学位報告 4

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# 主　論　文　の　要　旨

論文題目　Data-driven Personalized Vehicle Control by Modeling Subjective Driving Risk
(リスク感のモデル化に基づくデータ駆動型個人適応運転制御)

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## 論 文 内 容 の 要 旨

Most current research in the field of autonomous vehicle control assumes that all vehicles will follow the same patterns of automated driving behavior, resulting in systems with "conservative" or "average" driving styles. These systems may not be acceptable to drivers who prefer a more aggressive style of driving, however, extremely cautious drivers may consider the standard outputs to be too aggressive. To improve the wider acceptance of autonomous driving, and to improve the trust in autonomous driving systems, a framework that can collect users' feedback on usage and improve the driving experience accordingly will become more and more important. In order to quantify the acceptance of the autonomous driving system, subjective feedback from a user of an autonomous vehicle, which can be utilized to evaluate the driving experience, should be defined in some explainable way. Subjective risk is selected as the user's perception index, firstly because driving is safety-critical, and secondly, because driving behavior is adjusted to match each individual's acceptable risk. In order to model driving behavior in both longitudinal and lateral directions, lane change maneuvers were selected for analysis. In the field of perception, decision-making, and the control process, the control phase is targeted to generate personalized driving behaviors with lower subjective risk.

To address this problem, I set up three steps to build a framework for personalizing control when generating lane change maneuvers for autonomous vehicles, directly incorporating user preferences and risk perception.

In the first step, we model the relationship between subjective perception and driving behavior. The lane change scenario is used as the target scenario in this study, because it is considered relatively risky in driving, and it contains both longitudinal and lateral directions. Subjective risk is used to quantify users' perception of riskiness in driving circumstances including ego vehicle driving behavior and surrounding vehicle information. In this step, we identify which driving-related factor influences subjective risk perception.

In the second step, we combine risk classification with predictive controllers. Risk classification is used to detect the current situation as risky or non-risky ones. It was designed that safety-focused maneuvers should be generated when a risky situation is detected, while when non-risky situations are detected, personalized maneuvers would be generated in a preferable way for individuals. However, these individual preferences are not immutable because we prefer different driving styles interactively with the surrounding environment.

Therefore, in the third step, we propose Risk Sensitive Control (RSC), an inverse optimal control algorithm that estimates risk-sensitive driving features and incorporates them into a receding horizon controller. RSC uses a meta-learning algorithm to update the cost function parameters, continuously improving the controller online as more and more driving data is gathered from the user and subjective risk feedback. An estimator takes into account individual differences in subjective risk analysis, in terms of driving features and surrounding vehicle locations, by adjusting the cost function and its constraints.

We test this approach using five lane change scenarios, some safe and some risky, with thirty real drivers in a CARLA simulation environment. Our quantitative and qualitative evaluations demonstrate that the proposed framework is able to generate a user's preferred driving maneuvers during lane changes, i.e., control commands the user associates with lower subjective risk, outperforming conventional, model-based predictive control methods in terms of replicating the user's own driving behavior.