Virtual Safety Validation of Autonomous Vehicles: From Abstract Graphical Traffic Scenarios Towards Concrete Simulations

One does not need the gift of clairvoyance to predict that in the near future autonomously driving cars will occupy a significant place in our everyday life. In fact, in designated and even public test-drive areas it is reality even now. Autonomous driving comes with the ambition to make road traffic safer, more efficient, more economic, and more comfortable - and thus to “make the world a bit better”. Recent accidents with automatic cars resulting in severe injuries and death, however, spark a debate on the safety validation of autonomous driving in general. The biggest challenge for autonomous driving to become a reality is thus most likely not the actual development of intelligent vehicles themselves but their rigorous validation that would justify the necessary level of confidence.

It is common sense that classical test approaches are by far not feasible in this emerging area of autonomous driving as these would induce billions of kilometers of real-world driving in each release cycle. To cope with the tremendous complexity of traffic situations that a self-driving vehicle must deal with - without doing any harm to any other traffic participants - a promising approach to safety validation is virtual simulation, i.e. driving the huge amount of test kilometers in a virtual but realistic simulation environment. A particular interest here is in the validation of the behavior of the autonomous car in rather critical traffic scenarios.

In this presentation, we concentrate on one important aspect in virtual safety validation of autonomous vehicles, namely how rather abstract traffic scenarios can be properly executed in a simulation environment. The proposed workflow starts with the graphical yet formal specification of abstract traffic scenarios to create a scenario catalog for virtual validation. The formal semantics of these abstract scenarios then gives rise to determine concrete scenario instantiations using formal methods. As the criticality of traffic maneuvers also depends on the actual course of the road, we show how concrete road geometries can be easily created in order to simulate the concretized traffic scenarios on these specified roads. To properly execute a concretized traffic scenario in a simulation environment in the sense that the abstract scenario specification is met, we have to cope with the “autonomy” of the ego car under test, i.e. we need to compensate potential deviations of the ego car behavior related to the story of the concretized scenario by means of suitable reactions of the controllable surrounding traffic. For all that, it cannot be guaranteed in general that the simulated scenario actually complies with the abstract scenario specification. In order to detect such cases automatically, we show how scenario observers are derived from abstract traffic scenarios to monitor the simulation and to report coverage of the scenario catalog.