# Supervisor's review of PhD thesis

Topic:  **Higher Order Neural Unit Adaptive Control and Stability Analysis for Industrial System Application**s

PhD candidate::  **Ing. Peter Mark Beneš**


Peter M. Beneš became my student since early of his studies at  CTU in Prague. At the very beginning, I supervised Peter's Bachelor's thesis, where he became familiar with very fundamentals of computational intelligence algorithms and in particular with the neural networks, fuzzy rule-based systems, and their up-to-date techniques of implementation (in Python).

During his Master's studies, Peter inclined to further investigation of data-driven approaches of system approximation and control algorithms. In his Master's thesis, Peter derived and implemented an adaptive algorithm of system approximation with real application to hoist deceleration, and he proposed and simulated his first adaptive control solution. And this was the adaptive control concept that he further followed and systematically developed during his PhD studies. As an aside during his Master's studies, Peter was taking his active part during short-term visiting research at Tohoku University in Japan (and again later during his PhD studies), and he also helped with experimental study resulting in an impact factor publication (author's publication [8] in the thesis).

Then, Peter continued in developing adaptive nonlinear control with polynomial neural architectures. At first years of his PhD and aside of his regular teaching duties, Peter designed and implemented the nonlinear adaptive control of HW experiment in the laboratory of automatic control. Also, he had programmed the adaptive simulation software in Python that was available as open-source, and that was later used in several defended theses by other students.

Then, Peter successfully designed and implemented HW solution for data-driven control of the lateral skew of experimental roller rig in cooperation with the Department of Automotive, Combustion Engine and Railway Engineering.

Aside from the proper investigation and applications of nonlinear MRAC control with polynomial neural units (HONUs), he researched and significantly extended the fundamental concept of nonlinear time-variant state-space representation of HONUs. Peter proposed novel nonlinear time-variant state-space representations of HONUs and extended it to control loops with HONUs with possible real-time

adaptation.

The main theoretical contributions of Peter's thesis are several concepts of (BIBO and BIBS) stability of nonlinear adaptive control loops with HONUs, where the most impressive property is the instant evaluation of a nonlinear control loop stability. At the same time, the common Lyapunov approach is lagged, which corresponds to the fact that the Lyapunov technique serves to stabilization while the proposed stability conditions represent the stability of a nonlinear system as such. The methods have been theoretically derived and validated by simulations as well as via real experiments.

Unfortunately, Peter did not become a faculty member during his studies. During his full-time studies (red diplomas for both Bc. and Ing.) he was working in Schindler company, and later he was found and hired by the division of railway automation in Siemens, where he continues his career as a senior manager in R&D department, and where he also implemented the (already published) control algorithm and its HW solution for a real world railway application.

Nevertheless, Peter's research and publication activity significantly supported our research projects at FS, CTU in Prague, including the Centre of Advanced Aerospace Technologies.

As regards Peter's focused research topic, Peter is the very first (soul) author of 1x international journal paper, 1x book chapter, 3x Springer book series chapters, 1x IEEE prestigious conference paper.
(I am not mentioning other papers involving winning and top awarded papers at student conferences at CTU as well as outside CTU).

In total, Peter contributed as the author or co-author of at least 21 publications, including 1x IF journal (2.197), 2x international journal, 2x book chapter (IGI), 3 x Springer book series chapters, and several prestigious conferences (2x IEEE IJCNN, IEEE SSPD).


After the defense of his Ph.D. thesis, I agree with appointing the Ph.D. degree to Ing. Peter. M. Beneš.


In Prague, January 1, 2020                                        ……………………………………
                                                                                      doc. Ing. Ivo Bukovský, Ph.D.