SAFIR: Sichere Trajektorienführung mittels Fahrroboter

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

Introduction

- Driving robots are meant for reproducible and manufacturer independent implementation of driving tests
- Realization of a desired trajectory depends on the vehicle and environmental conditions
- Adaption of certain parameters of the driving robot to the driving conditions is necessary

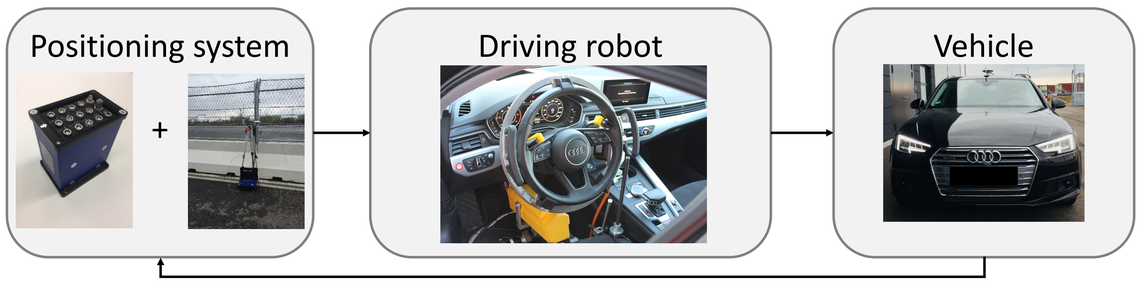


Figure 1: Overall framework of the driving robot system

Optimization of relevant parameters

- The Gradient-Descent algorithm is used for the optimization of b_s and c_s
- The side force $\hat{F}_s$ is estimated based on the measurements from the ADMA
- The cost function J for the optimization is:

$$J(b_s, c_s) = \frac{1}{2m} \sum_{i=1}^{m} (\hat{F}_s^i - F_s^i)^2$$

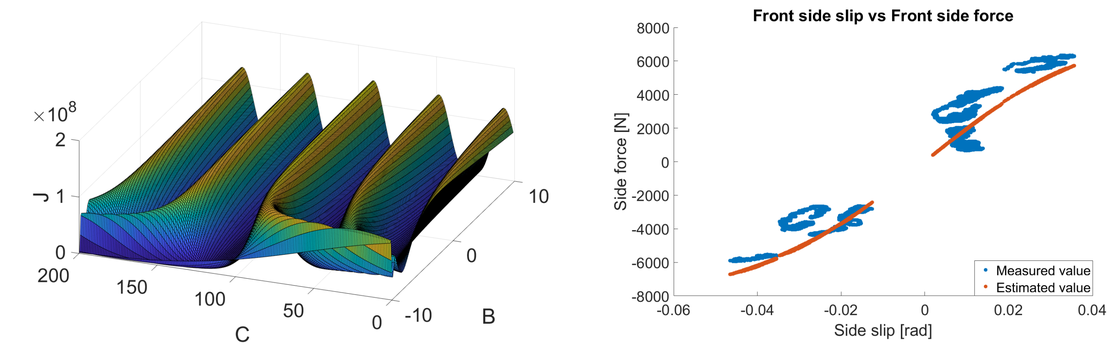


Figure 2: Left: Optimization curve; Right: Results of optimization on measured values from tests with real vehicles

Overview of work packages

WP 1

- *Title*: Automatic determination of parameters for the lateral controller of the driving robot
- *Objective*: Find and implement a method to estimate the parameters in an automated way based on only a small set of driving tests

WP 2

- *Title*: Driving robot control for test scenarios in the dynamic limits of the vehicle
- *Objective*: Find ways to safely control the vehicle through the driving robot, even at the limits of driving dynamics

WP 3

- *Title*: Quality measures and trajectory planning for safe test operation
- *Objective*: Estimate the drivability of a trajectory and thus calculate quality measures with regard to drivability and, if necessary, propose strategies for adapting the planned trajectory

Simulation environment

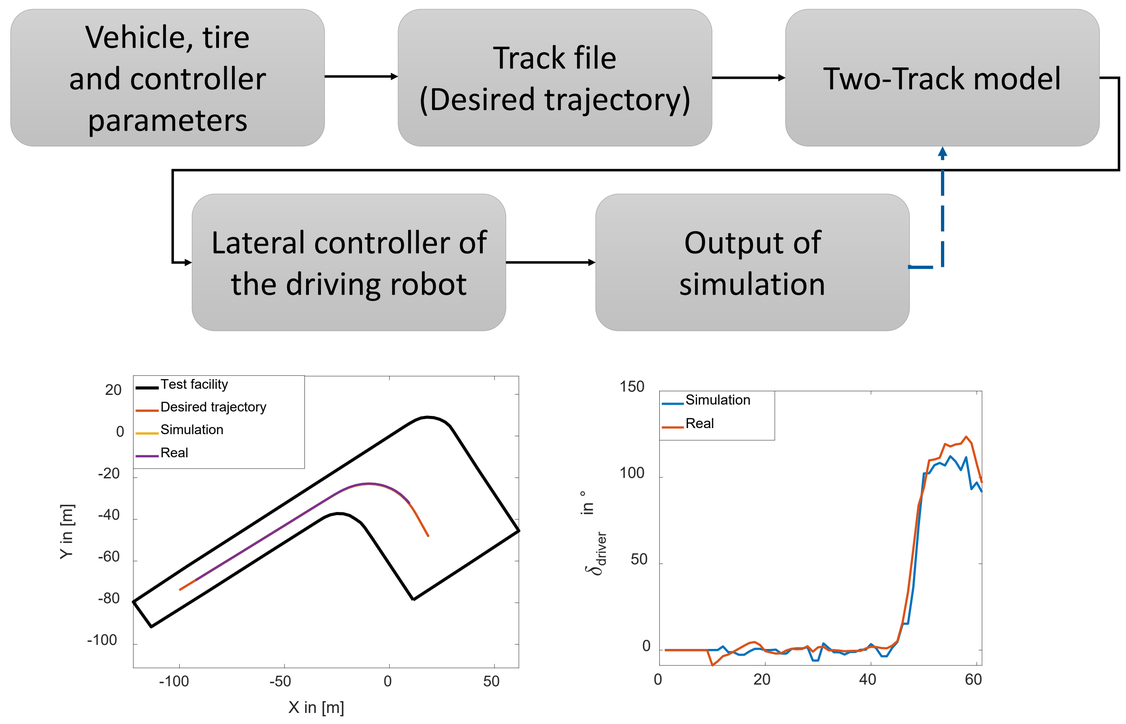
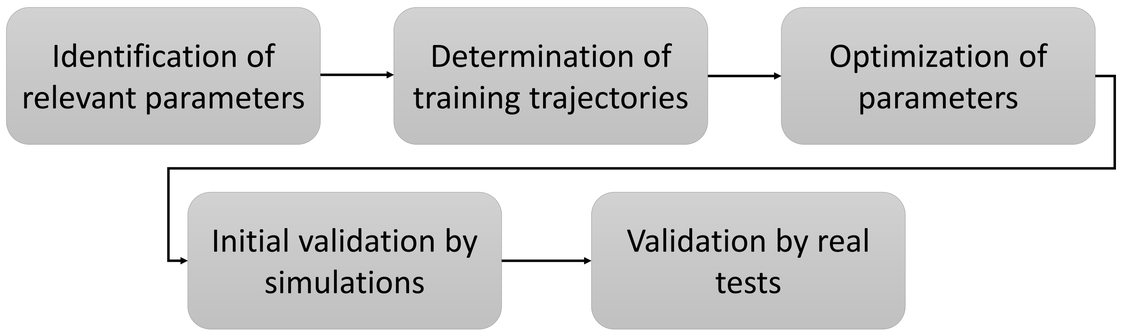
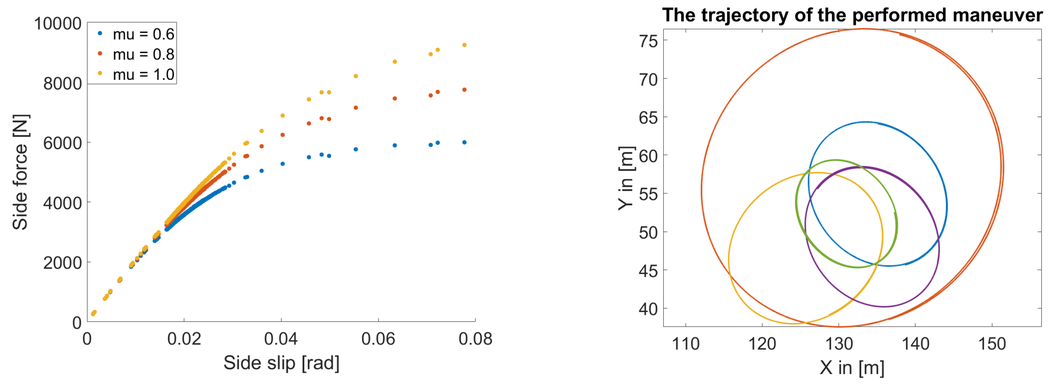


Figure 3: Comparison between tests in the simulation environment and the real vehicle. The two trajectories are almost identical

Optimization of parameters of the driving robot



- *Relevant parameters*
  - Parameters of Magic Formula tire model
  - Steering ratio (Dynamic): The steering angle is dependent both on the velocity of the vehicle and the steering wheel angle
- *Training trajectories*
  - Full braking maneuver: Estimate the coefficient of friction μ
  - Circles of constant radius and speed: Estimate the parameters of the Magic Formula tire model



Detection of limits of driving dynamics

- Machine learning based on Random Forest used for the detection of dynamic limits of the vehicle
- The data generation is performed using the simulation environment
- Side slip is used as a measure to determine the dynamic limits and label the generated data

Drivability of a trajectory

- The gain of the lateral dynamics controller of the driving robot is made dependent on speed
- An algorithm based on brute force search is developed to adjust the gain offline via the simulation environment

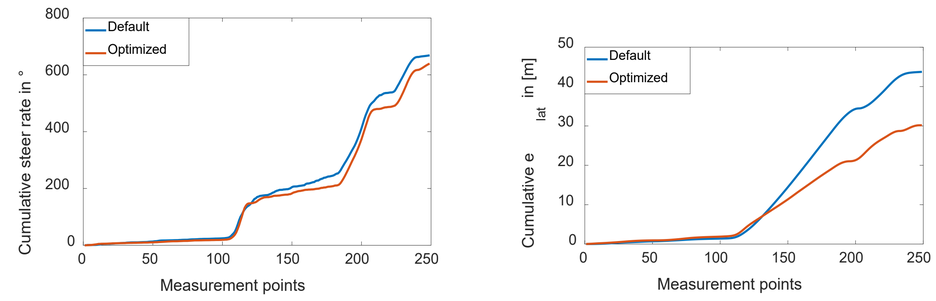


Figure 4: Error metrics for the default and the optimized speed-dependent gain for the lateral dynamics controller

Conclusion

- Algorithm to automatically identify the parameters of the lateral controller of the driving robot is developed
- A machine learning algorithm to detect the driving dynamic limits of a vehicle is trained and an algorithm based on brute force search to estimate the speed dependent gain for the lateral controller is designed

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