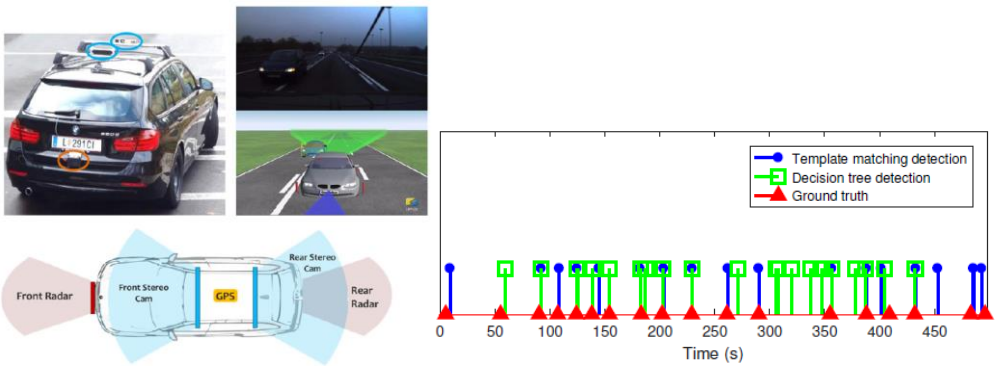
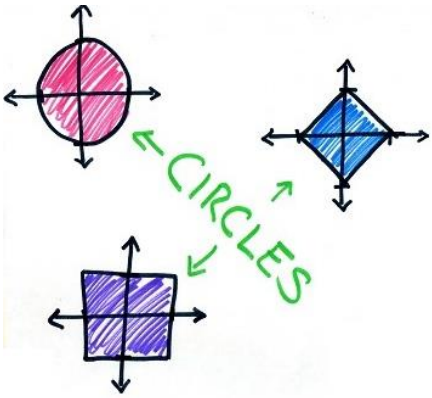
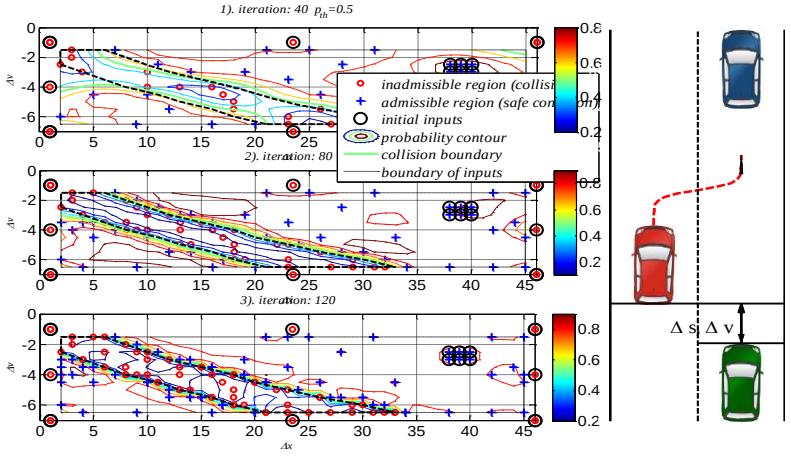
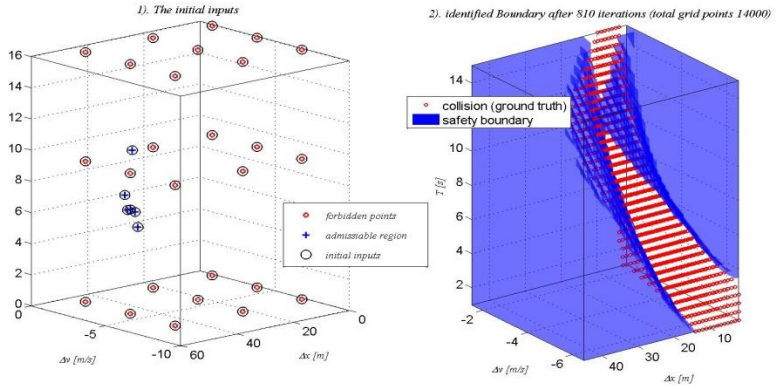
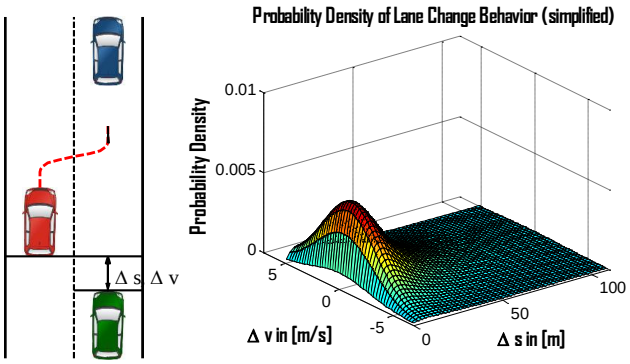
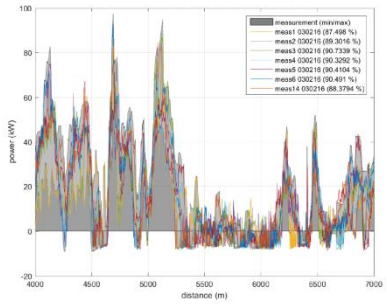
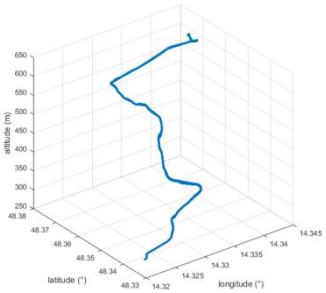
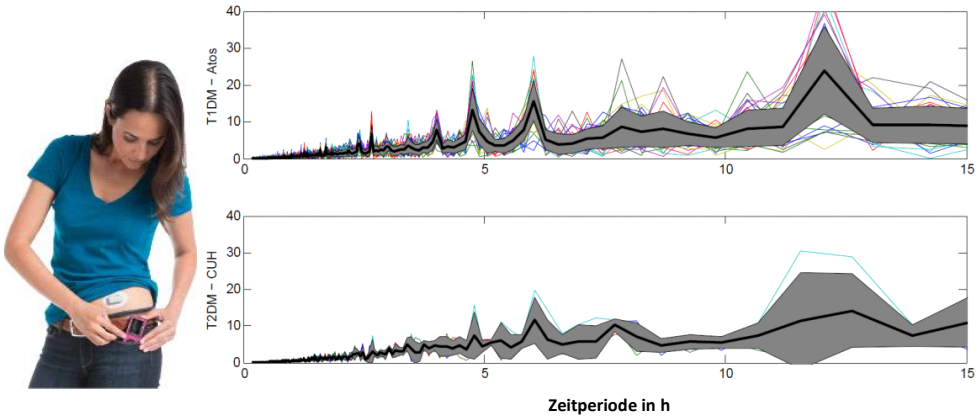
Bachelor Thesis	**Maneuver Identification in Highway Traffic Using Elastic Template Matching**
Background	Early identification and interpretation of traffic maneuvers will become key elements of modern driver assistance systems. Currently, only simple traffic situations can be detected by using a decision tree (DT) procedure in most cases. Even though this approach is straightforward, it still requires an expert to build a different DT for every maneuver. Moreover, for complex driving behaviors such simple logic identification does not work. In a background work, a template (or pattern) matching (TM) algorithm for maneuver recognition in highway traffic with a particular focus on a cut-in maneuver has been developed.
Goal	The goal of this work will be to apply the developed TM algorithm to other (simple) driving maneuvers, such as following, pull-in and pull-out, overtaking etc. The idea is using the real data collected from sensors to do the following: 1. Extract the maneuvers under study from the data; 2. Build a maneuver template; 3. Adjust the algorithm parameters; 4. Evaluate the developed identifications for each of the maneuvers.
Optional	An on-line algorithm for a full description of the surrounding highway traffic. 
Prerequisites	The student should be interested in the topics data analysis, system identification, machine learning Theory 10%, Data Analysis 50%, Modelling/Simulation 40 %
Direct Supervisor	Pavlo Tkachenko

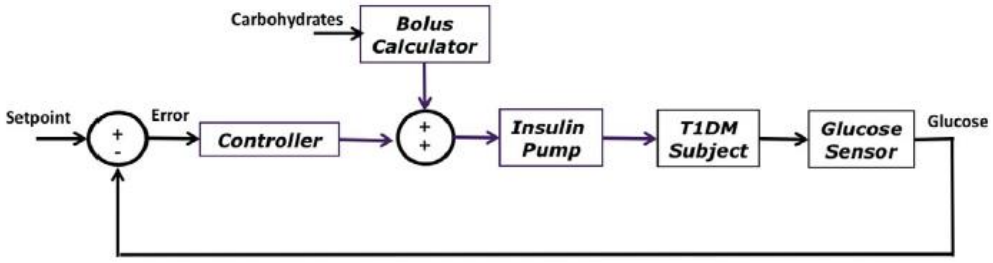
Bachelor Thesis	**Analysis of different metrics for system identification**
Background	Typically, the *squared* prediction error (least squares method) is minimized when system identification is used for modeling, so the unknown model parameters can be computed in one step in the case of an ARX structure. Also for non-ARX structures *many people use a quadratic error norm, but is this really a good idea* in all cases? This bachelor thesis should investigate this question. The least squares estimator is only optimal, when certain requirements are met. If the setting deviates from these requirements, it could be more useful to use a different metric as cost function for identification.
Goal	This thesis aims at investigating the influence of using different alternative metrics as the cost function (such as L_1norm, L_∞norm or a combination of both) on the identification result. Accordingly, an evaluation of different metrics used for parameter estimation (identification) with respect to a single predefined validation metric (e.g. fixed linear error tolerance) should be performed. The evaluation should be done using a simulation analysis for a given mathematical class of (practically relevant) known systems, where the statistical properties of the estimated parameters are compared against the true system parameters using for example Monte Carlo simulations.  **Unit circle in different metrics** *[http://mathwithbaddrawings.com]*
Optional	In the case of identification with nonlinear regressors (such as polynomials) regressor selection (reduction of the model on the essential terms) plays an important role. The use of different metrics could also be analyzed for the regressor selection part.
Additional information	Interest in the field of system identification is appreciated. An evaluation with real data of a physical system (e.g. engine test bench) should be performed. Theory 30%, Simulation 60%, Practice 10%
Direct Supervisor	Patrick Schrangl

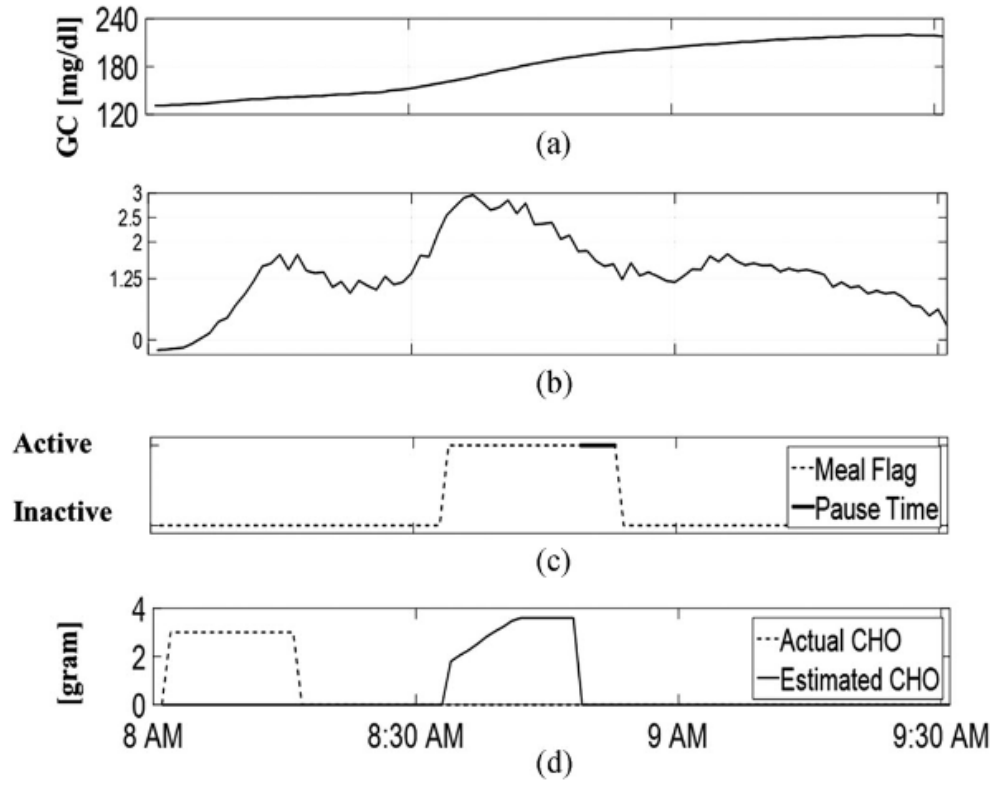
Topic	Extension of a GPC based DoE method for safety boundary identification
Background	In the previous work, a Gaussian Processes Classification based Design of Input method is proposed for the identification of safety boundary for n-dimensional parameter set optimally. This method can be directly apply to higher dimension case. However, it may cause computational problems because of large input data sets. Against this background an approximation method such as Sparse Gaussian Processes (SPGP) needs to be applied to make the computation feasible. 
Goal	The goals of this work is to investigate different approximation methods of Gaussian Processes and evaluate the performance. The implemented algorithm should be applied to a of a parameterized traffic scenario (n >= 5) and evaluated in terms of the performance and reliability. 
Prerequisites	Interest in stochastic modeling is appreciated. Matlab package of Gaussian process is provided for implementation. Theory 60%, Implementation 40 %
Direct Supervisor	Jinwei ZHOU

Topic	**Analysis of driving maneuvers and estimation of construction of multivariate density estimation based on limited number of measurements**
Background	In the previous work, a data driven method is proposed to approximate the driving maneuver through a static model with multiple parameters. To evaluate the how these parameters correlate to each other, a multivariate joint probability distribution should be derived from measurements. However, the estimation of the correlation among these parameters (multivariate density) becomes a very challenging task, when the requirement on measurements increase exponentially with the rising number of parameters. Furthermore, a complex driving scenario, consisting of multiple maneuvers, can lead to a static model of high dimensional parameter set, so that estimation of multivariate density in a traditional way needs an unaffordable amount of measurements. 
Goal	The goals of this work is to investigate different methods of multivariate density estimation for a high dimensional data set with limited measurements. Based on a parameterized basic scenario, different methods proposed in the literatures should be tested and evaluated. A selected complex scenario is to analyze and parameterize afterwards to test the estimation method for a high dimensional parameters set.
Prerequisites	Interest in stochastic modeling and data analyze is appreciated. Theory 60%, Data Analyze 10%, Modeling/Simulation 30 %
Direct Supervisor	Jinwei ZHOU

Bachelor Thesis	**Stochastic Gearshift Control:**
Background	In order to improve emissions and fuel consumption information on the road profile ahead is already used to improve the gear shifting strategy. The state of the art approaches are built as a “rule based” approach. Since more and more data is available from the vehicles driving the streets, this could be changed towards a data driven approach.  
Goal	The goal of this work is to improve the overall performance of the vehicle (in terms of fuel consumption, number of gear shifts, …) by exploiting probabilistic information on the powertrain demand. Therefore in the beginning of the work a probabilistic prediction model for the torque and speed profile will be developed. The model should be based on a dataset containing fifty repeated test drives on the same road, which will be provided. Once a model is found, a gear shifting control should be developed, which makes use of the probabilistic information in order to improve the gear shifting policy. Finally the new method should be compared with a baseline (rule based) strategy to assess the potential improvement.
Steps	• Theory and literature research • Stochastic demand modelling • Stochastic control design • Validation and comparison
Additional information	The main focus will be on stochastic modeling and control. Literature 10%, Modelling 30%, Control development 30%, Simulation 30%
Direct Supervisor	Philipp Polterauer

Bachelor Thesis	**Analysis of CGM Signals in the Frequency Domain**
Background	In order to inform diabetic patients about their blood glucose dynamics it is becoming more and more common to use continuous glucose monitoring (CGM) systems for this purpose which supply patients with glucose values at a high measurement frequency. However, it is believed that so far the full potential of CGM devices is not yet tapped. So far analysis of CGM data is limited to observing glucose values and trends in the time domain. It is thought that additional information could potentially be gained by analyzing signals in the frequency domain. Analysing CGM signals of clinical trials in the frequency domain reveals significant differences between patients with type 1 and type 2 diabetes (see picture below).
Goal	The goals of this work are twofold: First, simulation studies should help to better understand the peaks of CGM signals in frequency domain. For this purpose simulations with a complex computer model of the glucose metabolism of diabetic patients (UVa/Padova simulator) should help to identify correlations between day-to-day variations in life style as well as the stage of the diabetes disease (extend of the beta cell failure) and the extend and positions of peaks in the frequency spectrum. In a next step the analysis of real CGM data in the frequency domain using a sliding time window for analysis (methods from Fault Detection and Isolation, see e.g. [Pichler et al, „Monitoring procedure in frequency domain using...“, SYSID 2009]) should be used to try to analyze the correlation between the characteristics of CGM signals in the frequency domain and the risk of very low or high glucose values to occur (hypo-/hyperglycemias). Such a correlation between the high frequency content of CGM signals and the risk of hypoglycemias was already suggested in [Reiterer et al 2016 – chapter in Springer book].
Optional	Design of a real-time capable algorithm for the early detection of impeding hypoglycemias / hyperglycemias (if possible).  **Remark: For this work the student needs to get access to CGM datasets!**
Prerequisites	The student should be interested in the topics of biomedical engineering, data analysis and modeling of physiological systems Theory 20%, Data Analysis 40%, Modelling/Simulation 40 %
Direct Supervisor	Florian Reiterer

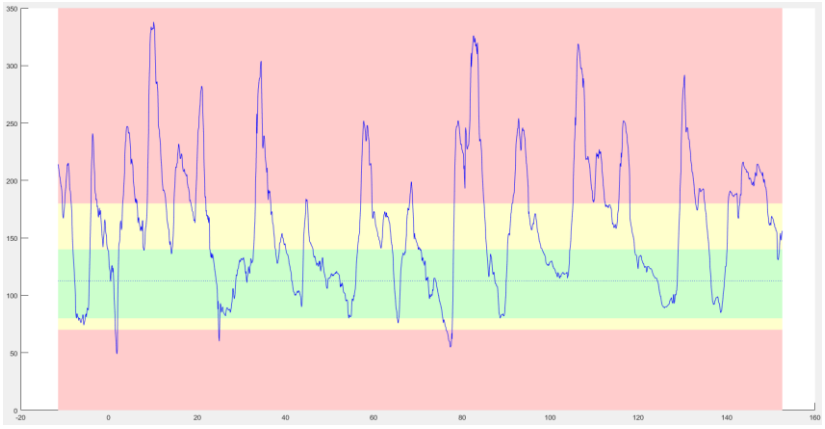
Topic	**Adaptive Bolus Calculator Algorithm for Use in a Hybrid Artificial Pancreas (Bachelor / Master Thesis)**
Background	Because of the high risk of hypoglycemia the correct dosing of insulin in type 1 diabetes mellitus (T1DM) is an especially challenging task. The immense interpatient and intrapatient variability in insulin needs asks for an adaption of treatment doses on a daily basis. For each meal an adequate dose of fast-acting insulin has to be injected to counteract the effect of the meal carbohydrates on the BG level (known as a ``meal bolus''). In order to determine meal insulin doses many patients rely on so-called bolus calculators (BCs). These are algorithms that compute the required insulin amount based on BG level, meal carbohydrates, as well as on patient and daytime specific BC settings. In a previous work the so-called ``Adaptive Bolus Calculator'' (ABC) has been proposed, an algorithm that can automatically adjust the settings of a BC. However, so far this algorithm has only been used for open-loop standard basal-bolus therapy in T1DM. On the other hand in hybrid Artificial Pancreas (AP) approaches, so far the bolus insulin is injected based on a standard BC manually tuned by a medical doctor or the patient himself/herself.
Goal	The goal of the thesis is to extend the ABC algorithm for application in hybrid AP approaches. In a first step the existing ABC should be tested together with a hybrid AP. Based on the results possible modifications and extensions should be suggested and implemented.
Optional	In a last step the performance of the modified ABC could be compared to that of a different smart bolus calculator algorithm from the literature (abc4d by Imperial College).  **Remark: For this work the student needs to get access to CGM datasets!**
Prerequisites	The student should be interested in the topics of biomedical engineering, data analysis, and modeling / simulation of physiological systems. Theory 10%, Modeling/Simulation 90 %
Direct Supervisor	Florian Reiterer

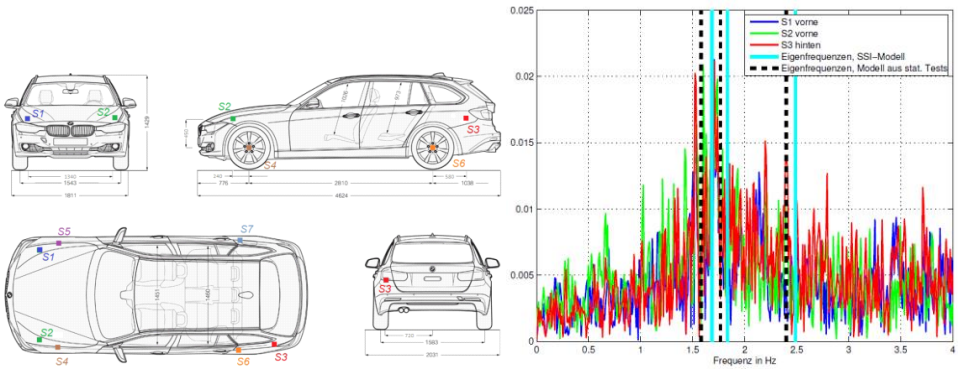
Topic	Fully Closed Loop Glucose Control in Type 2 Diabetes (Bachelor / Master Thesis)
Background	The ongoing improvement of continuous glucose monitoring (CGM) sensors and of insulin pumps are paving the way for a fast diffusion of artificial pancreas (AP) for type 1 diabetes (T1D) patients. The case for type 2 diabetes (T2D) patients is less obvious since usually some residual beta cell function allows for simpler therapy approaches, and even multiple daily injections (MDI) therapy is not very widespread. However, the number of insulin dependent T2D patients is vastly increasing. In pre-analyses the potential benefit of AP systems for T2D has been demonstrated. However, so far only standard hybrid AP approaches have been tested. Because of the lower level of glycemic variability fully closed loop systems without meal announcements seem a promising alternative for T2D patients.
Goal	The goal of the thesis is design a fully closed loop AP tailored towards application in T2DM patients. The first step is to implement and test different automatic meal detection algorithms from the literature and analyze their performance in a fully closed loop AP. Based on the results of those calculations enhanced meal detection and AP control algorithms for application in T2D should be proposed.
Optional	 **Remark: For this work the student needs to get access to CGM datasets!**
Prerequisites	The student should be interested in the topics of biomedical engineering, data analysis, and modeling / simulation of physiological systems. Theory 30%, Modeling/Simulation 70 %
Direct Supervisor	Florian Reiterer

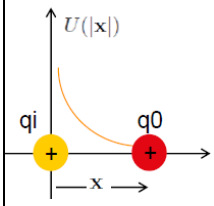
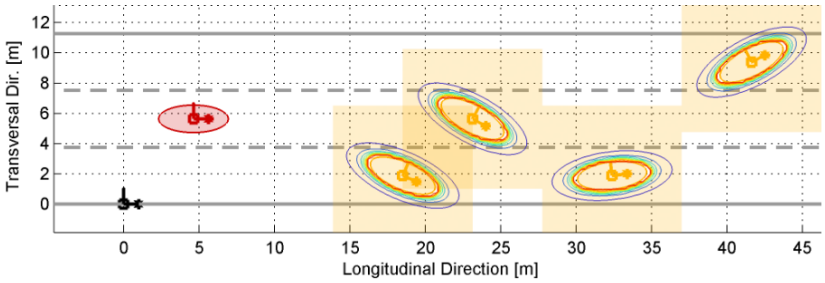
Bachelor Thesis	**Analysis of Model based Performance Assessment for Advanced Driving Assistance Systems (ADAS):**
Background	Due to more complex ADAS entering the marked, suitable methods are needed to assess the performance of these systems for certification purposes. There is a general consensus that simulations, using traffic models, are needed to assess the performance of such systems in real traffic, because sufficient real world road testing is not feasible. In a previous project a data-based stochastic traffic-environment model (STEM) was developed, which describes the surrounding traffic of a car in a two lane highway situation. This model, which can be calibrated by using real traffic data, should be used for performance assessment of ADAS.

Goal	The goal of this work is to show, how a model based performance assessment (PA) procedure for ADAS can work and how the data, used to calibrate the traffic-environment model, influence the PA result.
	
	Therefore, as a proof of concept, a huge amount of traffic data should be generated by a 3rd party high fidelity simulation environment, which is used as a virtual reality environment (VRE) in this work. With this data, the STEM should be calibrated and an assessment method (AM), with a suitable key performance indicator (KPI), has to be implemented.
	
	Using this assessment method and one selected ADAS (e.g. adaptive cruise control, ACC) one can assess the performance of the system using the data-based STEM and in parallel the ''real'' KPI can be derived using the VRE (which acts as the real world in this work). Using statistical methods, the variance of the results depending on the used data (parts) should be analyzed and compared between the data-based assessment and the real performance assessment in the VRE. The results should be:
	
	- First compare the results of the assessment between using data-based STEM and assessment within the VRE, e.g. do they converge to a similar value?
	- Show statistical properties of the result depending on the used data and e.g. answer questions like
	  o what is the data amount we need to get a certain KPI using the AM with STEM (compared to the true KPI we get from using VRE)
	  o which length (in hours or driven km) of data sequence is needed to get results with a certain confidence interval
	  o do the statistical properties converge in a similar way with the AM using STEM or using VRE with increasing data amount

Steps	• Theory and literature research (traffic models, assessment methods) • Data generation and data-based model calibration • Implementation of an assessment method • Statistical analysis (similarity of the KPI's, variance of the results depending on the used data)
Additional information	The main focus will be on stochastic modeling and statistical analysis of data/test results. Literature 10%, Modelling 10%, Implementation 40%, Data Analysis 40%
Direct Supervisor	Martin Großbichler

Bachelor Thesis	**Region of Interest Data-Driven Modelling**
Background	High quality models are essential for the performance of many control related tasks. If the structure of the system is known, first principle models can be set up, and they are the best choice for most uses, their advantages include the possibility to perform parametric studies without building the corresponding hardware. However, for many real systems this approach is hardly possible, either because the detailed knowledge of the system structure is not available or because the model would be too complex to be useful or parametrized. Against this background, it has become common to use data-driven models, i.e. concentrating on reproducing correctly the input-output behavior of the system without trying to describe correctly its physics. However, in many practical situations, the system under study can reach potentially dangerous operational regions. It is clear, that the requirements to a model quality in such regions should be much higher than in safe zones.
Goal	The goal of this work will be to investigate the multi-modelling approach, where a particular model is applied for different operational regions of interest. First, the question whether such extension can lead to a better approximation should be addressed. It could be done by means of simulated examples. In case of success of the approach, it should be analyzed, which models to use and how they should be combined?
Optional	An application of the developed algorithms to real data 
Prerequisites	The student should be interested in the topics system identification, data analysis, experiments design Theory 30%, Modelling/Simulation 50%, Data analysis 20%
Direct Supervisor	Pavlo Tkachenko

Bachelor Thesis	**Identification of Damping Ratios from Output-Only Data**
Background	Operational Model Analysis (OMA) summarizes methods to identify modal properties of a system using only measured output data during normal operation, but no information about input data. In previous works a methodology has been proposed to identify natural frequencies from accelerometer data of passenger cars and to use this information in order to generate a model of the vehicle suspension. In this methodology data is recorded during a ride with constant speed over a rough, but relatively flat and straight country road (changes in speed and turns/curves are not accounted for in the methodology). The problem with the current methodology is that the natural frequencies are hardly influenced by the damping of the car, and therefore additional measurements are required to obtain information about damping parameters and to complete the suspension model. However, in case one would be able to identify also the damping ratios in the OMA, this would enable to skip the subsequent additional measurement step and to directly obtain a fully parametrized model of the vehicle from the OMA data.
Goal	In pre-analyses it turned out to be much more difficult to identify the damping ratios using OMA compared to the identification of natural frequencies. However, it also showed to be feasible under certain conditions. The goal of this work is to systematically check and quantify those conditions and to propose a methodology for the reliable identification of damping ratios and natural frequencies of passenger cars from accelerometer data. Besides the methods from Stochastic Subspace Identification (SSI) that are currently in use for this purpose, also alternative methods operating in the frequency domain should be evaluated. Analyses should first be performed using simulation data and results then verified and extended in real experiments using the model of a quarter car (available at our institute's lab). In a last step, the methodology should be validated using data recorded with a real passenger car.
Optional	Based on the findings of the simulation studies and the analysis of experimental data of the quarter car, a new experimental protocol for the application of OMA on real passenger cars can be proposed and verified with the institute car (BMW 320d) and already available measurement equipment (accelerometers). 
Prerequisites	The student should be interested in the topics of automotive engineering, system identification and data analysis Theory 20%, Simulations: 20%, Experimental Work 20 %, System Identification / Data Analysis 40%
Scientific Advisor	Philipp Polterauer

Topic	A Flexible Molecular Framework for **Safe and Comfortable Autonomous Driving in Stochastic Environment**
	This is for two Bachelor Thesis
Background  	Autonomous driving in Traffic is a complex procedure involving a wide spectrum of constraints (Cs): physical boundaries (PhB: road size, speed limits), energetic constraints (En: expended power along the journey, fuel consumption, etc.), emission of pollution (Em: Nox emission) and minimum time travel (mT). Such constraints can be in competition during a typical journey of the controller vehicle (Ego-V). For example the optimal solutions for the minimum time problem would produce highest reachable speed for a given street segment profile which will compete with fuel consumption and emission limits constraints. Among these constraints, moving traffic participants (TPs) represent themselves the main risk of accidents in the real traffic situation and perturb the solution resulting from the optimal control problem subject only to the remaining constraints (PhB, En, Em, mT). The general purpose of the current MT proposal is: to apply the strong theory of *effective potential fields* to design an interaction mechanism able to encode in the ADAS controller of the Ego-vehicle a perception of the dangerousness of the surrounding traffic, which would allow *naturally* breaking and overtaking maneuvers. 
Goal	The MT-candidate will: 1. Develop a *modular* Simulink Toolbox able to simulate the whole Traffic Flux and to drive a Virtual Autonomous Vehicle with assigned tasks accounting a defined/(possibly all) classes of constraints(Cs) ; 2. Evaluate the ADAS control block in a predefined testing traffic scenarios comparing the results with the actual existing code developed internally to the DESREG institute. The performance analysis will cover two main aspects and distinct phases. 1. A first phase (deterministic) in which the optimal control of the Ego-vehicle will be perturbed by the predefined deterministic and characteristic trajectories of a number of TPs. 2. A second phase (stochastic) in which a stochastic optimal control of the Ego-V will be set up to interact and adapt to with a partial knowledge of the behavior of the surrounding TPs.
Optional	If and once the main Goal have been fully accomplished, the candidate could extend the validated modular software to other traffic scenarios.
Prerequisites	The ideal candidate has not to be just interested in the topics of optimal and robust control (OC) of driving autonomous vehicles, but also be able to: - Formulate and solve autonomously OC problems (60%) - Have a sufficient background in Theory and Applied probability (40%) - Code in MATLAB and SIMULINK with a specific attention to real time application (70% workhours) - Critically synthetize and compare results (30% wh.s)
Direct Supervisor	Davide Gagliardi