Rancang Bangun Sistem Coupled-Tank untuk Pengendalian Ketinggian Air Berbasis Programmable Logic Controller dan Reinforcement Learning dengan Algoritma Twin-Delayed Deep Deterministic Policy Gradient = Design of a Coupled-Tank System for Water Level Control based on Programmable Logic Controller and Reinforcement Learning with Twin-Delayed Deep Deterministic Policy Gradient Algorithm

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Abstrak

Sistem coupled-tank merupakan konfigurasi yang digunakan pada industri dalam hal pengendalian ketinggian air, biasanya dengan metode pengendalian proportional, integral, derivative (PID). Namun, metode lain seperti reinforcement learning (RL) juga bisa diterapkan. Metode RL dapat dikombinasikan dengan programmable logic controller (PLC) yang sering digunakan dalam proses industri. PLC mengontrol ketinggian air dengan membaca data dari water level transmitter dan mengatur bukaan control valve berdasarkan algoritma RL yang sudah dilatih untuk mencapai kontrol optimal. Algoritma RL yang digunakan adalah twin-delayed deep deterministic (TD3) policy gradient. Performa algoritma ini diukur menggunakan parameter seperti overshoot, rise time, settling time, dan steady-state error, lalu dibandingkan dengan pengendali PID konvensional. Hasil simulasi dan pengujian pada hardware menunjukkan bahwa algoritma RL menghasilkan overshoot sebesar 6.59% dan steady-state error sebesar 3.53%, di mana steady-state error ini terjadi karena sensor yang sensitif sehingga data ketinggian air tidak pernah terekam konstan dan stabil. Sebagai perbandingan, pengendali PID memiliki overshoot sekitar 23.38% dan steady-state error terkecil berkisar pada 7.15%, yang berarti pengendali RL sudah memiliki performa yang lebih baik dibandingkan pengendali PID.

.....Coupled-tank system is a configuration commonly used in industry, mainly for water level control with proportional, integral, and derivative (PID) control method. But, other methods like reinforcement learning (RL) can be implemented for this control problem. This RL method can be combined with programmable logic controller (PLC) which is often used in industry process. PLC will control water level by reading data from water level transmitter and controlling a control valve opening according to a trained RL algorithm to gain an optimal control. The RL algorithm used is twin-delayed deep deterministic (TD3) policy gradient. The algorithm’s performance will be measured by parameters such as overshoot, rise time, settling time, and steady-state error, and then compared with the conventional PID control method. According to the results from simulation and from the real hardware, the overshoot value that happens is only in the range of 6.59% with the smallest steady-state error value ranged around 3.53%, which happens due to the sensitive sensor so that water level data never recorded at a constant and stable state. For comparison, the PID control has an overshoot around 23.38% and smallest steady-state error around 7.15%, which means that the RL control method has a better performance than the PID control method.