Abstract

- Objective: Configuration of multiple mobile sensors to explore an unknown region, where the exploration trades off between two desiderata:
  - To continue taking data in a region known to be interesting with the intent of refining the measurements versus
  - Taking data in unobserved areas to attempt to discover new interesting regions

- Proposed Framework:
  - Prediction stage: Predicts the behavior of phenomenon of interest (PoI) at unseen locations
  - Decision maker stage: Deciding on the next trajectory of sensors

Background on Gaussian Processes (GPs)

- Gaussian process (GP) modeling
- Assumption: The PoI can be evaluated via an unknown function \( f(\cdot) \)
- GP is a non-parametric model
- Core idea: Any observation is an outcome of a Gaussian random variable
- All of these random variables are jointly Gaussian

Gaussian Process Regression (GPR)

- Suppose we have access to a set of \( N \) noisy observations \( y = f(U) + \varepsilon \sim \mathcal{N}(0, \Sigma(\varepsilon)) \)
- Goal: Prediction of \( f \) evaluated at some other input data set \( U = [u_1, ..., u_M]^T \)

\[ \| \mu_x - \mu_y \|^2 = k(U, U) + \lambda^2 \| \gamma - \mu_y \|^2 \]

\[ \Sigma_x = k(U, U) - k(U, U)k(U, U)^T k(U, U) \]

Simulation Results

- An example showing the satellites orbits and the region of under study
- From left to right: Initial measurement, measure of variance, and reconstruction of PoI

- Results using the initial and the first two determined trajectories for case (1) i.e., when \( \lambda = 0.25 \)
- Results after 13 determined trajectories for case (1) i.e., when \( \lambda = 0.25 \)
- Results after 13 determined trajectories for case (2) i.e., when \( \lambda = 2 \)
- Results after 13 determined trajectories for case (3)
- Results after 13 determined trajectories for case (4)

Future Work

- Sensor array configuration via the feasible trajectories and orbit assignment via \( \Delta V \)-budget
  - Assumption: There is a dictionary of possible trajectories generated via Keplerian orbital elements
  - Compute the required \( \Delta V \) for the orbit transfer for all the satellites in the constellation
  - Find the one which requires minimum \( \Delta V \) to transfer to the target orbit
  - Example: The decision making on the orbits here is only based on the exploration desire

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