

The Review of Ph.D. Thesis *Modelling and control of walking robots* by Milan Anderle

Reviewer – prof. Ing. Pavel Václavek, Ph.D., Brno University of Technology

Significance for the scientific field

The thesis is aimed at control of walking robots. While many teams are working on this topic, design of reliable and computationally feasible control algorithms for walking robots is still big challenge. It is also important that the work on this topic can bring also new results in the field of non-linear systems control that can be generalized for other applications. That is why I consider the thesis topic to be significant.

Contents and structure of the thesis

The thesis has 120 pages and consists of 8 chapters. The first chapter provides introduction and description of the state-of-the-art as well as definition of the thesis goals. The next chapter is devoted to modeling of under-actuated mechanical systems including impact effects. The chapter is based on classical Euler-Lagrangian approach, but presents also interesting results on implementation of impact effects in the models. The third chapter describes technique of partial feedback linearization which is applied to the models obtained in chapter 2 to be able to design linear controllers for the planned trajectory tracking. The ideas of trajectory design both for Acrobot and 4-link are elaborated within chapter 4. The most important part of thesis is chapter 5 where several techniques for the reference trajectory tracking are designed. Unfortunately, this chapter lacks better explanation of advantages/disadvantages of the individual proposed methods. Chapter 6 provides information on design of state observers to reduce number of necessary mechanical sensors that would be otherwise needed for the robot walking control. Very important is chapter 7 with its results on stability of the overall control structure. The last chapter deals with conclusions and assessment of the defined goals achievement. It also provides overlook of follow-up research activities including expected test on real mechanical models.

The goal of the thesis

The main goal of the research is to design new control algorithms for under-actuated walking robots and to improve existing algorithms. The second goal of the thesis is to provide observer for non-measured states to be able to apply the developed control algorithms without need of additional sensors. The goals are well defined and in line with the topic of study.

Technical correctness and quality of presentation

The topic requires strong knowledge of non-linear dynamical systems analysis and synthesis. The presented approach is well documented, unfortunately some of the obtained conclusions are not clear (see Questions section). The thesis is well written and structured; it provides reasonable extent of references with good coverage of related works. Some parts of the thesis can be also considered to be well written tutorial material allowing study of advance non-

linear control methods. The manuscript contains only very limited number of typographical errors.

New results and contribution of the author

Described results demonstrate that the thesis goals were achieved. The author delivered new interesting results namely in the area of modeling of the Acrobot including impact effects and partial feedback linearization of the model. Another significant result is a set of trajectory tracking algorithms with proved stability. The results were published in one article in impacted journal and several recognized international conferences.

Questions and comments


While most parts of the thesis are clearly written, there are several points that should be better explained:

- On page 29, there is a statement, that zero dynamics is used to investigate internal stability. Unfortunately, the result of this investigation is unclear.
- Several algorithms for reference trajectory tracking are described within chapter 5. It would be useful to provide comparison of their properties and to make some conclusions about their possible practical use. What are the benefits of individual techniques, which one is suggested for this application?
- The designed algorithms were verified in simulation. It would be good to describe at least briefly the simulation environment used for the experiments.
- Work on the practical testing in laboratory experiments is mentioned in the conclusion. Is there any progress in practical evaluation of the designed algorithms?

Conclusion

The presented thesis describes relatively complicated control problem. The author contributed to the topic with his original results that were also sufficiently published in impacted journal and conference articles. The manuscript fulfils the conditions laid on Ph.D. thesis. That is why, I recommend to award the Ph.D. degree to the candidate.

In Brno, October 17th, 2015



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