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Review of PhD thesis

by mgr inż. Marek Balcerzak

entitled *"Optimization of control system parameters with use of the new Lyapunov exponents estimation method"*
Supervisor: dr hab. inż. Artur Dąbrowski

The review report has been elaborated on the order of Vice-Dean for Science of Mechanical Engineering Faculty of Łódź University of Technology.

1. General characteristic of the thesis, main objectives and applied methodology

The delivered PhD thesis entitled *"Optimization of control system parameters with use of the new Lyapunov exponents estimation method"* by Marek Balcerzak deals with a problem of optimal control based on Lyapunov exponents estimation. The monograph counts 103 pages divided on 10 main chapters, list of symbols, references and summaries in English and Polish languages.

Author presented a theoretical background of dynamical system and control and a definition of Laypunov's exponents as well as methods of their estimation. On the basis of recent publications he presented a new method of the maximal Lyapunov exponent estimation and then its extension to estimation of the spectrum of Lyapunov exponents. Advantages of the new method have been demonstrated numerically.

The next chapters of the thesis have been focused on control concepts of dynamical system. Basic definitions and classical methods of control have been presented and then a possibility of application of the novel method of the largest Lyapunov exponent estimation to control the dynamical systems has been discussed. An inverted pendulum has been selected as an example of practical application of the new, Lyapunov exponent based, control strategy. A mathematical model of the inverted pendulum and two control method based on velocity control and force control have been discussed in detail. The tested numerically concept of the control has been applied to a real structure. This required a design of a test rig, a proper selection of electrical and mechanical elements, sensors, actuators and other electrical components as well as an identification of the model parameters (including friction). The proposed control method

the art, and of quality adequate for getting PhD degree. Furthermore, the results can be applied in practice.

Taking into account the original contribution I confirm that the PhD thesis by Marek Balcerzak entitled *"Optimization of control system parameters with use of the new Lyapunov exponents estimation method"* satisfy all conditions required for getting PhD degree and can be presented during a public defence.