MSEAS Seminar Series

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Wingsail Design Methodology and Performance Evaluation Metrics for Autonomous Sailing

Abstract: This dissertation explores an innovative approach to the design of aerodynamically-actuated wingsails, along with advancements in marine vehicle autonomy focused on vessel tracking and collision avoidance. The first segment of this research introduces a deterministic wingsail design optimization framework that leverages geometric programming to efficiently generate optimal wingsail designs. The proposed methodology is then validated through the development and deployment of a novel data acquisition system called the WingDAQ, which enables quantitative analysis of the unsteady forces affecting wingsail performance in realistic sailing conditions. The results highlight the limitations of traditional aerodynamic models due to unsteady flow conditions, and suggest that wingsails designed with higher lift-over-drag ratios and faster natural frequencies enhance sailing performance. This thesis also introduces a novel formulation of the unscented Kalman filter (UKF) that is particularly well suited to long-distance surface vessel tracking, and facilitates affordable collision avoidance capabilities on autonomous surface vessels. One such low-cost collision avoidance system is presented, utilizing real-time data from the Automatic Information System (AIS) and the behavior-based autonomy middleware, MOOS-IvP. Field tests confirm the robustness of this framework, establishing a foundation for the integration of physics-based design optimization and adaptive autonomy for wind-powered marine vehicles.

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