ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Learnable state estimator for multi-legged robot**
Author's name:	**Jiří Kubík**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Computer Science
Thesis reviewer:	Vladimír Kubelka
Reviewer's department:	Computer Science and Software Engineering, Université Laval

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

Evaluation of thesis difficulty of assignment.

The author was investigating a new approach to solving a relevant problem of modeling dynamics of a legged robot through several different machine-learning techniques. For the scope of a master thesis, I consider this problem a challenging one.

Satisfaction of assignment **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The points 1 to 5 from the assignment have been fulfilled. The last 6th point was not possible to achieve from the objective reasons explained in the thesis. I presume that the author himself or somebody else will further develop the ideas of the thesis, fix the identified problems, and eventually demonstrate the functions through the task of the 6th point.

Method of conception **correct**

Assess that student has chosen correct approach or solution methods.

I have no objections to the selected approach. Based on the in-depth literature review and the constraints laid by the robotic platform, three regressors were chosen. The training on the initial dataset looked promising, but the actual deployment revealed problems. The author then performed the analysis of the behavior of the regressors to find the source of the problem. Thanks to this, the next researcher can build on the results.

Technical level **A - excellent.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The state-of-the-art review is thorough and the regressor choice is well explained. The strongest part of the thesis is the failure analysis. I presume that if there were more time, the lessons learned from that analysis would eventually lead to a system that would work in a satisfactory way.

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

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis is written in the style of a research paper, with some minor details that would need fixing before submitting to a conference or journal (given that the problem with regressors is fixed). I appreciate writing in English and just recommend using a grammar correction tool to help adding all the missing articles (our typical problem) to improve the readability of the text. Grammarly is a good tool for this purpose. Regarding the structure of the text, in section **5.5**, it would be better to comment on the obtained results, not to leave the interpretation to the reader. Generally, we put figures or tables to relay some message, and that message should be explicitly stated primarily in the text. Similarly with figures: Figs. 20, 26, or 27 - for example - nicely relay a clear message. Figures 28 and 29 not so much, but they take two pages. In this case, it is enough to say that there is no special pattern, and the readers will believe.

Selection of sources, citation correctness	**A - excellent.**
Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.	
The literature review section is done thoroughly and covers all necessary sources. My only comment is related to the style of the section: It might be easier for the reader if there were more comments on how the cited works relate to the thesis problem. Whether they are applicable or not, if their approaches differ from ours, or if we aim to be better than some of them. Of course, this is not possible with all references, and I am commenting on this more from the point of view of a journal or conference paper reviewer, as a suggestion for improvement for future publication.	

Additional commentary and evaluation
Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.
The thesis approached a research problem, and with those, our initial assumptions don't always hold. The initial dataset was designed soundly, and the behavior of the regressors was good. I presume that the fact it did not work when deployed on the robot was quite a surprise, at least that is my impression from the story of the thesis. However, this is the nature of our work, it would be boring otherwise.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The author approached a difficult research problem and although he did not achieve the performance required by the assignment, he has shown a constructive approach to the problem when analyzing the source of the failure. The thesis is well structured, and it is easy for a reader to follow the story and the motivations for the performed experiments and analysis. In my opinion, it confirms the author`s ability to independently work on technical or research problems.

I have a few technical questions and comments:

- Q: With 100Hz, have you considered subsampling to cover longer time horizons in the set of samples you provide as the regressor input? How much does the servo move with the selected n=5 samples (i.e. in 0.05 sec) versus the measurement noise? (It seemed that at least on the dataset experiments, it worked for you, but then, your analysis has shown that just the first sample is important. Could it be that the following 4 are almost the same?)

- Q. regarding the different velocity profiles issue: Could adding joint velocities as features into the regressors help? It looks that the system is depending on the velocity profile which in turn depends on the "points per sec" value. This parameter is to some degree hidden from the regressors, and in my opinion, the learning methods nor the datasets can generalize over it. If not velocity features (too noisy perhaps), would there be some other potential features, which would eliminate the influence of this parameter?

- Comment on subsection **5.11.3**: The results of this analysis are not too surprising. All these special artificial datapoints are probably too far from the ones in the datasets. Keep in mind that the regressors just try to match the function through the training datapoints. Thus, if you are close to them, there is a good chance that the value also makes sense. But as you get further, the function may not make sense at all.

REVIEWER'S OPINION OF FINAL THESIS

I evaluate handed thesis with classification grade **A - excellent.**

Date: **4.9.2021**

Signature: Vladimír Kubelka