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Evaluation PhD Manuscript Kamil Dolinský

To whom it may concern,

Herewith you find my comments on the PhD thesis submitted by Mr. Kamil Dolinský.

The thesis concerns the estimation of parameters and states for underactuated walking robots. The thesis starts with an introduction, containing a clear overview of the state-of-the-art, the problem definition and the statement of the objectives. Chapter 2 is devoted to establishing the necessary background, on models for robotic walking, and on estimation algorithms (grounded in Kalman filtering and recursive least-squares), respectively.

The main contributions are contained in Chapter 3, which concerns the off-line parameter estimation. A particular advantage for the adopted approach is that the model under consideration has linear dependence on the unknown parameters to be estimated. The price to pay is that measurements of angles and torques are required. While this is in practice relatively easy to achieve for torques and relatives angles, the determination of the absolute angle / orientation of the robot constitutes a major challenge. As a first contribution, two complementary directions for measuring the absolute angle are explored: a direct approach based on measuring the distance from a known point on the robot to a point on the surface, and an indirect one, based a gyroscopic model and the use of accelerometers. As a second contribution, in the overall parameter estimation problem the noise level, mainly induced by the inaccuracy of the measurement of the absolute angle, is addressed by using a maximum likelihood estimator. The resulting estimation algorithms are validated using both simulation, on a model for a bipedal walking robot, and experiments, where parameters of a leg of a laboratory prototype are estimated. These experiments clearly demonstrate the performance of the maximum likelihood based estimators.

Chapter 4 is devoted to the development of online state estimation algorithms (for the overall system, including a controller). The novelty of the approach consists of the adaptation of the Extended Kalman filter and the Unscented Kalman filter, which does not rely on the availability of Jacobians, towards systems exhibiting state jumps, and their successful application to robotic walking (by including the transition map induced by the modeling of the impacts). Both estimators are extensively compared by means of simulations.

In the last chapter, the main contributions are stated, which are in line with the objectives, as well as promising directions for future research. Some appendices complete the presentation.

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From my reading of the thesis, it is clear that the candidate masters the topics very well. The problems addressed are challenging, due to the high level of noise on the absolute angle's measurement, the complicated dynamics of walking (controlling of a limit cycle, impacts giving rise to a hybrid system model), and due to the characteristic that realistic walking is inherently underactuated..Nevertheless adequate solutions are provided, which are well validated through simulations and experiments. This is also a multi-facet thesis, with its combination of theory, algorithm design, uncertainty quantification, simulation and experiments.

The results obtained in the framework of the thesis already led to several publications, including an article in the prestigious journal IEEE Transactions on Control Systems Technology, of which Mr. Dolinský is the first author.

In conclusion, 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.

Yours sincerely,

Wim Michiels