Master's Thesis Proposal

Statistical Assessment of ADAS Function Improvement Using AI-Based Interpolation of Transient Target Losses Under ACC Control

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1 Introduction

Advanced Driver Assistance Systems (ADAS) are becoming increasingly complex due to the growing interaction between sensors, control systems, and artificial intelligence components. As a result, conventional rule-based validation methods are no longer sufficient to evaluate the performance and reliability of modern ADAS functions. Future validation approaches therefore require statistical methods capable of analyzing large-scale driving campaign, fleet, and vehicle simulation data.

The performance of Adaptive Cruise Control (ACC) systems is particularly sensitive to transient target losses caused by sensor limitations or environmental conditions. These target losses do negatively affect vehicle comfort, safety, and energy efficiency. Recent developments in artificial intelligence, especially neural-network-based interpolation techniques, offer the potential to improve ACC substantially by intelligent handling of such events.

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2 Problem Statement

Although AI-enhanced ACC systems show promising improvements in vehicle behavior, there is currently no robust statistical framework to quantify these improvements with high confidence. Existing validation approaches often rely on deterministic test cases and fail to capture their repeatability as well as the natural variability and uncertainty present in real-world driving scenarios.

This thesis addresses the problem of statistically evaluating the improvement achieved by an AI-based ACC system compared to a conventional ACC system as well as an ideal reference system.

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3 Research Objectives

The main objectives of this thesis are:

- To develop a statistical validation framework for evaluating ACC system improvements.
- To generate large-scale validation data using open-loop simulation in IPG CarMaker.
- To pairwise compare conventional, AI-enhanced, and ideal ACC systems in terms of statistical tests

- To extract and analyze Key Performance Indicators (KPIs) measuring driving comfort, safety, and energy efficiency.

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4 Methodology

Validation data will be generated using an open-loop simulation approach. Road geometry and target-vehicle behavior will be obtained from recorded testing-campaign data, while ego-vehicle behavior will be simulated in IPG CarMaker for three different ACC modes:

1. Conventional ACC system
2. AI-enhanced ACC system
3. Ideal ACC reference system

The generated validation snippets will be analyzed using two primary KPIs:

- **Jerk exceedance events**, representing driving comfort.
- **Energy dissipation ratio during braking events**, representing efficiency and safety behavior.

The statistical frequency distributions of events associated with these KPIs will be evaluated and compared using pairwise statistical tests between the three ACC modes. The analysis will determine whether the observed differences are statistically significant at a defined confidence level.

In addition, the thesis will investigate potential simulation pathologies, such as invalid scenarios or system-limit violations, and propose mitigation strategies to improve validation quality and automation capability.

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5 Expected Outcomes

The expected outcome of this thesis is a robust and partially automated statistical validation pipeline for evaluating AI-enhanced ADAS functions. The work aims to demonstrate how simulation-based and data-driven validation approaches can be used to assess improvements in future autonomous driving systems with statistical confidence.

Furthermore, the thesis is expected to provide insights into the effectiveness of neural-network-based interpolation methods for improving ACC performance during transient target-loss situations.

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6 Conclusion

This thesis contributes to the development of scalable and statistically reliable validation methods for next-generation ADAS systems. By combining simulation-based validation, AI-enhanced control strategies, and statistical hypothesis testing, the proposed framework aims to support the evaluation and release of increasingly complex autonomous driving functions.