Contents

Abstract

Adaptive algorithms for yacht motion control problem are investigated in this thesis. As a special type of marine vessels, the unique wind-powered mechanism makes yachts more sensitive to the sailing environment disturbances such as wind speed, wind angle and waves. Even the distribution of crew affects a yacht's dynamics. The experience of the helmsman who sets the sails' angles based on personal preferences varies the motion dynamics as well. Due to the highly nonlinear characteristics of a yacht's motion, fixed control strategies are not able to control this motion. This research aims to develop adaptive autopilots algorithms satisfactory for yacht motion and stabilization control problems.

Adaptive self-tuning proportional derivative (PD) and proportional integral derivative (PID) algorithms for yacht autopilots via the linear quadratic regulator (LQR) and the $\mathcal{H}_\infty$ criteria are studied in the thesis. By making the yacht autopilots have the same behaviors of the desired specifications of a 2^{nd} or 3^{rd} order systems which are characterized by the natural frequency ω_0 and the damping rate ξ, the time-consuming tuning procedure for weights in matrices Q and R, and for the norm γ can be omitted. The consequence of this is that the developed adaptive self-tuning PD/PID autopilots can be implemented online.

The adaptive yacht rudder roll damping control problem is investigated first in this thesis. Adaptive LQR steering control, adaptive LQR rudder roll damping control with a PD steering controller, and adaptive LQR steering and rudder roll damping controller are developed. The simulations show that the rolling reduction in the case of adaptive LQR roll damping plus PD steering controller performs better than LQR steering and roll damping autopilots.

The concept of full-adaptive LQR control, that is, the weights of Q and R matrices are tuned online with respect to the variation of a yacht's parameters. A genetic algorithm (GA) is used to tune these weighting matrices online. The proposed GA based LQR autopilot is applied on both the ship "Sea Scott" and a 12-meter America's Cup Racing yacht. Simulation results prove that the developed GA based adaptive LQR autopilot gives a better performance than its counterpart with fixed weighting matrices.

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Key Words: Autopilot, Stabilization, Rudder-Roll Damping, Yacht Hydrodynamics, Modelling, Adaptive PID, LQR, $\mathcal{H}_\infty$, GAs, Full-Adaptive LQR Control

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