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Doctoral thesis review

Higher Order Neural Unit Adaptive Control and Stability Analysis for Industrial System Applications

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Study branch: Control and System Engineering
Supervisor: doc. Ing. Ivo Bukovský, Ph.D.

Nonlinear closed loop stability analysis and adaptive control methods are the main topics of the thesis. Higher Order Neural Units (HONUs) are used as nonlinear polynomial process model and as state feedback controller based on the Model Reference Adaptive Control (MRAC) concept. The maim contribution of the thesis lies in the stability study of HONUs and close loop control applications to several laboratory and industrial processes. Two methods for stability evaluation based on the BIBO/BIBS stability definition are the key contributions of the thesis.

Thesis with 134 pages consists from 13 chapters. After introduction and adaptive control methods overview in chapters 1 and 2 the objectives and contributions of the thesis are defined in chapter 3. Theory for adaptive identification and control methods with HONUs is summarized in chapter 4. HONU MRAC control methods are applied to two-tank, railway stand and barrier processes in chapter 5. Discrete-time and decomposed discrete-time HONU stability is proposed in chapter 6 and 7. Experimental stability analysis for HONU adaptive models and HONU-MRAC control loops is presented in chapter 8. Discussion, next research activities and conclusions are stated in chapters 9, 10 and 11. Literature and appendix are in chapters 12 and 13.

Objectives of the thesis are:

1. Recall and extend on theories of HONU adaptive control
2. Propose new pointwise state-space representation of a HONU
3. Propose new pointwise state-space representation of a HONU via polynomial decomposition
4. Derive a new ISS based stability condition for BIBS stability assessment of HONU polynomial architecture
5. Experimental analysis to validate the proposed DHS and DDHS approaches

All the objectives have been met in the thesis. The level of the current-state analysis is very good and detailed. The theoretical contribution of the dissertation lies in the discrete-time HONU BIBO/BIBS stability analysis. The practical contribution is connected with HONU stability ensuring and monitoring for industrial processes. Ph.D. candidate chose appropriate methods for above formulated objectives and also practical validation was performed correctly.

The Ph.D. candidate proved his excellent knowledge in the area of nonlinear polynomial control stability analysis and also the ability to apply theoretical knowledge for the practical applications. I appreciate also ASPI kit software and stability analysis library in Python programming language for engineers and practitioners.

Formal side of the thesis is weaker than the theoretical contribution which is better combination. Text sizes in pictures are not uniformed. The same hold for the labels and axes in the graphs and for graphs themselves. However, this does not reduce the quality of the submitted thesis.

Picture in Figure 7 do not correspond to the process model equations (28) and (29) – those equations describe parallel two-tank system.

Ph.D. candidate should react to following question:

Did you meet problems with adaptive strategy in steady state parts of the control experiments? Relevant information about the dynamics of the controlled system could be lost and controller can be very sensitive to the subsequent disturbance or setpoint change.

The quality of the thesis is very good and meets all criteria so I can recommend it for the defence.

In Pardubice, 14th of April 2020 ……..

Ing. Daniel Honc, Ph.D.