Exponentially Stable Underactuated Dynamic Positioning of Marine Vehicle

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Abstract

Dynamic positioning is mostly limited to fully actuated vessels. However many vessels, especially small ones, are underactuated with only two control inputs (throttle and rudder angle). We present an exponentially stable control system for dynamic positioning of an underactuated marine vehicle. A state feedback controller, such as a linear quadratic regulator (LQR), controls the heading of the vehicle and the longitudinal error relative to the desired position. For certain initial conditions the final transverse error will also be zero. These initial conditions form a manifold in the state space. A separate manifold convergence controller drives the vehicle states toward this manifold. Both controllers converge when the vehicle is at the desired position and orientation. Convergence of the state feedback controller within a large calculable region of the state space is proven using contraction analysis. The performance of the control system is demonstrated with simulations and with experiments using a 3.71-meter autonomous surface vessel.

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