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# Reinforcement learning for chemical process control

Kinga Szatmári[1], Sándor Németh[1], Alex Kummer[1,2]

*[1]Department of Process Engineering, University of Pannonia, Egyetem st. 10, H-8200 Veszprém, Hungary*
*[2]HUN-REN-PE Complex Systems Monitoring Research Group, University of Pannonia, Egyetem st. 10, H-8200 Veszprém, Hungary*

*e-mail: szatmari.kinga@mk.uni-pannon.hu*

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Reinforcement learning (RL) algorithms are well-suited for sequential decision-making tasks, making them an excellent choice for chemical process control, where making decisions is required continuously. In this paper, we explore the application of RL at different levels of hierarchical process control to assess its potential to improve efficiency and robustness. We present two case studies of chemical process control applications, one with resilience engineering and explainable reinforcement learning, and one with multi-agent reinforcement learning. In the first case study, an intervention action is designed with RL to prevent reactor runaway in a batch reactor, and resilience is applied as a reward function. Two explainable reinforcement learning methods are investigated, a decision tree, as a policy-explainer, and the Shapley value as a state-explainer. The decision boundary of the decision tree is compared with the runaway boundaries defined by runaway criteria, and the Shapley value explains how different state variables influence the agent's decisions over time. The results show that this method is applicable to the developement of a resilience-based mitigation system, and can be explained and presented transparently. In the second case study, two RL controllers are applied, one RL controller varies the feed rate in the feed phase of a semi-batch reactor, while the other RL controller in the mixing phase works as a master controller in a cascade control structure. The multi-agent structure enables the handling of more complex chemical processes beyond the capabilities of a single agent. The developed RL controllers perform effectively and can keep the temperature at the desired setpoint.

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