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Safe and Efficient Deep Reinforcement Learning Control Model: A Hydroponics Case Study

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Abstract : Safe performance and efficient energy consumption are essential factors for designing a control system. This paper presents a reinforcement learning (RL) model that can be applied to control applications to improve safety and reduce energy consumption. As hardware constraints and environmental disturbances are imprecise and unpredictable, conventional control methods may not always be effective in optimizing control designs. However, RL has demonstrated its value in several artificial intelligence (AI) applications, especially in the field of control systems. The proposed model intelligently monitors a system's success by observing the rewards from the environment, with positive rewards counting as a success when the controlled reference is within the desired operating zone. Thus, the model can determine whether the system is safe to continue operating based on the designer/user specifications, which can be adjusted as needed. Additionally, the controller keeps track of energy consumption to improve energy efficiency by enabling the idle mode when the controlled reference is within the desired operating zone, thus reducing the system energy consumption during the controlling operation. Water temperature control for a hydroponic system is taken as a case study for the RL model, adjusting the variance of disturbances to show the model’s robustness and efficiency. On average, the model showed safety improvement by up to 15% and energy efficiency improvements by 35%- 40% compared to a traditional RL model.

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