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External Examiner's Report on Doctor of Philosophy Thesis of Mr. Marek Balcerzak entitled „ Optimization of Control system parameters with use of the new Lyapunov exponents estimation method"

1. Introduction

Reviewed work consists of ten chapters. The first four, introductory ones, present the objectives, scientific theses, description of dynamical systems, methods of Lyapunov exponents estimation and an introduction to control systems. In section 4.5 the novel Lyapunov exponents estimation is proposed as an control performance assessment. The fifth and sixth chapters are devoted to modelling of the inverted pendulum and its construction, respectively. The seventh chapter concerns a fundamental part of work i.e. discussion and analysis of control system of the inverted pendulum. In the eighth chapter, model parameters are identified. Chapter ninth is devoted to controller optimization, results of simulations and experimental verification of simulations. Last, chapter tenth, contains a summary and conclusions.

Ph. thesis contains a large set of experimental researches and numerical simulation results.

2. Ph. thesis evaluation

Pendula are ubiquitous in our daily life. Furthermore they are an interesting engineering discovery. Their functionality is proved by a fact that they are frequently used in engineering modeling. Stabilization problems of an inverted pendulum by means of horizontal or vertical excitations acting on it's fixed point were subject of numerous papers in the field of mechanics and control; e.g. analyses were motivated by stability problem of buildings and high structures in earthquake regions. The subject is still actual and demands continuation and development.. I think that the experimental research and analysis of controlled inverted pendula could be a subject of a Ph. thesis.

Summarizing the evaluation based on merit of Ph. thesis, I consider that:

- adaptation of the new LLE estimation method to control systems quality,
- effective estimation of parameters of the controlled object by means of the analysis its step response and the neural networks friction model,
- minimization process resulted in the set of controller constants that assured decent regulation quality and shorter stabilization time than in case of linear methods,
- experimental validation

are original elements of a scientific task and could be a basis for obtaining a technical science doctor's degree. Theses presented on the 5th page of discussed work are proved.

Only one critic consideration is connected to the narration style. In my opinion this work is too extensive and has a partly monographic character. With ease, the Author would be able to restrict its volume by 30%.

3. Conclusion

My evaluation of the PhD dissertation entitled " Optimization of control system parameters with use of the new Lyapunov exponents estimation method " by Mr. Marek Balcerzak is positive. I highly value the content of the thesis, its editorial structure and its usefulness for the higher education in Poland. I think, that mgr. inż. Marek Balcerzak has correctly formulated and solved in the presented thesis original scientific tasks, which are the adaptation of the novel Lyapunov exponents estimation method to the optimization of control system parameters and the successfully performed experimental validation. He demonstrated also his competence in applied mechanics and control theory fundamentals, experimental and simulation methods used in mechanics.

Opinioned work corresponds with conditions connected to the Act on Academic Degrees and Scientific titles from 12th of September 1990 with changes from 14th of March 2003, hence allows public defense of previously mentioned thesis.