Model Predictive Control using MATLAB
7: NMPC - Simulation results

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Overview

1. NMPC: Algorithm

2. NMPC: Simple Pendulum

NMPC: Algorithm

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Algorithm 1 : NMPC

1: Require $\mathbf{f}, N_T, N, n, m, \mathbf{Q}, \mathbf{R}, \mathbf{Q}_{N_T}, \mathbf{F_x}, \mathbf{g_x}, \mathbf{F_u}, \mathbf{g_u}$
2: Initialize $\mathbf{x}_0, \mathbf{z}_0$
3: Construct $\mathbf{Q}_X, \mathbf{R_U}, \mathbf{H}, \mathbf{F}, \mathbf{g}$
4: **for** $k = 0$ *to* $N_T - 1$ **do**
5: $\quad \mathbf{x}_k = [\mathbf{X}]_{k+1}$ (obtain $\mathbf{x}_k$ from measurement/estimation)
6: $\quad$ Compute $\mathbf{z}^* = \begin{bmatrix} \mathbf{X}_k^* \\ \mathbf{U}_k^* \end{bmatrix}$ by solving the optimization problem
7: $\quad$ Apply $\mathbf{u}_k = [\mathbf{U}_k^*]_1$ to the system
8: $\quad$ Update $\mathbf{z}_0 = \mathbf{z}^*$
9: **end for**

- MATLAB function for solving the constrained optimization problem

$$\mathbf{z}^* = \text{fmincon}(f, \mathbf{z}_0, \mathbf{F}, \mathbf{g}, \mathbf{lb}, \mathbf{ub}, \mathbf{f}_{eq}) \tag{1}$$

NMPC: Simple Pendulum

Simple pendulum system

- State equation

$$\mathbf{x}_{k+1} = \mathbf{f}(\mathbf{x}_k, \mathbf{u}_k) = \begin{bmatrix} x_{1_k} + T x_{2_k} \\ x_{2_k} + T\left(-\frac{g}{l} sin(x_{1_k}) - \frac{B}{Ml^2} x_{2_k} + \frac{1}{Ml^2} u_k \right) \end{bmatrix} \quad (2)$$

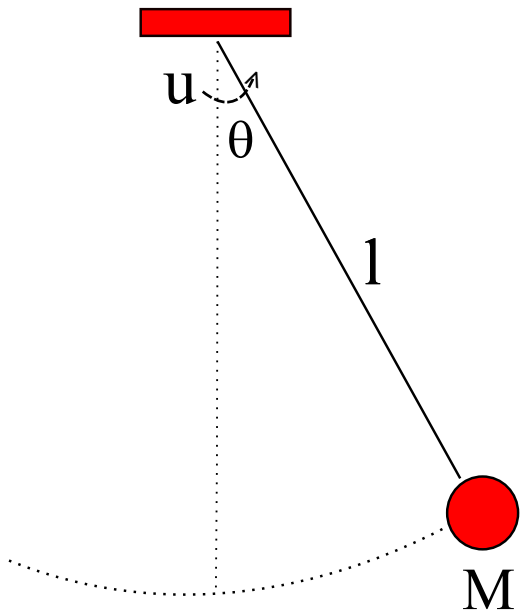

Figure 1: Simple pendulum

NMPC: Simulation results

- System parameters

$$M = 1, l = 1, B = 3, g = 9.8, T = 0.1 \tag{3}$$

- Simulation parameters

$$N_T = 50, N = 5, \mathbf{Q} = \mathbf{I}_2, \mathbf{R} = 1, \mathbf{x}_0 = \begin{bmatrix} 2 \\ 1 \end{bmatrix} \tag{4}$$

- Constraint set parameters

$$\mathbf{F_x} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 0 \\ 0 & -1 \end{bmatrix} \quad \mathbf{g_x} = \begin{bmatrix} 5 \\ 5 \\ 5 \\ 5 \end{bmatrix} \quad \mathbf{F_u} = \begin{bmatrix} 1 \\ -1 \end{bmatrix} \quad \mathbf{g_u} = \begin{bmatrix} 0.1 \\ 0 \end{bmatrix} \tag{5}$$

NMPC: Simple pendulum system

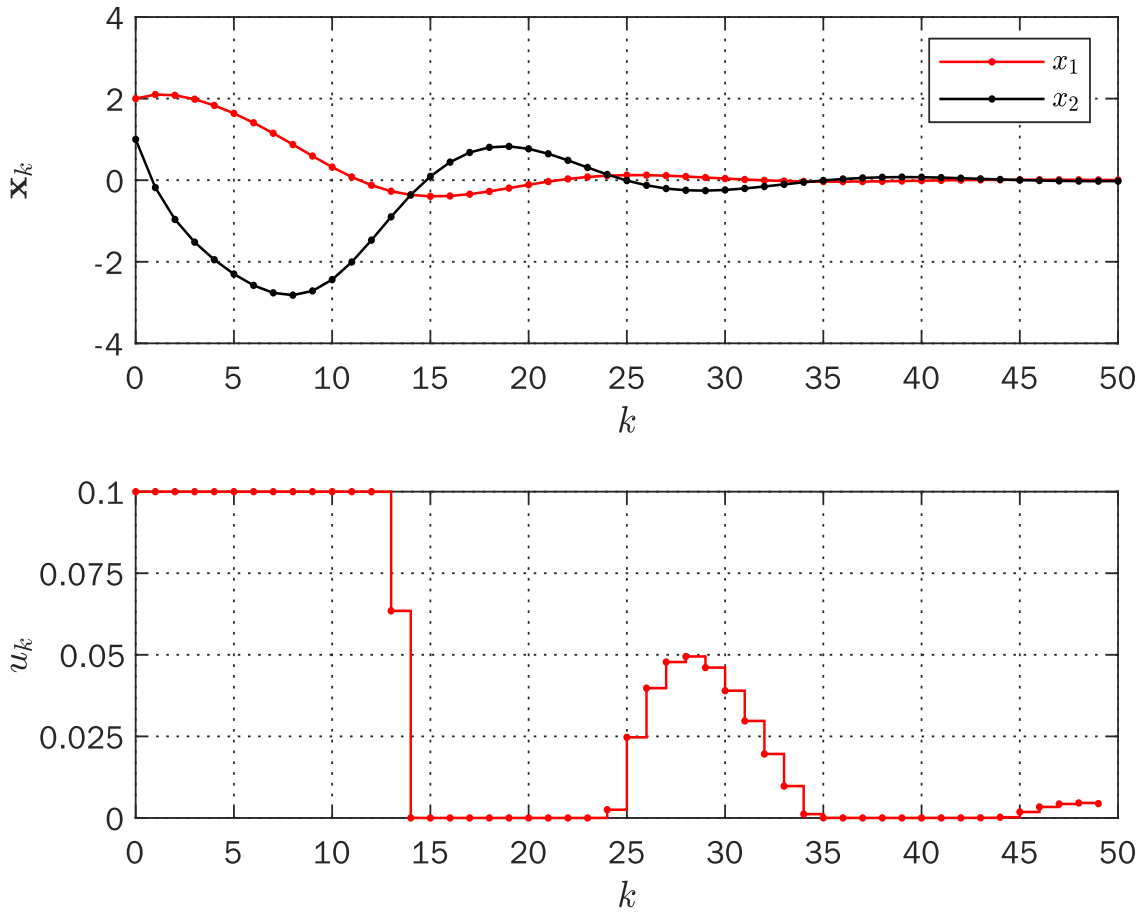

Figure 2: Simple pendulum: stabilization

Thank you