ANALISIS RESPON DINAMIS KURSI RODA LISTRIK PADA TANJAKAN DENGAN BEBAN VARIATIF MENGGUNAKAN SENSOR INERTIAL DAN KENDALI *PROPORTIONAL INTEGRAL DERIVATIVE*

LAPORAN TUGAS AKHIR

Karya Ilmiah sebagai salah satu syarat untuk menyelesaikan jenjang strata satu (S-1) di Jurusan Teknik Elektro, Fakultas Teknik, Universitas Andalas

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2026

Judul	Analisis Respon Dinamis Kursi Roda Listrik Pada Tanjakan Dengan Beban Variatif Menggunakan Sensor Inertial dan Kendali *Proportional Integral Derivative*	Reivan Arya Witama
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Abstrak

Kursi roda listrik berperan penting dalam mobilitas penyandang disabilitas, namun stabilitasnya dapat terganggu saat melintasi lintasan menanjak akibat pengaruh kemiringan lintasan dan variasi beban pengguna. Penelitian ini bertujuan menganalisis respon kecepatan sudut *pitch* (ω_y) terhadap variasi beban, respon akselerasi longitudinal (α_x) terhadap variasi sudut tanjakan, serta mengevaluasi efektivitas kendali *Proportional-Integral-Derivative* (PID) dalam meredam gangguan tersebut. Penelitian dilakukan secara eksperimental pada kursi roda listrik *differential drive* yang dilengkapi sensor *Inertial Measurement Unit* (IMU) BNO055 untuk mengukur ω_y dan α_x secara *real-time*, serta antarmuka sinyal *Electrooculography* (EOG) sebagai perintah maju dan berhenti. Parameter PID ditentukan melalui metode *trial-and-error* dengan pendekatan *parameter sweep* pada titik operasi beban 50 kg dan sudut 15 derajat, menghasilkan konfigurasi *fixed gain* Kp 2,0, Ki 0,7, Kd 0,05 untuk *loop* ω_y dan Kp 20, Ki 1, Kd 2 untuk *loop* α_x. Pengujian dilakukan pada variasi beban tanpa beban, 40 kg, 50 kg, dan 60 kg untuk ω_y, serta variasi sudut 0°, 5°, dan 15° untuk α_x, dengan indikator *Peak*, RMS, *Rise Time*, *Settling Time*, dan *Steady-State Error*. Hasil menunjukkan *settling time* ω_y berkisar 2,674–3,693 detik, dengan performa terbaik pada beban 50 kg (*Peak* 6,168°/s, RMS 3,939°/s), sedangkan performa α_x terbaik pada sudut 0° dan menurun tidak linier pada sudut 5° dan 15°. Dibandingkan tanpa PID, kendali PID menurunkan *Peak* ω_y 41,0%, RMS ω_y 26,7%, SSE ω_y 87,3%, *Peak* α_x 64,0%, dan RMS α_x 76,5%. Hasil ini menunjukkan kendali PID efektif meningkatkan *disturbance rejection* meskipun performanya belum konsisten pada seluruh variasi beban dan sudut akibat keterbatasan *fixed gain*.

Kata kunci: Kursi roda listrik, kendali PID, IMU BNO055, kecepatan sudut pitch, akselerasi longitudinal.

Title	Dynamic Response Analysis of an Electric Wheelchair on Inclined Paths with Load Variation Using an Inertial Sensor and *Proportional-Integral-Derivative* Control	Reivan Arya Witama
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Abstract

Electric wheelchairs play an important role in the mobility of people with disabilities, yet their stability can be disrupted when traversing inclined paths due to the influence of slope angle and variations in user load. This study aims to analyze the pitch angular velocity (ω_y) response to load variation, the longitudinal acceleration (α_x) response to incline angle variation, and to evaluate the effectiveness of a *Proportional-Integral-Derivative* (PID) controller in suppressing these disturbances. The research was conducted experimentally on a *differential-drive* electric wheelchair equipped with a BNO055 *Inertial Measurement Unit* (IMU) sensor to measure ω_y and α_x in real time, along with an *Electrooculography* (EOG) signal interface serving as forward/stop commands. PID parameters were determined through a *trial-and-error* method using a parameter-sweep approach at an operating point of 50 kg load and a 15-degree incline, yielding fixed-gain configurations of Kp 2.0, Ki 0.7, Kd 0.05 for the ω_y loop and Kp 20, Ki 1, Kd 2 for the α_x loop. Tests were performed under load variations of no load, 40 kg, 50 kg, and 60 kg for ω_y, and incline variations of 0°, 5°, and 15° for α_x, evaluated using Peak, RMS, Rise Time, Settling Time, and Steady-State Error indicators. Results showed ω_y settling time ranging from 2.674–3.693 seconds, with the best performance at 50 kg load (Peak 6.168°/s, RMS 3.939°/s), while α_x performance was best at 0° and declined non-linearly at 5° and 15°. Compared to the no-PID condition, the PID controller reduced ω_y Peak by 41.0%, ω_y RMS by 26.7%, ω_y SSE by 87.3%, α_x Peak by 64.0%, and α_x RMS by 76.5%. These results indicate that the PID controller effectively improves disturbance rejection, although its performance remains inconsistent across all load and angle variations due to the limitations of fixed-gain control.

Keywords: Electric wheelchair, PID control, IMU BNO055, pitch angular velocity, longitudinal acceleration.