

M250005: Design and Implementation of an Enhanced Adaptive Controller

Chih-Hui Chiu^{1*}, Chieh-Min Lin², and Hsin-Yi Huang³

^{1,2}Department of Communications, Navigation and Control Engineering, National Taiwan Ocean University, No.2, Beining Rd., Zhongzheng District, Keelung City, 20224, Taiwan, R.O.C.; chchiu@ntou.edu.tw

³Department of Electronic Engineering, National Muzha Vocational High School, No. 77, Sec. 4, Muzha Rd., Wenshan Dist., Taipei City, Taiwan, R.O.C.

Abstract

Problem: In adaptive control, compensatory controllers can keep increasing control input over time, risking actuator saturation, instability, or failure—especially during long tracking/disturbance periods.

Cause: Unbounded growth of the compensatory term when errors persist, leading to unnecessary control-energy accumulation.

Proposed Solution: An enhanced compensatory controller with a built-in stabilizing mechanism.

Core Mechanism: Embed an attenuation term in the adaptive law so the compensatory input decays as the tracking error shrinks.

Effects: Prevents runaway control escalation; keeps inputs within practical limits.

Benefits: Improves safety, robustness, and stability, maintaining performance under uncertainties and disturbances.

Use Case Focus: Prolonged tracking/disturbance scenarios where conventional compensators tend to drift upward.

Adaptive type-1 fuzzy logic control scheme

The adaptive type-1 fuzzy control scheme with supervisory controller total force is in the following form.

$$u_{AF}(t) = u_{Fuzzy}(t) + u_R(t)$$

u_{Fuzzy} is the type-1 fuzzy control force. And,

$$u_R = E^T E \hat{\xi}(t) \text{sgn}(E^T P B_m)$$

$$\dot{\hat{\xi}}(t) = E^T E \beta \left| (E^T P B_m) \right|$$

Accordingly, the asymptotic convergence of the tracking error to zero is ensured, and the stability of the proposed closed-loop control system is guaranteed.

Simulation Results

The proposed controller will be used to control a two-axis platform with a ducted fan. Simulation results under nonzero initial condition and disturbance.

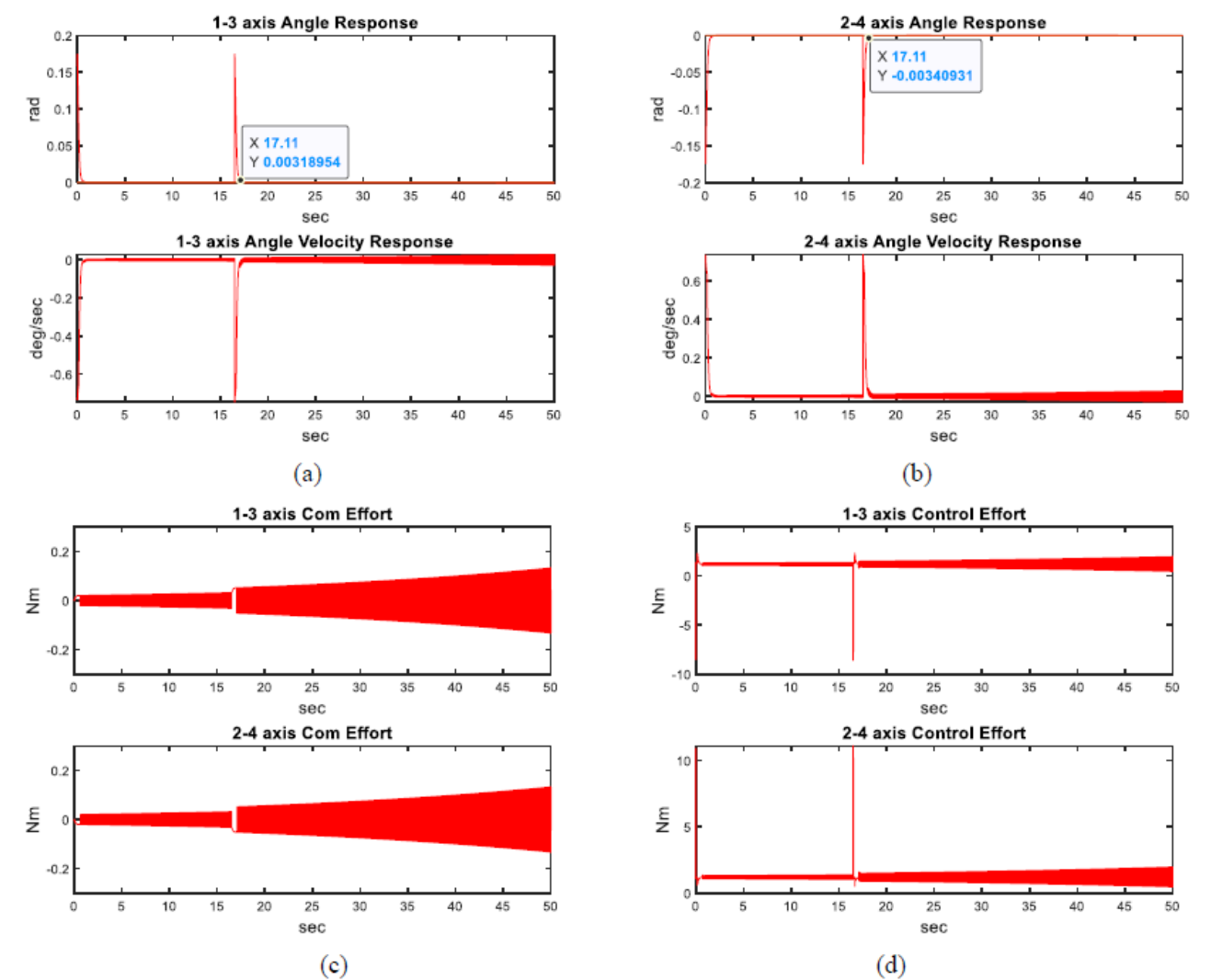


Fig. 4. Simulation results of tracking a zero-degree reference using the fuzzy controller proposed in [16], under nonzero initial conditions and an external disturbance. (a) Angle and angular velocity responses along the 1–3 axis.(b) Angle and angular velocity responses along the 2–4 axis.(c) Compensatory control input.(d) Total control effort.

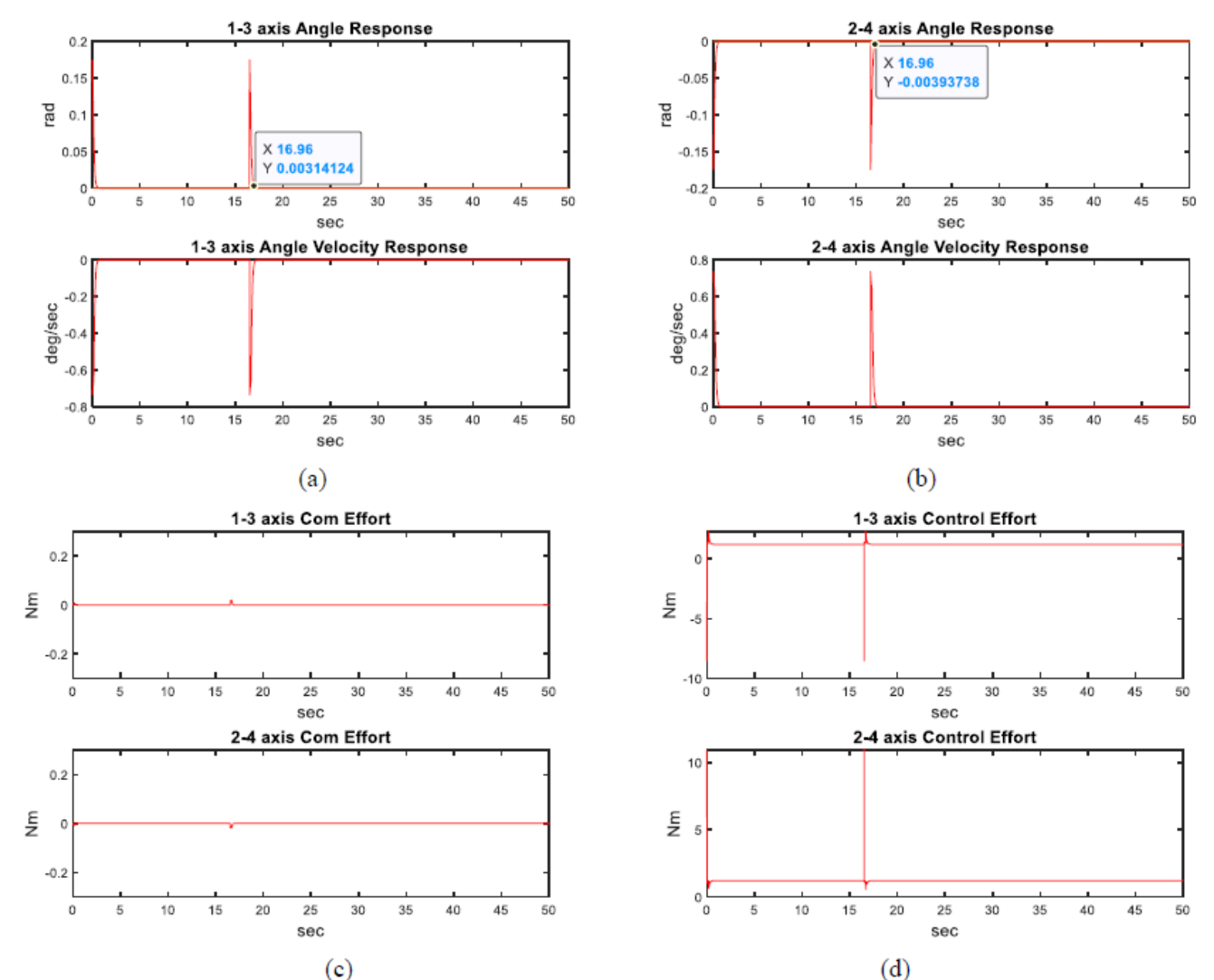


Fig. 5. Simulation results of tracking a zero-degree reference using the enhanced adaptive control scheme proposed in this study, under nonzero initial conditions and an external disturbance. (a) Angle and angular velocity responses along the 1–3 axis.(b) Angle and angular velocity responses along the 2–4 axis.(c) Compensatory control input.(d) Total control effort.

Simulations validate the platform as a safe, versatile testbed for advanced control and introduce a refined method that keeps compensation bounded and preserves long-term stability.