PhD THESIS EVALUATION FORM

PhD Candidate

Name:

David Vosahlik

Title of the Thesis:

Advanced Algorithms for Vehicle Dynamics Control

Thesis Evaluator

Name: Aleksandr Sakhnevych

Affiliation: Department of Industrial Engineering, University of Naples Federico II

Email address: ale.sak@unina.it

The thesis describes contributions in the field of control and safety of modern vehicles, focusing on traction control allocation, tire-to-road interface estimation, and vehicle trajectory planning. After reviewing the PhD thesis, it is clear that several sections should be detailed better, justifying the modelling and hypotheses choices as well as highlighting the eventual limitations, generally discussing better the pros and the cons of the chosen approaches and algorithms.

For the sake of completeness, below are several key points that could be elaborated on in the future to improve the overall discussion and depth of the analysis conducted:

a) The hypotheses regarding the plane motion of the high-fidelity vehicle model should be clarified: for example, it is important to confine the assumptions (as it appears that ride comfort may have been overlooked, though this is not explicitly stated). It should be made clear that these assumptions are not adaptable to all vehicles, but rather apply to vehicles with rigid suspensions and more constrained body movements. Addressing this will help avoid overgeneralization and ensure that the applicability of the model is better defined.

b) The validation of the digital twin must be further elaborated, especially since it serves as a reference plant model throughout the thesis outcomes. It is important to mention whether the vehicle was objectively validated using typical automotive KPIs through objective tests, as slow-ramp-steer or braking/traction, sine-sweep, etc. At a minimum, a description of the manoeuvres performed, the sensing equipment used, and its characteristics should be provided, as well as the dynamic and kinematic range validated in these tests.

c) There appears to be a potential issue with Equation 2.7, where v^2 is written as a product of the velocity magnitude and its individual components. It would be beneficial to either provide a source that validates this formulation or clarify within the text if this represents a simplification. Further justification of this formulation is recommended.

d) The quantity β do not seem defined within the text. Moreover, Equations 2.20 and 2.21 need further explanation regarding their applicability—are these equations valid for any slip values, or are they constrained to the tire's linear range? It is important to detail the hypotheses underlying these equations to clarify their scope and limitations.

e). The robustness of the proposed control logic needs to be better demonstrated. A more in-depth explanation and evidence of how this robustness is ensured, especially in varying operational conditions, would strengthen the argument and support the validity of the control approach.

f) A key issue with the vehicle plant model estimation is the noise injection required to represent a real-world system, particularly regarding wheel encoders, whose misestimations are velocity-dependent. How has the author accounted for this issue in their plant model? A discussion addressing the introduction of measurement noise, and its handling, is crucial for accurately representing real-world conditions.

g) Further clarification is needed regarding how Equation 3.6 for the wheel dynamics was derived. Detailing the assumptions and the derivation process will help ensure the equation's applicability and accuracy.

h). The slip curve should account for a combined interaction, suggesting a potential modification to Equation 3.15. Is this equation correct as presented, or should it be adapted? Moreover, it should be specified whether the reported algorithm is suitable for all vehicle operating conditions or if limitations should be introduced, such as restricting lateral velocity (like $|v_y| < \varepsilon_y$) to ensure the initial slip curve remains unmodified.

i) A discussion on how the identification process has been optimized is necessary, particularly with regard to minimizing the number of iterations required for the numerical identification using the "lsqnonlin" function in Algorithm 1. Additionally, is this approach suitable for real-time, onboard implementation within a closed-loop control system? This consideration is important for assessing the practical feasibility of the proposed method.

k). A discussion should be added regarding the strategy for calculating the vehicle path when the friction value changes over time. For example, thermal effects may cause tires to heat up or cool down, altering their behaviour. It could be interesting to include an analysis of how such time-varying friction conditions are accounted for in the path-planning process.

FORM

In conformity with the requirements for awarding a Ph.D. degree in the Czech Republic, the review contains the following opinions:

- The thesis addresses several of the most pressing challenges currently faced by the scientific community. It tackles critical issues such as control allocation methods and the challenge of accurately estimating the tire-road interface, including both actual and potential friction. Additionally, it contributes to the development of advanced path planning methodologies in complex, non-convex scenarios, which are highly relevant to modern vehicles and increasingly automated transportation systems. These topics are at the forefront of research in vehicle dynamics, control systems, and autonomous driving technologies, making the thesis highly relevant to current scientific needs to what extent the main objectives of the work have been fulfilled.
- The methodologies described and employed in the thesis are generally appropriate and effective for addressing the research questions. However, further minor revisions are recommended to refine certain aspects and improve the clarity and generalizability of the findings.
- The main results and contributions of the thesis include the development of an advanced control allocation method and innovative strategies for estimating the tire-road interface, particularly in terms of actual and potential friction, specifically addressing the state-of-the-art methodologies.
- The work is important for the further development of science, particularly in the fields of vehicle dynamics, control systems, and autonomous driving. By addressing critical challenges such as tire-road friction estimation, control allocation, and path planning in complex environments, the thesis represents a necessary step for advancing technologies in automated and connected vehicles.
- The proposed contributions are not only technically sound but also push the boundaries of current knowledge, making the work both creative and scientifically significant.

OVERALL ASSESSMENT

The author of the thesis proved to have an 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.

Date ______24/10/2024________