It's time for a Switch!

A popular science summary on the Master's thesis "Development of a controller to switch between relative and absolute path for target vehicles in simulation scenarios" *

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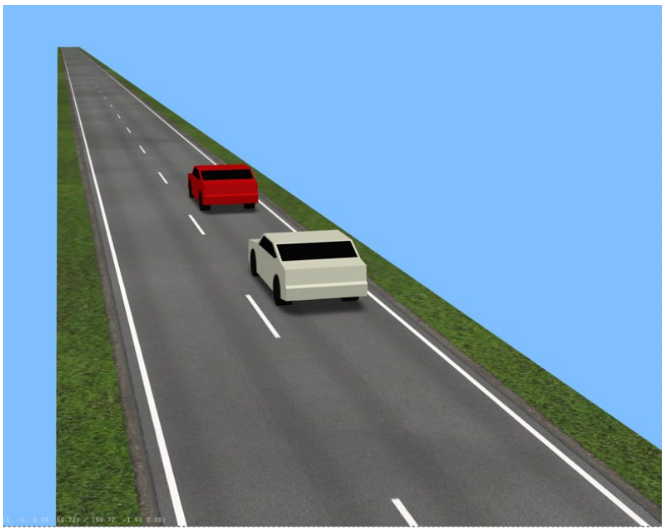

Esmini is a traffic simulator designed by Volvo Cars in order to test autonomous driving (AD) and active safety software. Esmini provides a minimalistic alternative for simulating traffic scenarios. These traffic scenarios usually contain an autonomous vehicle, which is controlled by AD software, and one or more target vehicles. Target vehicles can be used in order to define collision scenarios with the autonomous vehicle, which is useful for testing the software controlling the autonomous vehicle. This is significantly easier to do by defining the motion of the target vehicle relative to that of the autonomous vehicle. However, this approach can cause the target vehicle to react to the behaviour of the target vehicle in an unrealistic way. For example, if the target vehicles speed is set to 1 m/s slower than that off the autonomous vehicle, the target vehicle will reverse into the autonomous vehicle if the autonomous vehicle stands still. The solution to this is a controller that switches from relative to absolute control when unrealistic behaviour is detected.

The controller has been implemented using a "prediction-algorithm". This algorithm uses data from Esmini as well as a simple vehicle model in order to predict what the future states of the target vehicle will be. If an active safety function is triggered by the autonomous vehicle, the predicted states of the target vehicle will deviate significantly from its actual states. This causes the "prediction error" to rise. If the prediction error exceeds a threshold set by the user, the controller switches from relative to absolute control. Using a prediction algorithm for switching means that the controller can switch from relative to absolute control in a variety of different types of scenarios. Different parameters involved in the switching algorithm, such as the error threshold, can be tuned in order to tailor the controller to a specific scenario. This makes the controller very adaptable to a variety of different traffic simulation scenarios.

After switching from relative to absolute control, the controller defines a new control objective for the target vehicle. Depending on how the kinematic motion for the target vehicle was defined before the switch, the controller will calculate a new speed for the target vehicle. The target vehicle will then continue to move on its predefined path with the new speed, regardless of what the autonomous vehicle does.

The controller was also extensively tested in Esmini, for which a black-box testing approach was used. Black-Box testing essentially involves comparing the simulation model to another simulation that is known to function correctly. If the inputs to both models are the same, the outputs of both should match each other as close as possible. Hence, the first step in validating the controller is to run a given simulation scenario where no active safety function is triggered. In this simulation, the target vehicle is assumed to behave "correctly". Afterwards, the same simulation is run again, however, this time the autonomous vehicle does trigger an active safety function. Ideally, the target vehicles states in the second simulation should match that of the first simulation as closely as possible. In addition, the autonomous vehicle is controlled by a vehicle dynamics simulator called CSPAS. This means that the autonomous vehicle, is controlled externally, and that there is no data available on what the autonomous vehicle will do next.

Overall, the controller was validated using this method in 4 different Esmini scenarios. These scenarios featured a wide variety of different settings where Volvo Cars has a great need for the controller to adequately control the target vehicle. Overall, the results show satisfactory performance in all 4 scenarios. The controller does however need to be tuned in order to work for some scenarios, which can come at the expense of user-friendliness. The next steps for the development of the controller is to test it on a wider range of different scenarios in order to further validate it. In addition, the controller can be improved to reduce the need for tuning it, which will make it more user-friendly.

*Available at https://lup.lub.lu.se/student-papers