Deferred Decision Trajectory Optimization

Purnanand Elango, Selahattin Burak Sarsılmaz and Behçet Açıkmeşe

Autonomous Control Laboratory, University of Washington, Seattle

### Deferred Decision for Robust Mission Planning

- Deferred decision trajectory optimization (DDTO) is a deterministic framework for ensuring robustness to uncertainties by generating trajectories that keep multiple candidate targets accessible for as long as possible while also respecting constraints due to fuel consumption or control effort.
- In many practical scenarios, the vehicle might lack complete information about its environment. So, it is desirable to defer decision to choose a target until more reliable information about the environment is acquired.

### Multi-target Trajectory Optimization

A branch point is the farthest state (in time) until which all candidate targets are accessible.

### Delay Branch Point by Quasiconvex Optimization

Given $n$ targets, the problem of delaying a branch point for as long as possible is a quasiconvex optimization problem which can be solved via bisection search.

**Problem:**

$$\text{minimize} \quad t \in \mathbb{R}^n$$

subject to

$$u_j \in U, \quad j = 1, 2, \ldots, n$$

$$x(t) \in \mathbb{R}^n$$

**Solution:**

Maximize quasiconvex function:

$$g(U^t, U^j) = \max \{ t \mid x_j^t = x_j^j, \quad j = 1, \ldots, l \}$$

### Sparse Minimization

- The problem of deferring the branch point associated with trajectories to two targets is equivalent to the problem of minimizing the $l_1$ norm of the difference between the states of the two trajectories at each time instant.
- For the $n$-target case this connection is slightly weaker. Generating a hierarchy of branch points for subset of targets is similar to minimizing the $l_1$ norm of the difference between states of any two trajectories.

**Problem:**

$$\text{minimize} \quad \sum_{i=1}^{l} ||x_i - x_i'||$$

subject to

$$x_i' \in \mathbb{R}^n, \quad u_i' \in U, \quad \tau \in T$$

**Solution:**

### Polytopic DDTO Algorithm

- Deferring decision for robust mission planning.
- Defer decision to choose a target as long as possible is a problem of delaying a branch point for a shrinking set of targets.

### References