

ABSTRAK

Menjaga kestabilan kecepatan robot mobil pada lintasan menaik dan menurun sangat penting dalam aplikasi industri yang memerlukan mobilitas andal. Penelitian ini merancang sistem kendali kecepatan robot menggunakan metode *Linear Quadratic Regulator* (LQR) pada kemiringan lintasan 10° , 15° , dan 25° . LQR dipilih karena memiliki performa lebih unggul dibandingkan metode kontrol lain seperti PID dan Fuzzy Logic, terutama dalam menghasilkan waktu respon cepat, tanpa *overshoot*, dan ketahanan terhadap gangguan. Studi sebelumnya menunjukkan bahwa LQR mampu mencapai settling time lebih cepat dan *overshoot* yang lebih kecil dibanding PID, serta tetap stabil saat sistem terpapar *noise*. Pada sistem ini, sensor MPU6050 digunakan untuk mendeteksi sudut kemiringan, dan *rotary encoder* untuk mengukur kecepatan motor secara *real-time*. Matriks pembobot Q dan R disusun untuk menghasilkan gain optimal yang mengatur umpan balik keadaan. Hasil pengujian terbaik menunjukkan bahwa LQR mampu menjaga kecepatan robot mendekati *set point* 0,2 m/s pada lintasan menaik 15° , dengan nilai $Q = [0.5, 0.0, 0.0, 13.0]$, $R = [1.0]$, gain $K = [0.1312 \ 3.4105]$ menghasilkan nilai *rise time* 1,3 detik, *settling time* 8,6 detik, *max overshoot* 30%, dan *error steady state* 2,5%.

Kata Kunci: Kendali Kecepatan, Robot Mobil, LQR, Menanjak, Menurun

ABSTRACT

Maintaining the stability of the speed of a mobile robot on uphill and downhill tracks is very important in industrial applications that require reliable mobility. This study designs a robot speed control system using the Linear Quadratic Regulator (LQR) method on track slopes of 10°, 15°, and 25°. LQR was chosen because it has superior performance compared to other control methods such as PID and Fuzzy Logic, especially in producing fast response times, no overshoot, and robustness to disturbances. Previous studies have shown that LQR is able to achieve faster settling times and smaller overshoots than PID, and remains stable when the system is exposed to noise. In this system, the MPU6050 sensor is used to detect the tilt angle, and the rotary encoder to measure the motor speed in real-time. The Q and R weighting matrices are arranged to produce optimal gains that regulate state feedback. The best test results show that LQR is able to maintain the robot speed close to the set point of 0.2 m/s on a 15° uphill trajectory, with values of $Q = [0.5, 0.0, 0.0, 13.0]$, $R = [1.0]$, gain $K = [0.1312 \ 3.4105]$ resulting in a rise time value of 1.3 seconds, settling time of 8.6 seconds, max overshoot of 30%, and steady state error of 2.5%.

Keywords: Speed Control, Robot Car, LQR, Uphill, Downhill