Path Planning for Environmental Monitoring with AUVs
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Introduction: AUVs for Environmental Monitoring

AUV Capabilities
- Can measure temperature and salinity
  Collected by a CTD on the AUV
- Little or no communication while underwater
  Must be fairly autonomous
- May be not be much faster than the current
  Must take currents into account when planning a path

Goals
- Plan a path for the AUV that will allow it to collect useful data.
  “Usefulness” of data can be quantified in various ways. We typically try to reduce the expected error in some model.
- Allow for some constraints on the path (time required, for instance)
- Take into account data collected by buoys and other vehicles
  Don’t want to waste resources collecting the same data twice, when we could be taking readings in other areas.

Problem Description: Plan the Path to Collect “Best” Sensor Data

Path Planning on a Discrete Graph
- Discretize the area of interest into a set of waypoints.
- Add edges between nearby waypoints, in order to represent possible paths for the AUV.
- A path for the glider corresponds to a sequence of waypoints \( P = [v_1, v_2, \ldots, v_k] \) that the glider will visit.
- Function \( h(P) \) which takes a path and returns the set of locations at which sensor measurements will be taken.
- Function \( f(h(P)) \) which takes the set of measurements location and returns a real number corresponding to how “useful” the measurements are expected to be.

Proposed Solution: Use Discrete Planning Algorithms and Gaussian Process Models

Correlation of temperature data over spatial locations, shown at 6 hour intervals. The points are spatially spread out over the yellow region in the middle figure. Correlation values were calculated using 80 days of historical data from an ocean model.

Waypoint graph: large circles are waypoints, and small circles are additional measurements taken as the glider moves.

Experiment area near Catalina Island. This area was chosen because of relatively low boat traffic. The correlation plots to the left are for points distributed over this region, as shown in the waypoint graph on the right.

Path planned by our algorithm. The path is colored to show time; blue is at time \( t=0 \) and dark red is for \( t=48 \) hours.

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