Course › Week 9 › Proble... › Model ...

Model Predictive Control

Model Predictive Control, Part 1

0.0/10.0 points (graded)

Given a discrete linear system, corresponding to a discretization of a second order system,

$$x[k+1] = \begin{bmatrix} 1 & 0 & .1 & 0 \\ 0 & 1 & 0 & .1 \\ 2 & -2 & 1.2 & 0 \\ 0 & 1.5 & -1 & .7 \end{bmatrix} x[k] + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 1 & -2 \\ 0 & 1 \end{bmatrix} u[k]$$

Write a quadratic program (QP) to do model predictive control. From an initial state $x[0] = x_0$, find a sequence of inputs that minimizes the cost function: *[Math Processing Error]*

$$\sum_{k=1}^{N} ||u[k-1]||^2 + .01||x[k]||^2$$

such that the state is driven to the origin, $x[N] = 0^{4\times1}$. Please use the QP format given--note that your solution will be graded on correctness of the control sequence. Ensure that the matrix "u" in your solution is $2 \times N$, where $u[k]$=u(:,k+1). You may implement this as a shooting or transcription type approach.

To avoid confusion, write the QP in the same format as MATLAB's quadprog:

$$\begin{aligned} \min .5z^T Hz + f^T z \\ \text{s.t.} Az \leq b \\ Bz = c \end{aligned}$$

```
        % PROBLEM SETUP, DO NOT CHANGE
        A_sys = [1 0 .1 0;0 1 0 .1; 2 -2 1.2 0; 0 1.5 -1 .7];
        B_sys = [0 0;0 0;1 -2;0 1];
```

```
        N = 10;
        x0 = 10*randn(4,1);

        % QP SETUP HERE
        H =
        f =
        A =
        b =
        B =
        c =

        % SOLVE QP
```

Unanswered

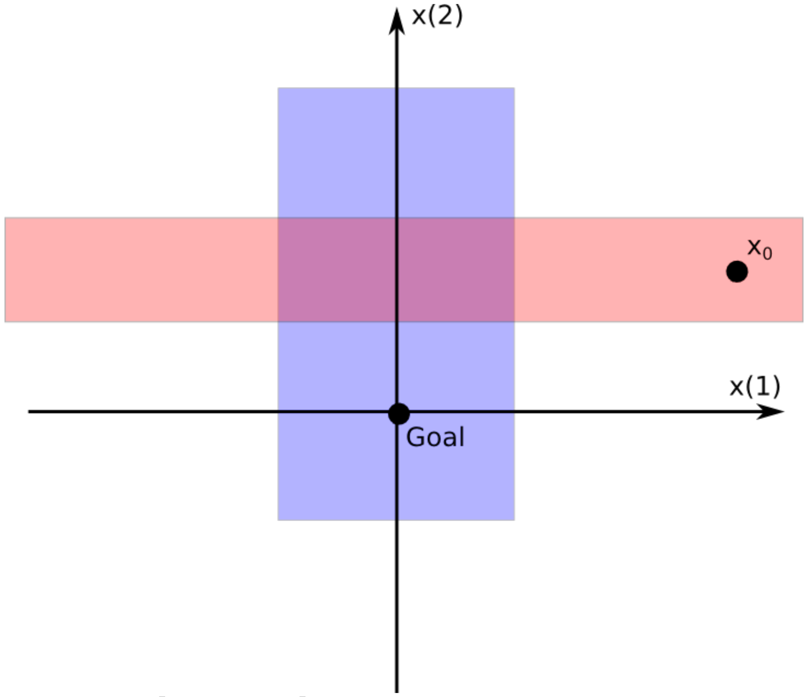
Run Code

Submit You have used 0 of 3 attempts

Model Predictive Control, Part 2

0.0/10.0 points (graded)

Let's make the previous problem a a little more interesting. Suppose now that we have to stay inside a pair of intersecting corridors. In particular, for all $x[k]$, we must have $x(2) \in [2,4]$ **OR** $x(1) \in [-2,2]$, referring to the second and first element of the vector x respectively. Note, we are only enforcing this constraint at the discrete points, not between them!



For $x_0 = [5; 3; 0; 0]$, modify the previous program so that the first condition above holds for $k = 1, \ldots, m$ and the second condition holds for $k = m, \ldots, N$. Note the overlap on index m! Run your program for all possible values of m, and select the optimal u, as in Part 1, and the optimal point m^*.

Note that the program may not always be feasible! Be sure to check the solutions for feasibility.

```
        % PROBLEM SETUP, DO NOT CHANGE
        A_sys = [1 0 .1 0;0 1 0 .1; 2 -2 1.2 0; 0 1.5 -1 .7];
            B_sys = [0 0;0 0;1 -2;0 1];
            N = 10;
            x0 = [5;3;0;0];

        m_star =
        u =

```

Unanswered

Run Code

Submit You have used 0 of 3 attempts

Model Predictive Control, Part 3

0.0/7.0 points (graded)

For the QP from **Part 1**, which of the following statements are true?

- [ ] The program is guaranteed to return a control sequence $\boldsymbol{u}[k]$.
- [ ] The program has a unique optimal control sequence $\boldsymbol{u}[k]$.
- [ ] The first control element, $\boldsymbol{u}[0]$ is *continuous* with respect to the initial state $\boldsymbol{x}[0]$.

Submit You have used 0 of 1 attempt