Engineering Risk Analysis Group
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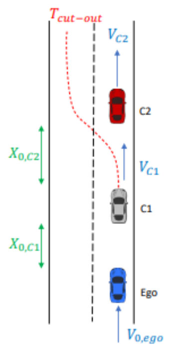
MSc thesis

Reliability Assessment of Complex Vehicle Scenarios with Subset Simulation

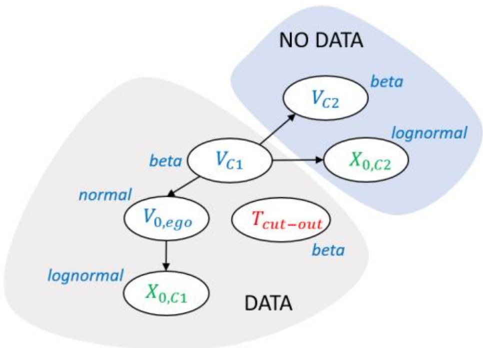
Spencer Sharp, October 2020

Background

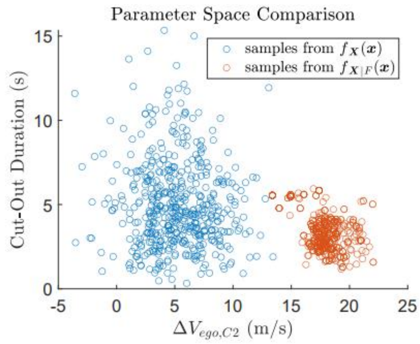
Validating the safety of autonomous driving (AD) software is a significant challenge which must be addressed prior to at scale deployment of autonomous vehicles. Brute force road testing, while simple and realistic, is not a viable solution on its own. The use of virtual simulation has already proven to be a promising alternative, but its scope of possible test scenarios has traditionally been limited by available data. This thesis proposes an alternative framework for validating the safety of AD software using virtual simulation, which expands the scope of possible test scenarios. By supplementing existing driver data with expert assumptions and alternative sources of data, it is possible to build a statistical model of a complex vehicle scenario and subsequently assess the reliability of AD software conditional on the scenario.



Parametrized highway cut-out scenario, sourced from Euro NCAP



Bayesian network for the parametrized scenario, with the chosen distributions as well as an indication of which parameters required supplementary data and assumptions



Samples from original joint distribution plotted (blue) against samples from the distribution given failure (orange), illustrating the shift in parameter space

Methodology

Once a complex vehicle scenario has been identified, it is parametrized, with distributions fit to each parameter, using either available data or expert assumptions. Next, a Bayesian network is constructed in order to define the dependencies between parameters, thus enabling the construction of the statistical model. In a subset simulation framework, samples – or test cases – are generated from the model and simulated using AD software to quantify the probability of failure. Samples from the failure domain are used to compute the sensitivity index of each parameter.

Conclusion

The proposed framework was proven with two different complex vehicle scenarios. For each scenario, the probability of failure was computed and critical test cases were derived. The sensitivity analysis serves as a feedback loop to focus efforts on distribution refinement. The proposed approach is useful in augmenting existing validation efforts of both proven AD features and those in early development. Results are limited by the quality of assumptions, so future research could focus on identifying additional sources of data to supplement expert assumptions.

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