Abstract

"Robotic GFD: collaborative tracking and control in time-dependent and stochastic flows"

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Monitoring of the ocean depends on a wide variety of autonomous underwater vehicles (AUVs) and autonomous surface vehicles (ASVs), in other words: robots. Optimal control of an ocean robot requires knowledge of flow properties, so we begin by examining a time-dependent and stochastic multi-gyre flow as a model of a wind-driven ocean. Phase space of the model shows stochastic switching between basins of attraction. The first problem I will discuss is how to keep a robot parked within a particular gyre. Combining uncertainty measures, almost invariant sets (AIS) and finite time Lyapunov exponent (FTLE) ridges allows a simple set-based corral control scheme to be designed, which optimally inhibits escape events by exponentially increasing the loitering time within a gyre.

Real robots do not usually have global flow knowledge. Instead they rely on locally sensed data, possibly sharing information with a local team or a wider network of agents. The second problem I will discuss is the design of a collaborative robotic control strategy to track stable and unstable manifolds, done in a collaboration led by Ani Hsieh of the Scalable Autonomous Systems (SAS) lab at Drexel. The control technique is based on local sensing, prediction, and correction and is implemented on a team of three robots to track coherent flow features on steady and time-dependent model flows, noisy experimental flow data and actual ocean data. I will wrap up with a description of the work now in progress, mostly in the lab, to extend these methods to a wider range of flows.