THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**Optimal planning and control of vehicle dynamics**
Author's name:	**Bc. Petr Turnovec**
Type of thesis:	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Ing. Jaroslav Bušek, Ph.D.
Reviewer's department:	Department of Informatics and Control Engineering, FME, CTU in Prague

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

How demanding was the assigned project?

The master thesis deals with a current topic, the solution of which is dealt with by all major institutions, not only from the academic field, which is evidenced by the student's cooperation with a private company. The student's task was to implement two methods of car path-planning, while its main benefit was the design of suitable modifications of these methods for the given application. For this reason, I consider the assignment to be challenging.

Fulfilment of assignment **fulfilled**

How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.

All partial tasks of the assignment were fulfilled without reservations. Nonlinear (high-fidelity) model of car single-track model was proposed. Two design models suitable for the given path-planning methods were derived from the high-fidelity model. Moth given methods (MPC, MVP) were implemented and validated by simulations. Three test scenarios were defined to assess the functionality of the given algorithms.

Methodology **correct**

Comment on the correctness of the approach and/or the solution methods.

The chosen approach is correct in general. Respecting methodology, I have reservations about some simplifications of the high-fidelity model in order to acquire design model (i.e. time constant t_{\omega}). However, the presented results imply that the accuracy of the design models is satisfactory for the given application. Besides that, I see other shortcomings in the evaluation (validation) of the accuracy of the design model. It is not entirely appropriate to evaluate the quality of the model according to the time horizon when the change of inputs takes place in sequence during this time. I would recommend evaluating the sensitivity to individual inputs separately with respect to the selected time horizon. However, there is no doubt that the chosen simplifications generate sufficiently accurate models for the given applications.

Technical level **A - excellent.**

Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?

The student demonstrably used the knowledge acquired during the basic study. In addition, he became acquainted with the current method of route planning (MVP) and was able to propose modifications for it to enable its application to the solution of the given problem. Both the justification of all steps taken, and the evaluation of partial results are performed clearly and at the appropriate technical level.

Formal and language level, scope of thesis **B - very good.**

Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?

The thesis is well-organized. The individual parts follow each other logically. Written English is at a very good level. The text contains a small number of typos. From the point of view of formal adjustment, I would point out the inconsistent style of some quantities (e.g. SoC). I would also point out that the unit display style should not use italics. This is observed only in some parts of the text.

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

THESIS REVIEWER'S REPORT

Selection of sources, citation correctness	**A - excellent.**
Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?	
The final work draws on adequate literature sources with the appropriate technical level. Student's work is clearly distinguished from earlier work in the field. However, it is more appropriate to cite published articles instead of the technical reports (i.e. [19], [26]) that were the basis for these articles. These articles have undergone a review process, which increases the quality of published results. In the part dealing with the MVP method, I would recommend adding some references (CasADi).	

Additional commentary and evaluation (optional)
Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.
In terms of technical skills, I appreciate the connection between MATLAB and Python for MVP simulation. Furthermore, the student's ability to critically evaluate the results and identify potential weaknesses of the implemented algorithms cannot be overlooked.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

The presented work presents the deployment of two algorithms for vehicle route planning, while three scenarios were chosen to assess their effectiveness. The starting point for the deployment of both methods was the creation of a mathematical model of the vehicle. For the purpose of deployment in the specified methods, certain simplifications of the model have been adopted. Although the work is based only on simulation results, its significance cannot be questioned. I appreciate the student's ability to identify the shortcomings that arose during the implementation of the assigned methods and his approach to the design of appropriate modifications.

Questions for defense:

Q1: What was the evaluation criterion for claiming that the model is sufficient in section 3.1.4?

Q2: Based on impossibility to minimize the time to reach, is the NMPC suitable for such application? Does the chosen prediction horizon make the method disadvantageous?

Q3: Does SoC_ref=SoC+2% mean that the SoC should increase over the path as stated in section 4.4.1? Is it a reasonable choice? Why?

Q4: How is it possible to prevent not reaching given final position for the chosen method of path planning (MPC)? Even though the vehicle reaches most often a point close to/on trajectory towards destination point, the task is to reach the goal position.

Q5: Is the grid size equidistant for precomputed trajectories? You proposed a solution with smaller grid size around (moving) obstacles to decrease demand on hardware and to increase precision of trajectory around obstacles. How hard would be the implementation? How would you choose grid size change around obstacle?

Q6: Which of the methods, after subjectively considering the advantages and disadvantages, would you recommend for practical implementation? And why?

The grade that I award for the thesis is **A - excellent.**

Date: **17.6.2021** Signature: