Realistic Simulation of Cooperative Adaptive Cruise Control (CACC) Degradation Under Random Packet Loss

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Abstract: Connected and Autonomous Vehicles (CAVs) are an active area of research due to their potential benefits to traffic flow on public roads. The vast majority of recent studies in this area utilise mixed-traffic simulations to gauge the potential effect of CAVs on traffic flow. These vary from microsimulations, which investigate the interactions between small numbers of vehicles in great detail, to macrosimulations, which investigate the emergent behaviours of thousands of vehicles.

This thesis analyses a number of recent studies of CAV effects on traffic flow, and evaluates them along various criteria, including the addition of realistic network simulation, and the complexity of the road network.

We find that CAV studies which include realistic network simulation alongside microscopic vehicle simulation tend to be based on less complex road network scenarios, and that CAV studies based on more complex road network scenarios omit realistic network simulation. We also find that no studies to date have been performed on the effect of packet loss on the traffic flow effects of CAVs in mixed-traffic scenarios including a complex road network. We hypothesise that there is no significant benefit of realism to be gained by performing network simulation in a complex road network, and that varying the reliability of the network in such a simulation should have little effect on traffic flow.

To refute this hypothesis, a recent study involving mixed-traffic macrosimulation on a realistic road network is extended to include realistic network simulation. This required evaluating a number of longitudinal CAV models, state-of-the-art vehicular and network simulation software, and then designing and running a number of large-scale simulation experiments designed to falsify this hypothesis. These experiments utilised a realistic vehicle simulator coupled with a realistic vehicular network simulation framework. The following parameters were all varied: amount of traffic (low/high), the longitudinal CAV controller, CAV market penetration rate, and packet drop rate.

These simulations required days of real computer time to run, and produced gigabytes of vehicle trajectory data. Some modifications to the underlying simulation software were also required in order to run these simulations. The results of these simulations were then used to evaluate the hypothesis, and it was not found possible to reject the hypothesis based on these results. While no significant effects of packet loss on the rate of CAV traffic flow were found in this study, more investigation is required before further conclusions can be drawn.