Safety-critical Receding-horizon Motion Planning and Containment Control of Autonomous Surface Vehicles via Neurodynamic Optimization

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***Abstract*—This paper addresses the safety-certified motion planning and containment control of under-actuated autonomous surface vehicles subject to model uncertainties, external disturbances, and input constraints in the presence of stationary and moving obstacles. A three-level modular control architecture is proposed with a trajectory generation module at its planning level, an adaptive guidance module at its guidance level, and a kinetic control module at its control level. Specifically, at the planning level, a safety-certified containment trajectory generator is designed to generate safe trajectories over a rolling time window to achieve containment formation and collision avoidance with neighboring ASVs, stationary obstacles, and moving obstacles via dynamic control barrier functions and two-timescale neurodynamic optimization models. At the guidance level, an adaptive line-of-sight guidance law is developed based on a finite-time predictor to estimate unknown sideslip angles and generate guidance commands. At the control level, an optimal control law is designed based on finite-time neural predictors and control Lyapunov functions for the autonomous surface vehicle with input constraints to follow the desired guidance commands. The effectiveness and characteristics of the proposed method are demonstrated via simulations and hardware-in-the-loop experiments for cooperative exploration.**

***Index Terms*—Autonomous surface vehicles, safety-certified motion planning, containment control, dynamic control barrier function, two-timescale neurodynamic optimization model.**