UNIVERSITAS
GADJAH MADA
Sistem Kendali Heading pada Autonomous Underwater Vehicle
Romdlon Musyaffa Akbar, Oskar Natan, S.ST., MTr.T., Ph.D.; Dr. Andi Dharmawan, S.Si., M.Cs.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

SISTEM KENDALI *HEADING* PADA AUTONOMOUS UNDERWATER VEHICLE

Oleh

Romdlon Musyaffa Akbar

22/500294/PA/21548

Heading merupakan variabel penting pada Autonomous Underwater Vehicle (AUV) karena menentukan kemampuan wahana dalam mempertahankan arah hadap selama bergerak di bawah air. Penelitian ini bertujuan mengembangkan sistem kendali *heading* AUV berbasis *Linear Quadratic Regulator* (LQR) untuk mengurangi *miss-heading*. Sistem dirancang menggunakan model *state*-space, *Extended Kalman Filter* (EKF) sebagai *state estimator*, dan *control allocator* untuk mendistribusikan sinyal kendali ke delapan *thruster*. Pengujian dilakukan melalui karakterisasi *thruster*, uji kestabilan stasioner, *heading hold* pada gerak *surge* dan *sway*, serta *step-heading* dari 0° menuju 180°.

Hasil penelitian menunjukkan bahwa model karakteristik gaya dorong tiap *thruster* perlu dibedakan karena hubungan PWM dan gaya dorong tidak identik pada setiap aktuator. Pada pengujian kestabilan stasioner, sistem LQR mampu menjaga kedalaman dan orientasi dasar AUV dalam batas toleransi yang ditetapkan, yaitu ±0,12 meter untuk kedalaman, ±4,5° untuk *roll* dan *pitch*, serta ±9° untuk *yaw*. Pada pengujian *heading hold*, kendali LQR menghasilkan RMSE *heading* sebesar 1,43° pada gerak *surge* dan 1,61° pada gerak *sway*, jauh lebih kecil dibandingkan kendali konvensional sebesar 46,87° dan 46,34°. Pada pengujian *step-heading*, LQR menghasilkan *rise time* sebesar 2,11 detik dan *settling time* sebesar 4,25 detik pada gerak *surge* , serta *rise time* sebesar 1,57 detik dan *settling time* sebesar 8,61 detik pada gerak *sway*. Meskipun *overshoot* pada gerak *sway* mencapai 72,93°, sistem tetap mampu kembali mendekati referensi akhir dengan *steady-state error* sebesar -0,16° ± 2,25° dan RMSE *yaw rate* sebesar 0,50°/detik. Secara keseluruhan, sistem kendali *heading* berbasis LQR lebih efektif dalam mengurangi *miss-heading* dan meredam *yaw rate* dibandingkan kendali konvensional berbasis logika kondisional.

Kata kunci: Autonomous Underwater Vehicle (AUV), *heading*, *miss-heading*, Linear Quadratic Regulator*, Extended Kalman Filter*, *state-space*

UNIVERSITAS
GADJAH MADA
Sistem Kendali Heading pada Autonomous Underwater Vehicle
Romdlon Musyaffa Akbar, Oskar Natan, S.ST., MTr.T., Ph.D.; Dr. Andi Dharmawan, S.Si., M.Cs.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

ABSTRACT

HEADING CONTROL SYSTEM FOR AN AUTONOMOUS UNDERWATER VEHICLE

by

Romdlon Musyaffa Akbar

22/500294/PA/21548

Heading is an important variable in an Autonomous Underwater Vehicle (AUV) because it determines the vehicle's ability to maintain its direction of orientation while moving underwater. This research aims to develop an AUV heading control system based on Linear Quadratic Regulator (LQR) to reduce miss-heading. The system was designed using a state-space model, Extended Kalman Filter (EKF) as the state estimator, and a control allocator to distribute the control signal to eight thrusters. The tests were conducted through thruster characterization, stationary stability testing, heading hold tests during surge and sway motions, and step-heading tests from 0° to 180°.

The results show that the thrust characteristic model of each thruster needs to be differentiated because the PWM-thrust relationship is not identical for each actuator. In the stationary stability test, the LQR system was able to maintain the AUV depth and basic orientation within the specified tolerance limits, namely ±0.12 meter for depth, ±4.5° for roll and pitch, and ±9° for yaw. In the heading hold test, the LQR controller produced RMSE heading values of 1.43° during surge motion and 1.61° during sway motion, which were much lower than the conventional controller values of 46.87° and 46.34°. In the step-heading test, the LQR produced a rise time of 2.11 seconds and a settling time of 4.25 seconds during surge motion, as well as a rise time of 1.57 seconds and a settling time of 8.61 seconds during sway motion. Although the overshoot during sway motion reached 72.93°, the system was still able to return close to the final reference with a steady-state error of -0.16° ± 2.25° and an RMSE yaw rate of 0.50°/second. Overall, the LQR-based heading control system was more effective in reducing miss-heading and damping yaw rate compared with the conventional controller based on conditional logic.

Keywords: *Autonomous Underwater Vehicle (AUV), heading, miss-heading, Linear Quadratic Regulator, Extended Kalman Filter, state-space*