Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

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B.A. (Reed College, 2002)

“Characterization and Control of a Saab Seaeye Thruster”

Department of Mechanical Engineering

Wed, April 8, 2015
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Engineering & Computer Science Building
468

Supervisory Committee:
Dr. Bradley Buckman, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Colin Bradley, Department of Mechanical Engineering, UVic (Co-Supervisor)

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Abstract

The use of Remotely Operated Vehicles (ROVs) in exploring and building infrastructure in the ocean is expanding. ROVs are performing tasks underwater that would be difficult or impossible to do with human divers. These vehicles are being used in increasingly complicated and demanding environments that require improvements in the methods for controlling these vehicles. Currently, research into semi-autonomous control is being conducted to aide ROV pilots in compensating for environmental disturbances and unknown dynamics. To effectively implement semi-autonomous control, precise thrust forces must be elicited from the thrusters. This work discusses a low-level thruster controller that can be used as part of a semiautonomous guidance, navigation and control system for a ROV. A thruster dynamics model describing the thrust force of a propeller-type underwater thruster was derived and implemented for the thruster on the Saab Seaeye Falcon ROV. The thruster dynamics model described is a quadratic equation that uses the propeller velocity to determine thrust force. This model includes a mechanism for compensation against the external motion of the thruster, such as occurs when the ROV moves through the water. Several experiments were performed to fully characterize the quadratic thruster dynamics model and test its ability to accurately predict thrust force based on a known ambient water velocity and propeller angular velocity. The drag force was calculated and removed from the force measurements to get the thrust force used in the model. The model coefficients were determined and then the resulting model was tested against experimental data to determine the efficacy of the model in the lab environment and compare it to a widely used linear thruster dynamics model. The results showed the quadratic model improved upon the linear model, and the quadratic model was valid over a larger range of ambient water velocities. The quadratic model was then inverted to provide a thruster control algorithm that determines the propeller angular velocity necessary to produce a desired thrust force. This algorithm was used to design a low-level thruster controller. This controller was designed to be used on an existing vehicle where thrust force feedback is not available and difficult or expensive to add. This allows it to be used in a wider range of applications than controllers that rely on such feedback to operate. The controller was implemented using a PID control loop to drive the angular velocity of the propeller to the desired rate. An iso-parametric mapping, which transforms the linear PID output to the non-linear thruster input, was added to provide a faster response time for the controller over the entire range of the propeller velocity. The performance of this low-level thruster controller was demonstrated in the test environment. The low-level thruster controller followed a desired thrust force under a range of ambient water velocities. The thruster characterization and low-level thruster controller was designed to be used on an existing ROV. The motivation behind this work is to build a controller that may be implemented for use by a high-level vehicle controller. The low-level thruster controller presented here does not depend on sensors or equipment that is largely unavailable on vehicles without costly retrofits, and the experimental characterization does not require intimate knowledge of the inner workings of the thruster. This makes it easy to implement and generalize to a variety of thrusters. The results of this work show a low-level thruster controller than can be used in a control schema for existing ROVs.