactions of the system are eradicated
- The efforts caused by the testing of integrated safety functions are high
- Costs are expected to grow dramatically considering automated driving

Objective

- Contribute towards a reduction of kilometers driven for validation
- Automated identification, analysis and assessment of traffic scenarios
  - Generic representation of traffic scenarios
  - Feature definition to analyze traffic scenarios with machine learning
  - Group scenarios and extract representatives for template generation

Data Generation

- Videos recorded with a commercial drone at 50m, 75m and 100m height
- Vehicle equipped with a D-GPS RTK sensor (1cm accuracy)
- Vehicle driving in spirals on a test track to capture different poses and image regions
- To ensure repeatability, the trajectory was driven a by driving robot

Figure 1: Trajectory driven on test track, black: D-GPS, red: estimation

Framework

- **Pre-Processing**
- Image Resolution: 1920x1080 px (GSD: 3.5cm @ 50 m height)
- Image registration: fixed frame for all images in a sequence
- **Detection**
- Mask R-CNN: applied transfer learning and adjusted parameters with own, manually labeled data set.
- Semantic shapes used for rotated bounding boxes
- **Post-Processing:**
- Relief Displacement
- Benchmark: mapping coordinate frames
- Synchronization of both data sources

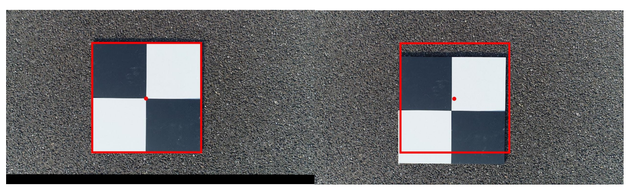

Figure 2: Fixed frame with image registration (left)

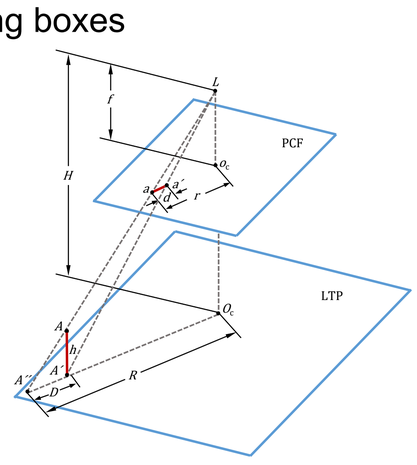

Figure 3: Relief displacement

Results

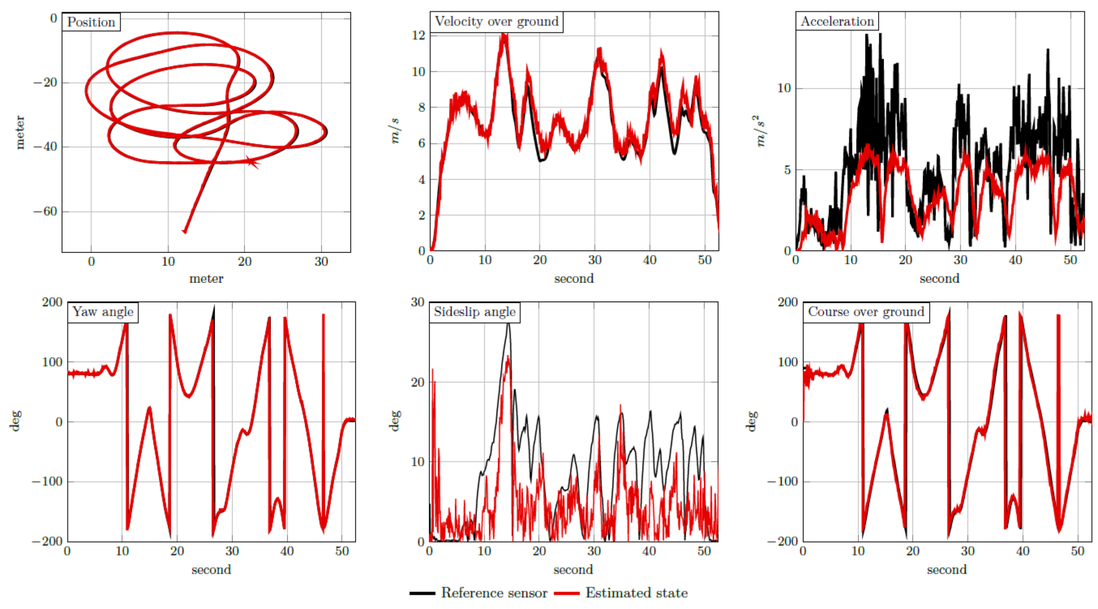

Figure 4: Estimated states variables against the reference sensor for one test drive with high longitudinal and lateral dynamics

Altitude	100 m				75 m				50 m			
Weights	Specialized		General		Specialized		General		Specialized		General	
Corrections	reg	reg+shift	reg	reg+shift	reg	reg+shift	reg	reg+shift	reg	reg+shift	reg	reg+shift
Median [px]	3.27	2.41	3.33	2.71	3.26	2.70	3.67	3.08	4.47	3.93	4.14	4.05
Mean [px]	3.87	2.95	3.96	3.27	3.75	2.99	4.09	3.34	4.53	3.98	4.47	4.26
90% [px]	7.39	6.01	7.52	6.50	6.98	5.28	7.42	5.80	7.04	6.08	7.75	7.12
99% [px]	11.19	8.88	11.33	9.58	9.67	8.08	9.60	8.27	9.97	8.10	10.81	10.05
99.9% [px]	11.85	9.72	12.23	12.07	11.15	9.63	11.07	10.04	10.83	8.95	12.89	13.27
Mean [m]	0.27	0.20	0.27	0.23	0.20	0.16	0.21	0.17	0.16	0.14	0.16	0.15

Table 1: Accumulated frequency of the error: Depicted for all three altitudes, both training weights and corrections

Traffic Scenario Clustering and Classification

- Data driven approach: data structure determines the scenario description and feature selection
- Feature set is provided to the clustering process, which delivers the similarity matrix
- Assigning classes according to similarity matrix and train supervised model in order to assign new traffic scenarios

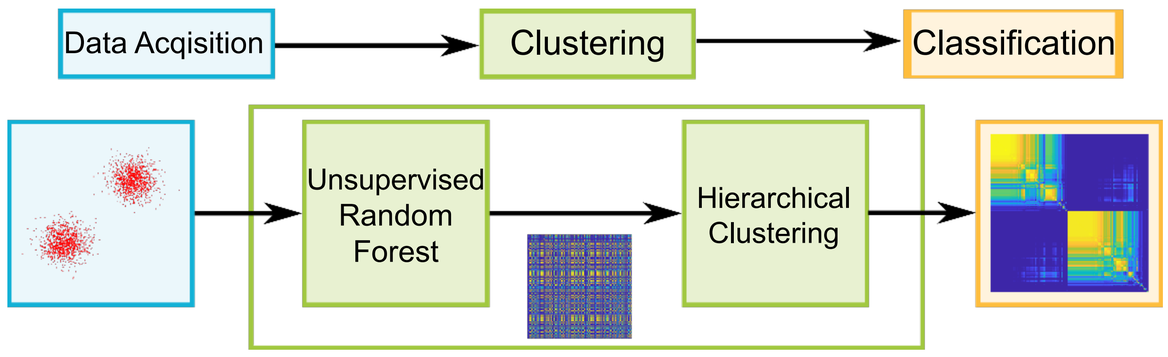

Figure 5: Unsupervised and supervised machine learning architecture for scenario categorization

Cluster Analysis

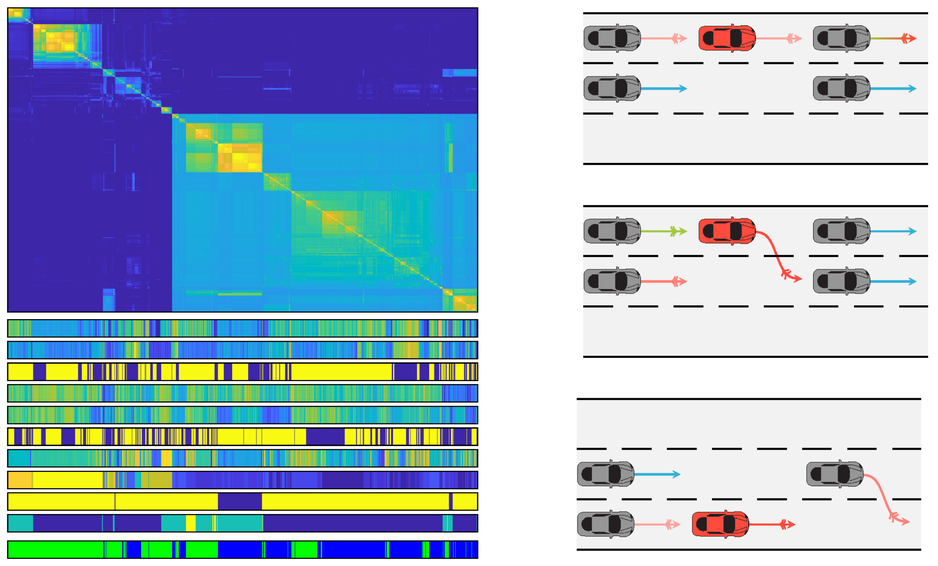

Figure 6: Clustering results with normalized feature value representation (left) and representative scenarios derived from clusters (right)

Conclusion

- Real world traffic data generation with drones and Deep Learning
- Clustering and Classification method for automated traffic scenario categorization developed and validated with real world data

Publications

- An Unsupervised Random Forest Clustering Technique for Automatic Traffic Scenario Categorization
  in 21st IEEE International Conference on Intelligent Transportation Systems, 2018
- Unsupervised and Supervised Learning with the Random Forest Algorithm for Traffic Scenario Clustering and Classification
  in 30th IEEE Intelligent Vehicles Symposium, 2019
- Highway traffic data - macroscopic, microscopic and criticality analysis for capturing relevant traffic scenarios and traffic modeling based on the highD data set
  in arxiv.org (open access platform), 2019
- Vehicle Position Estimation with Aerial Imagery from Unmanned Aerial Vehicles
  in 31th IEEE Intelligent Vehicles Symposium, 2020
- Accuracy Characterization of the Vehicle State Estimation from Aerial Imagery
  in 31th IEEE Intelligent Vehicles Symposium, 2020

Friedrich Kruber, Technische Hochschule Ingolstadt
Michael Botsch, Technische Hochschule Ingolstadt
Samarjit Chakraborty, University of North Carolina at Chapel Hill

Technische Hochschule Ingolstadt · CARISSMA Institute of Automated Driving · BayWISS Bayerisches Wissenschaftsforum · SAFIR · GEFÖRDERT VOM Bundesministerium für Bildung und Forschung · FORSCHUNG AN FACHHOCHSCHULEN