Development of an Autonomous Vehicle Model in SUMO for Resolving Traffic Situations

Master‘s Thesis of Felix Rampf

Mentoring:
Georgios Grigoropoulos
Andreas Keler

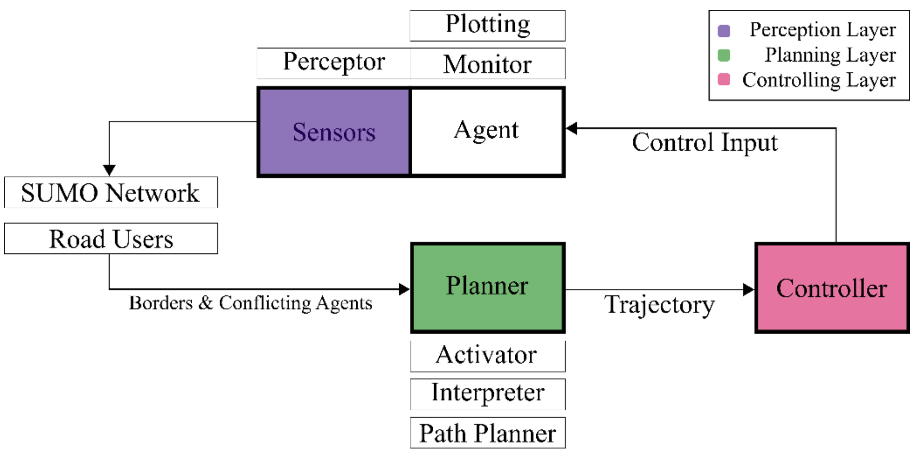

Fig. 1: Structure of the autonomous agent’s Control Logic developed in this work

With the undeniable advance of autonomous vehicles and their gradual integration in day-to-day urban traffic, many new technologies have been developed and offer great potential for an emerging field of research. However, several accidents have already shown that testing these technologies in real road traffic can still lead to some serious accidents. The virtual development and evaluation of autonomous vehicle models therefore offers a good opportunity to test new functions without any risk to human life. Software solutions such as Simulation of Urban Mobility (SUMO) are becoming very important, since they allow for a simple setup of various arbitrary complex traffic situations and, therefore, the evaluation of virtual autonomous vehicle models. However, SUMO does not yet offer a model for autonomous vehicles, so that scenarios simulating the interaction of autonomous vehicles with other non-autonomous road users such as cyclists, were not possible.

In order to create an interface for such evaluations and for further research of more complex autonomous driving function, i.e. in combination with real-world trajectory data, this thesis proposes an autonomous vehicle model, which features all aspects of self-driving cars. The first step was to development a control logic, represented in figure 1, which contains the four key elements of autonomous driving – Perception, Planning, Control, and Communication. The Path Planner of the autonomous agent is able to perform an overtaking manoeuvre on a straight road segment. In order to decouple the lane tie on an intersection, the Path Planner further has the possibility to bypass stopped vehicles on an intersection using Rapidly-exploring Random Trees (RRT*) with a subsequent optimization based on Dubins Paths, shown in figure 2. The behaviour of the developed vehicle model was then evaluated on the basis of five test scenarios and compared to the Car Following Models (CFMs) already implemented in SUMO. The results were also examined in terms of driving comfort and performance.

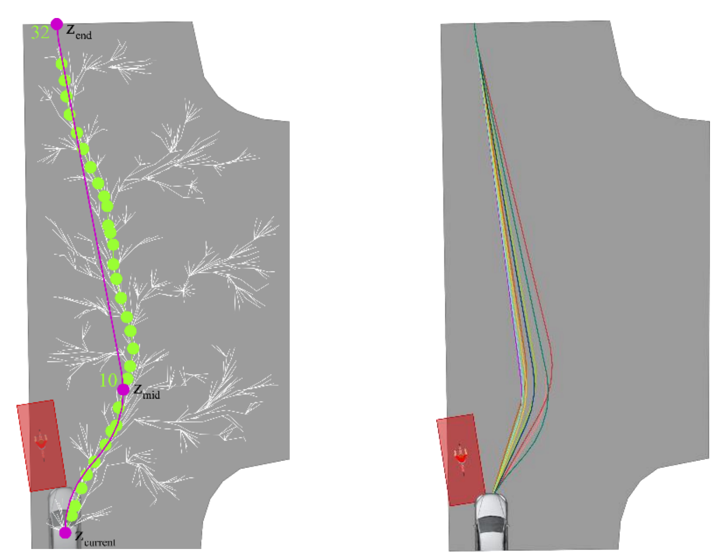

Fig. 2: Junction passing path based on RRT* (left) with a subsequent path optimization using Dubins Curves shown for ten iterations (right)

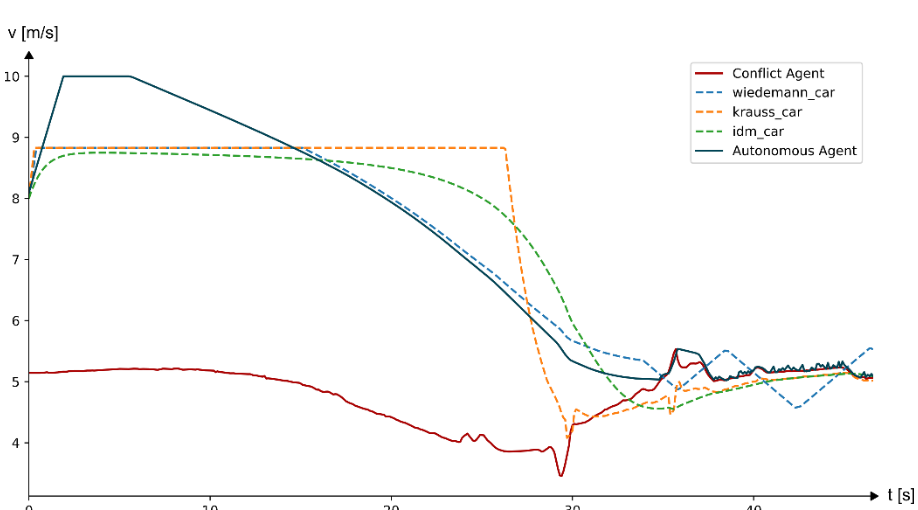

Fig. 3: Resulting speed profiles of the tested Car Following Models and the autonomous agent based on a simple car following scenario

The results show that the vehicle model developed within the scope of this work showed a significantly smoother driving behaviour in the test scenarios than the other CFMs (Figure 3 shows the generated speed profiles of one of the test scenarios). In addition, acceleration peaks and collisions with the conflicting agent were avoided. The extended functionality of the Path Planner and the possibility to avoid stopped vehicles even at intersections leads to much more realistic driving behaviour and provides a basis for further research, e.g. with regard to different stopping positions of the conflicting agent. For further research the developed autonomous vehicle model could be deployed as a permanently implemented Car Following Model in SUMO. Finally, it should be mentioned that the implementation of the RRT* was not performance focused and therefore led to a delay of the simulation. This should therefore be improved in further extensions to this work.