Perancangan Pengendalian Ketinggian Air pada Coupled-Tank MIMO System Berbasis Reinforcement Learning dengan Algoritma Deep Deterministic Policy Gradient = Design of Water Level Control in Coupled-Tank MIMO System Based on Reinforcement Learning with Deep Deterministic Policy Gradient Algorithm

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Abstrak

Coupled-tank system merupakan salah satu model plant yang umum digunakan dalam industri untuk pengendalian sistem multivariabel. Meskipun metode PID banyak digunakan dalam industri, pendekatan ini memiliki keterbatasan saat diterapkan pada sistem nonlinear seperti coupled-tank MIMO system. Oleh karena itu, metode RL DDPG hadir sebagai pendekatan inovatif untuk sistem kendali. Algoritma DDPG dipilih karena kemampuannya menangani state dan action yang kontinu seperti coupled-tank MIMO system tanpa memerlukan model matematis eksplisit. Perancangan dan pengujian dilakukan menggunakan software MATLAB dan Simulink. Kinerja metode RL DDPG dibandingkan dengan metode PID berdasarkan parameter performa sistem kendali, yaitu overshoot, rise time, settling time, dan steady-state error. Hasil penelitian menunjukkan bahwa metode RL DDPG memberikan performa pengendalian yang lebih baik. Rata-rata overshoot yang dihasilkan adalah 1,48% untuk tangki 1 dan 0,58% untuk tangki 2, jauh lebih rendah dibandingkan metode PID yang mencapai 20,86% dan 21,73%. RL DDPG juga menunjukkan rata-rata settling time yang lebih cepat, yaitu 119,23 detik untuk tangki 1 dan 111,66 detik untuk tangki 2, dibandingkan PID yang mencapai 196,79 detik (tangki 1) dan 177,54 detik (tangki 2). Parameter rise time dan steady-state error juga menunjukkan performa yang baik pada metode RL, masing-masing sebesar 35,64 detik dan 35,18 detik untuk rise time, serta 0,18% dan 0,25% untuk steady-state error. Berdasarkan hasil penelitian ini, metode RL DDPG cukup efektif sebagai solusi alternatif, terutama dalam hal kestabilan sistem.

.....The coupled-tank system is a widely used plant model in industry for multivariable control applications. Although the PID method is commonly applied due to its simplicity and effectiveness, it has limitations when applied to nonlinear systems such as the coupled-tank MIMO system. Therefore, the Reinforcement Learning (RL) method with the Deep Deterministic Policy Gradient (DDPG) algorithm is introduced as an innovative control approach. The DDPG algorithm was chosen for its ability to handle continuous state and action spaces, such as those in the coupled-tank MIMO system, without requiring an explicit mathematical model. The system was designed and tested using MATLAB and Simulink software. The performance of the RL-DDPG method was compared with the PID method based on standard control performance parameters: overshoot, rise time, settling time, and steady-state error. The results show that the RL-DDPG method provided better control performance. The average overshoot was 1.48% for tank 1 and 0.58% for tank 2, significantly lower than the PID method, which reached 20.86% and 21.73%, respectively. The RL-DDPG method also achieved faster average settling times, at 119.23 seconds for tank 1 and 111.66 seconds for tank 2, compared to 196.79 seconds (tank 1) and 177.54 seconds (tank 2) with the PID method. The rise time and steady-state error parameters also indicated strong performance with the RL-DDPG method, at 35.64 and 35.18 seconds for rise time, and 0.18% and 0.25% for steady-state error. Based on these findings, the RL-

DDPG method is considered an effective alternative solution, particularly in terms of system stability.