A Method for Identifying Most Significant Vehicle Parameters for Controller Performance of Autonomous Driving Functions

Abstract:
In this paper a method for the identification of most significant vehicle parameters influencing the behavior of a lateral control system of autonomous car is presented. Requirements for the design stage of the controller need to consider many uncertainties in the plant. While most vehicle properties can be compensated by an appropriate tuning of the control parameters, other vehicle properties can change significantly during usage. The control system is evaluated based on performance measures. Analyzed parameters comprise functional tire characteristics, mass of the vehicle and position of its center of gravity. Since the parameters are correlated, but Sobol' sensitivity analysis assumes decorrelated inputs, random variation yields no reasonable results. Furthermore, the variation of each parameter or set of parameters is not applicable since the numbers of required simulations is increased significantly according to input dimension. Therefore, the proposed methodology determines directly the influence of the parameters on performance measures of the lateral control function. First, a hierarchical nonlinear principal
component analysis using artificial neural networks is used to decouple inputs and reduce them to a lower dimensional subspace. In a second step Sobol’ sensitivity analysis is used to identify the significant parameters by sampling in the decoupled subspace and their evaluation by a full-blown vehicle dynamics simulation. The most significant parameters are merged in a static and dynamic variable resulting in four worst-case vehicle states. Applying the methodology of the Cooperative Design Approach, performance measures of the lateral control function (rising time, overshoot, number of oscillations) can be analyzed for each vehicle state yielding a robust control design.