Model Predictive Control using MATLAB
3: LMPC - Simulation results

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Overview

1. LMPC: Single input system

2. LMPC: Multi-input system

LMPC: Single input system

LMPC: Algorithm

Algorithm 1 : LMPC

1: Require $\mathbf{A}, \mathbf{B}, N_T, N, n, m, \mathbf{Q}, \mathbf{R}, \mathbf{Q}_{N_T}, \mathbf{F_x}, \mathbf{g_x}, \mathbf{F_u}, \mathbf{g_u}$
2: Initialize $\mathbf{x}_0, \mathbf{z}_0$
3: Construct $\mathbf{A_X}, \mathbf{B_U}, \mathbf{Q}_X, \mathbf{R_U}, \mathbf{H}, \mathbf{F}, \mathbf{g}$
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 $\mathbf{F}_{eq}, \mathbf{g}_{eq}$
7: $\quad$ Compute $\mathbf{z}^* = \begin{bmatrix} \mathbf{X}_k^* \\ \mathbf{U}_k^* \end{bmatrix}$ by solving the optimization problem.
8: $\quad$ Apply $\mathbf{u}_k = [\mathbf{U}_k^*]_1$ to the system.
9: $\quad$ Update $\mathbf{z}_0 = \mathbf{z}^*$
10: **end for**

- MATLAB function for solving the constrained optimization problem

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

LMPC: Single input system

- System parameters

$$\mathbf{A} = \begin{bmatrix} 0.5 & 0 \\ -1 & 1.5 \end{bmatrix} \qquad \mathbf{B} = \begin{bmatrix} 0.5 \\ 0.1 \end{bmatrix} \tag{2}$$

- Simulation parameters

$$N_T = 50, N = 5, \mathbf{Q} = \mathbf{I}_2, \mathbf{R} = 1, \mathbf{x}_0 = \begin{bmatrix} 10 \\ 5 \end{bmatrix} \tag{3}$$

- Constraint set parameters

$$\mathbf{F_x} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 0 \\ 0 & -1 \end{bmatrix} \quad \mathbf{g_x} = \begin{bmatrix} 10 \\ 10 \\ 10 \\ 10 \end{bmatrix} \quad \mathbf{F_u} = \begin{bmatrix} 1 \\ -1 \end{bmatrix} \quad \mathbf{g_u} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \tag{4}$$

LMPC: Single input system

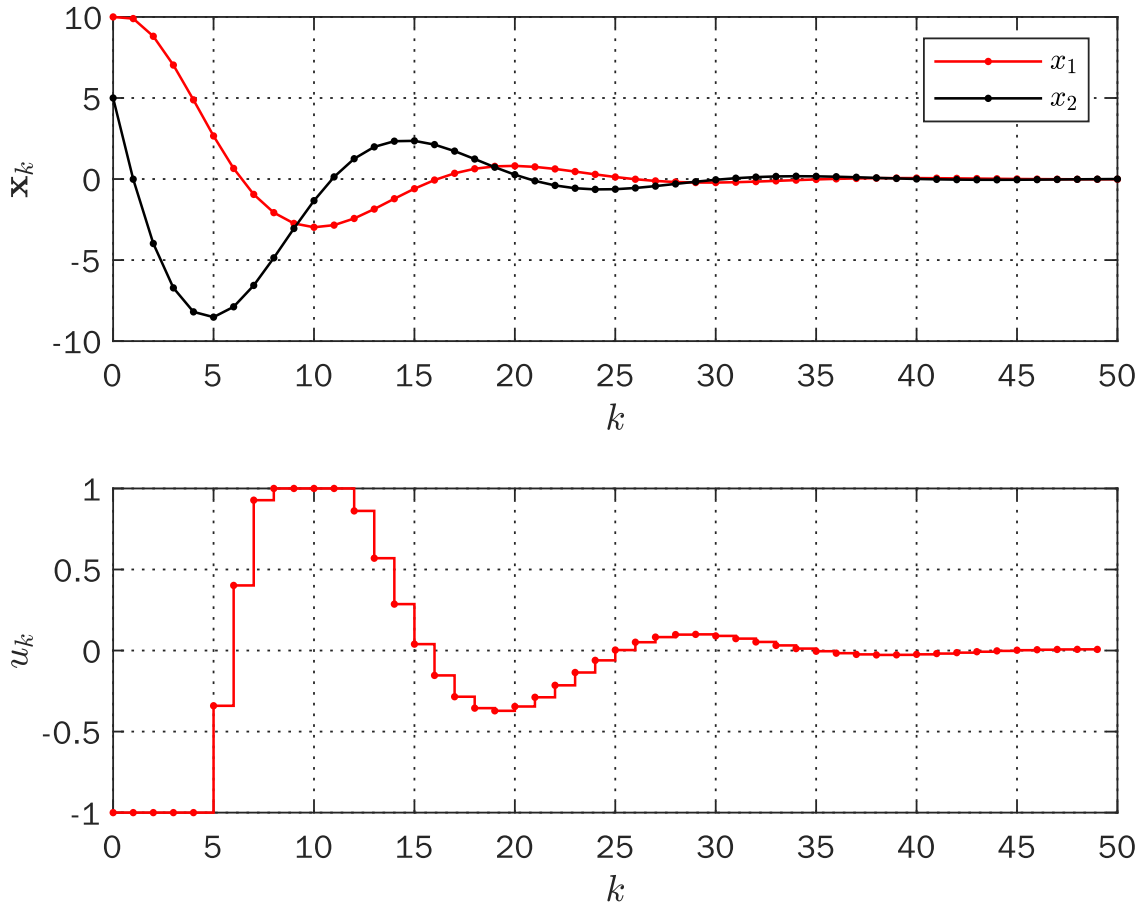

Figure 1: LMPC: Single input system

LMPC: Multi input system

LMPC: Multi input system

- System parameters

$$\mathbf{A} = \begin{bmatrix} 0.9 & 0.2 & 0.1 \\ -0.4 & .8 & 0.1 \\ 0.3 & 0.2 & 0.5 \end{bmatrix} \qquad \mathbf{B} = \begin{bmatrix} 0.1 & 0 \\ 0.2 & 0 \\ 0 & 0.1 \end{bmatrix} \tag{5}$$

- Simulation parameters

$$N_T = 50, N = 5, \mathbf{Q} = \mathbf{I}_3, \mathbf{R} = \mathbf{I}_2, \mathbf{x}_0 = \begin{bmatrix} 10 \\ 5 \\ 2 \end{bmatrix} \tag{6}$$

- Constraint set parameters

$$\mathbf{F_x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \quad \mathbf{g_x} = \begin{bmatrix} 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \end{bmatrix} \quad \mathbf{F_u} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 0 \\ 0 & -1 \end{bmatrix} \quad \mathbf{g_u} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \tag{7}$$

LMPC: Multi input system

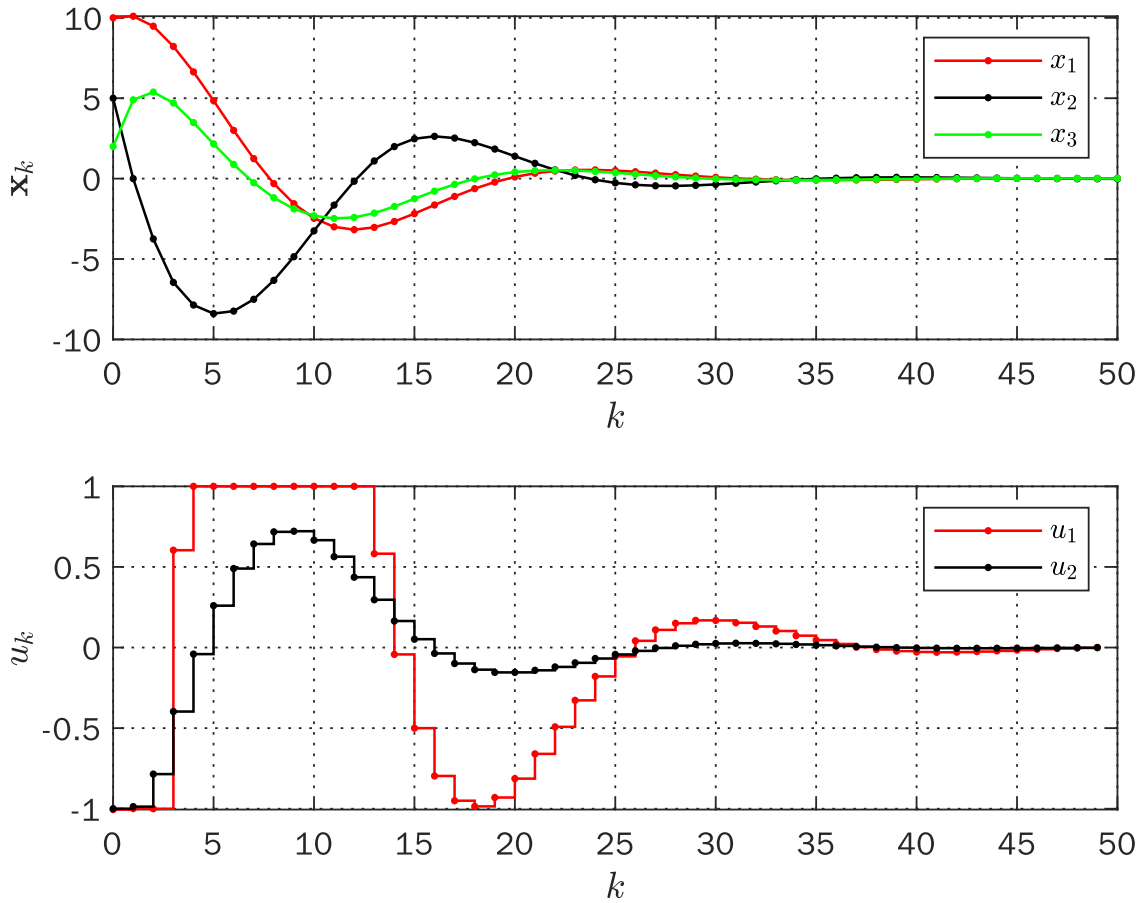

Figure 2: LMPC: Multi input system

Thank you