Abstract

Autonomous underwater vehicles (AUVs) have undergone significant advancements in vehicle design, actuators, and control strategies over the past decades. This thesis investigates modelling aspects and control strategies for two classes of AUVs: axisymmetric thruster-driven AUVs (ATD-AUVs) and fin-controlled non-body-of-revolution AUVs (NBR-AUVs). Central to this work is the development of detailed mathematical models for both ATD-AUV and NBR-AUV, including actuator force models, which are used for numerical simulation studies and control system design. The ATD-AUV considered in this thesis features a simple geometry with a cylindrical hull, a hemispherical nose, and a tapered tail section. The NBR-AUV has a fish-like shape inspired by the morphology of an Asian sea bass. The NBR-AUV is driven by an oscillating propulsion fin and is manoeuvred using multiple auxiliary fins. A systematic identification of model parameters is carried out for the ATD-AUV, which includes rigid-body parameters, hydrodynamic coefficients, and a four-quadrant propulsion model for thrusters. The identification process involves a combination of direct measurements, CAD-based analysis, empirical formulations, computational fluid dynamics (CFD) simulations, and experimental model testing. Model parameters for the NBR-AUV are also discussed. A robust control system based on the Uncertainty and Disturbance Estimation (UDE) framework is developed for the motion control of the ATD-AUV. Numerical simulation and experimental studies were conducted on actual ATD-AUV to validate the proposed UDE-based control strategy, and the results for depth and yaw control are presented and discussed. The open-loop dynamic behaviour of the NBR-AUV is examined for different oscillating frequencies of the main propulsion fin. The study is followed by an evaluation of the PID- and UDE-based control schemes, developed for the vehicle's pitch and yaw control. The effectiveness of the control strategies is demonstrated through numerical simulations using the NBR-AUV dynamic model. Finally, the conclusions of the study and its future scope are discussed.