Abstract

Autonomous Underwater Vehicles (AUVs) are becoming increasingly popular tools for undersea intervention. A number of technological advancements have been made during the last twenty years motivated by commercial needs and scientific curiosity. The development of AUVs continues to present a number of challenges. The dynamic behavior of underwater vehicles is highly nonlinear, coupled, and uncertain. Underwater navigational sensors can only provide data at a very low rate. These difficulties make efficient control a high priority task for high quality surveys. Limitations on the efficiency and capacity of power sources is another bottleneck in the development of long range AUVs.

In order to reduce the energy consumption of AUVs, thereby increasing their range/duration of operation, energy optimal control problem is studied in this thesis with an intention to determine approximate analytical solutions for a class of AUVs. This is useful for generating suboptimal trajectories on-the-fly. A relationship has been derived showing that energy consumption can be reduced for the case of forward propulsion by increasing the number of thrusters up to a certain extent. A novel controller based on simultaneous quadratic stabilization has been developed for AUVs. This controller is extended to include adaptation in order to handle uncertainty in AUV dynamics. Time delay control is another promising control technique in the robust control area which does not require the exact model of the plant. Recognizing its relevance to AUVs, a time delay control law is derived for AUVs and validated through simulations. A discrete-time version of this controller is also developed for implementation in hardware. In order to validate the controller developed in this thesis, a test-bed AUV with an open architecture is designed and developed. Several experiments are conducted for validating the discrete-time delay controller and the results for depth, pitch, yaw control are reported and discussed. To meet the future need for high speed and energy efficient AUVs which have slender body, a study is carried out on critical velocities of instabilities for AUVs modeled as slender free-free beams subjected to hydrodynamic forces and follower forces.

With the above mentioned set of studies, this thesis attempts to contribute some further insights into the problems addressed.