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Timisoara, March 25, 2022

Review of the doctoral thesis  
“Data-efficient methods for model learning and control in robotics”  
authored by Ing. Erik Derner

This letter represents the report of the doctoral thesis entitled “Data-efficient methods for model learning and control in robotics”, authored by Ing. Erik Derner, and supervised by Prof. Dr. Ing. Robert Babuška, to be defended at the Czech Technical University in Prague.

According to the university and faculty regulations, this is a standard thesis in which a specific research issue is investigated and the research results achieved are analyzed in depth. This form of the thesis definitely includes valuable material previously published by the candidate in high-level journals and conference proceedings.

This is a very good thesis that treats thoroughly interesting and actual problems specific to the growing fields of learning and control applied to robotics. Putting the thesis in the actual framework of the field of data science and engineering also proves that the author tracks the actual trends in all these fields. I actually enjoyed reading this thesis.

As correctly discussed in Chapter 1, which includes the thorough treatment of motivation and challenges, the author sets the objective of this thesis as follows: address the challenges in learning the model of the robot and its environment as far as data-driven model learning is concerned and reflected in control. In this regard, the subject of the thesis is relevant to the current needs of the scientific community. After reading the thesis I consider that the main objective of the work has been fulfilled 100%.

The thesis proposes new contributions in terms of the following contents, (1), (2), (3) and (4):

- (1) Symbolic regression (SR) is proposed as an effective tool for constructing robot models from data. SR is important for the further development of science as it produces accurate and compact models having a relatively low number of parameters.
- (2) The author proposes an approach to model learning. This is also important for the further development of science as it does not depend on the particular choice of the SR algorithm, and thus proves a certain generality degree.
- (3) A method based on the model prediction error and called PERMIT is proposed, to ensure the efficient selection of informative samples in model learning. The importance of this method for the further development of science is proved by its comparison to four sample selection methods reported in the literature.

(4) A method for visual localization of mobile robots in dynamic environments is proposed. This is important for the further development of science because in contrast to deep neural networks, the proposed method based on local features represents a data-efficient and computationally lightweight solution. Nevertheless it is more transparent compared to deep neural networks.

The author carries out the systematic treatment of modeling and control problems in relation to data and robotics. Other specific comments are formulated as follows:

1. The specific outcomes are useful, and they can lead to benefits for the researchers and also companies that work in robotics.
2. The objectives are clearly outlined and scientifically and systematically supported in all chapters.
3. The approaches are very methodological, clear algorithms are proposed, and the assumptions made are justified thoroughly. The methods used in the thesis are appropriate.
4. The models and the control algorithms are validated and tested by offering test-bench experimental results and simulation ones.
5. The thesis contributes to the state of knowledge in the modeling and control of actuators specific to the robotics industry. It is also an effective example on how to conduct research in robotics control application fields.
6. The candidate does his best to support the assumptions scientifically and to validate the new results by experiments, and extensive and realistic simulations.
7. The thesis is written clearly, it is well balanced in its chapters and in communication, and it contains an adequate number of actual references that are relevant to the subjects treated.
8. The summary points out correctly what the author has actually done and proposed in the thesis.
9. The thesis is supported by presenting the results in high-level publications. Author's results are published in many publications including the top journals Robotics and Autonomous Systems, Applied Soft Computing, Expert Systems with Applications, IEEE Robotics and Automation Letters, and the top conferences IEEE International Conference on Robotics and Automation (ICRA), IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), and Genetic and Evolutionary Computation Conference Companion (GECCO). The quality of these journals and conferences guarantee the high-level of author's contributions.

Overall I was pleased with the thesis, and I rank it in the top 25% theses assessed by me during the last three years.

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.

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