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# A reference-driver model for overtaking a cyclist

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An expected benefit of the introduction of Autonomous Vehicles (AVs) on public roads is improved traffic safety. One approach to assessing and verifying the improvements provided by AVs that has recently gained attention uses computational models of reference drivers as a safety benchmark. These models typically aim to describe a competent and careful driver's driving strategy and capability to respond to external stimuli (hence the expression "reference model"). Models for AV assessment can be divided into crash avoidance and conflict avoidance models. Crash avoidance is here any evasive maneuver aimed at avoiding an imminent crash. Differently, conflict avoidance is here any action (or, rather, driving strategy) aimed at minimizing the risk of ending up in a conflict. The model developed in this study focuses on driver conflict avoidance behaviors, and the simulations compare the performance of the AV system under assessment with that of the reference-driver model: the system should perform at least as well as the driver model. If an AV performs better than the model, the rationale is that it would also respond better than a careful and competent driver. Currently, reference-driver models are primarily being developed for highway driving. Scenarios such as cyclist overtaking, in which a driver overtakes and passes a cyclist, have not yet gained much attention in this field of research.

This study aims to create and demonstrate a novel reference-driver model to assess AVs, where the model represents a careful and competent human driver when approaching and overtaking a cyclist. This model, which can be included in virtual simulations, is intended to keep the virtual driver within the comfort-zone boundaries of a careful and competent driver. These boundaries characterize the limits of cyclists' and drivers' perceived safety (in terms of both time and space) during overtaking.

An existing computational driver model of the overtaking maneuver was used as the starting point for this work. This model describes the safety metrics that characterize the maneuver. These metrics include the lateral distance to the cyclist (which quantifies the objective and perceived safety mainly from the cyclist's perspective), and time-to-collision to an oncoming vehicle (which relates more to the objective and perceived safety from the driver's perspective). In this study, building on existing models, we present a model that can complete the overtaking, even as it is constrained to maintain a lateral distance that would be considered safe by a competent and careful driver, and while adhering to the constraints of the cyclist's perceived safety. The performance of the model is demonstrated by applying it to a set of normal driving data from a naturalistic driving study, as well as synthetically generated critical bicycle-overtaking situations.

The expected results include the documentation of a reference model of a careful and competent driver that aims to minimize the risk of conflicts (and, consequently, crashes) during cyclist overtaking. The model can be used as a safety target when assessing AVs in that scenario. The model's performance will be demonstrated by its application to naturalistic driving/riding data of cyclist overtaking and to a set of synthetically generated critical events. Additionally, a sensitivity analysis will investigate the influence of model parameters and input variables (such as the speeds of the overtaking vehicle and the bicycle) on the model's performance. We aim to make the model open-source as a controller in the esmini[1] virtual simulation software, to complement the existing highway-driving car-to-car models that currently exist in esmini.

In conclusion, this study will provide an open-source computational reference-driver model representing a careful and competent driver overtaking a cyclist, for use as a safety target for AVs in the cyclist-overtaking scenario.

[1] https://github.com/esmini