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Subject Review report: Ing. D. Efremov

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Review Report
PhD thesis "Vehicle-Road Safety and Stability Envelope Definition and Protection"
by Ing. Denis Efremov
Czech Technical University in Prague

The PhD thesis "Vehicle-Road Safety and Stability Envelope Definition and Protection", submitted by Ing. Denis Efremov, presents results in multiple pivotal topics, encompassing the system modeling and vehicle control strategies using Model Predictive Control. In this context, the PhD candidate conducted intensive research on issues related to vehicle safety and stability, control methodologies, and comprehensive simulations. The findings are presented in a well-organized thesis, which includes an analysis of cutting-edge solutions, the development of various control approaches, and the execution of simulation studies to validate the proposed research outcomes.

While the industry is investing heavily in enhancing automated driving technology, proving the safety of automated vehicles remains a major challenge. This challenge is particularly critical when it comes to edge cases, such as handling limits where the vehicle's stability can be lost. Ensuring that automated vehicles can safely navigate these scenarios is crucial for their widespread adoption and public trust. In this context, the subject of the PhD thesis is very relevant to both the scientific community and the industry. It addresses the fundamental issues of stability and control in automated vehicles, aiming to develop robust methods for maintaining safety even in the most demanding situations. This research contributes to the advancement of automated driving technology and provides valuable insights that can be applied to improve overall vehicle safety.

Ing. Efremov extended the concept of the lateral stability envelope by integrating it with longitudinal motion dynamics. As a result, he proposed the novel concept of a driving envelope, which considers the wheel level rather than the traditionally used vehicle-centric approach. This new approach allows for more precise control and understanding of vehicle behaviour, particularly in dynamic and complex driving scenarios.

The second conceptual innovation introduced by Ing. Efremov is related to the environmental envelope, which is based on vehicle dynamics and environmental perception. This concept enhances the vehicle's ability to interpret and react to its surroundings, thereby improving overall safety and performance.

To implement these concepts, the candidate applied comprehensive control techniques such as Model Predictive Control. The candidate demonstrated the feasibility of these techniques for real-time computation and their capability to be employed on embedded hardware.

Through this research, Ing. Efremov's contributions significantly advance the field of automated driving technology. His innovative approaches to stability and environmental envelopes, combined with the practical application of MPC, provide a robust framework for enhancing the safety of automated vehicles.

One of the primary strengths of this research is the comprehensive set of experiments conducted. Utilizing a high-fidelity vehicle dynamics simulator with a complex nonlinear vehicle model, the candidate demonstrates the practical efficacy of driving envelope protection. The rigorous testing in this simulated environment provides robust evidence of the proposed framework's capabilities. It is particularly impressive to see the demonstration that the proposed framework is able to guarantee vehicle safety and stability across functionalities that are typically handled separately, such as anti-lock braking, traction control, and vehicle stability control.

From the perspective of the environmental envelope, the inclusion of lane-keeping and collision-avoidance functionalities further highlights the framework's versatility and adaptability. These functionalities are critical for the real-world application of automated vehicles. The ability of the framework to incorporate these elements demonstrates its comprehensive approach to vehicle safety and automation.

As a further development, real-world testing beyond simulation would help validate the system's performance under various weather conditions, road types, and traffic situations.

In summary, the PhD thesis exemplifies significant progress in the methodological approach to achieving vehicle safety and stability. The work demonstrates sound logical reasoning and a well-elaborated modelling approach. The candidate exhibits strong research skills in complex subjects related to vehicle dynamics and control engineering. The text of the PhD thesis is deemed to be error-free and does not require further corrections.

Based on the content and results presented in this work, it is evident that Ing. Denis Efremov is deserving of the PhD degree for his thesis: "Vehicle-Road Safety and Stability Envelope Definition and Protection".

The author of the thesis proved to have the ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving a Ph.D. degree.

Best regards

Dr. Barys Shyrokau
Associate professor

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