Topic ID: 144-ARI-EN-02

The Use of Artificial Intelligence Methods for Time Delay Systems Control

Supervisor: Assoc. Prof. Ing. Pekař Libor, Ph.D.

Consultant: ---, ---

Department: Department of Automation and Control Engineering

Programme: Automatic Control and Informatics

Abstract:

Systems comprising internal delays represent a class of systems with a very complex dynamics characterized by an infinite spectrum, specific responses and characteristics in time and frequency domains. Tasks of their control often require the use of unusual solutions that are very specific, unlike conventional approaches known for undelayed systems. The presence of delays significantly influences the feedback dynamics; especially, it has a decisive impact to stability that can be sensitive to even small delay value changes.

A considerable amount of the existing solutions of time delay controller synthesis is based on highly advanced mathematical operations from the field of matrix calculus or calculus of variations, which (from the engineering point of view) makes their practical applicability more difficult or even impossible.

For the above-introduced tasks, it provides the use of artificial intelligence optimization methods that are mostly mathematically not very complicated, easily programmable and may provide real-time results. The goal of the PhD thesis is to suggest solutions of several problems related to stability attainment, an optimal controller design and tuning etc. The solutions are supposed to be based on advanced approaches and techniques of artificial intelligence and to be engineeringly utilizable. It is also supposed that not only some existing algorithms will be implemented but also their modifications concerning specific features of time delay systems will be proposed. The techniques are to be verified and validated via a suitable software tool as well as through a laboratory appliance.

Literature:

[1] BYRSKI, A., R. DREZEWSKI, L. SIWIK and M. KISIEL-DOROHINICKI. Evolutionary multi-agent systems. Knowledge Engineering Review [online]. 2015, 30(2), 171–186. DOI: 10.1017/S0269888914000289.

[2] DUTTA, D. and UPRETI, S. R. A reinforcement learning-based transformed inverse model strategy for nonlinear process control. Online. Computers & Chemical Engineering [online]. 2023, 178, art. no. 108386. DOI: 10.1016/j.compchemeng.2023.108386.

[3] FOUQUE, J.-P. and Z. ZHANG. Deep learning methods for mean field control problems with delay. Frontiers in Applied Mathematics and Statistics [online]. 2020, 6. DOI: 10.3389/fams.2020.00011

[4] HEATON, J. Artificial Intelligence for Humans, Volume 2: Nature-Inspired Algorithms. 1st ed. North Charleston, SC: CreateSpace Independent Publishing Platform, 2014. 242 p. ISBN 978-1499720570.

[5] MOHAMMADI, M, AREFI, M. M., SETOODEH, P. and KAYNAK, O. Optimal tracking control based on reinforcement learning value iteration algorithm for time-delayed nonlinear systems with external disturbances and input constraints. Information Sciences [online]. 2021, 554, 84-98. DOI: 10.1016/j.ins.2020.11.057.

[6] NEAPOLITAN, R. E. a X. JIANG, X. Contemporary Artificial Intelligence. 1st ed. Boca Raton, FL: CRC Press, 2015. 515 p. ISBN 978-1439844694.

[7] ROH, C. Enhancing Power Generation Stability in Oscillating-Water-Column Wave Energy Converters through Deep-Learning-Based Time Delay Compensation. Processes [online]. 2023, 11(6). DOI: 10.3390/pr11061787.

[8] YANG, J. Deep learning-based consensus control of a multi-agents system with unknown time-varying delay. Electronics [online]. 2022, 11(8), 1176. DOI: 10.3390/electronics11081176.