Introduction

• Networked Distributed Control Systems (NDCS) consist of a combination of multiple agents that operate simultaneously and have local controllers that regulate their performance and, in addition, handle the interconnections effect on their state.

• Information on the states and control signals is exchanged between the agents through a control/communication network.

• Common problems with NDCS include delays in the communication network or uncertainties in the interconnections, with examples in economic systems, power systems or robotic systems.

• Distributed controllers can weaken interconnections to avoid instability and at the same time avoid problems due to dimensionality.

Problem Statement

• Consider a set of $N$ linear time-invariant systems of the following form

$$\dot{x}_i(t) = A_i x_i(t) + B_i u_i(t) + \sum_{j=1}^{N} A_{ij} x_j(t) \quad (1)$$

• The control objective is to create an appropriate control law, so that all signals in the overall closed-loop system are bounded and $x_i(t)$ tracks the state of a reference model given by:

$$\dot{x}_{ref,i}(t) = A_{m,i} x_{ref,i}(t) + B_{m,i} r_i(t) \quad (2)$$

• The current state of the $i^{th}$ subsystem is considered to be known exactly at each time $t$, but the information about the neighboring systems is considered to be received with some communication delay $\tau_{ij} \in \mathbb{R}^+$, due to the communication network.

Discussion & Future Work

• In NDCS, the proposed distributed control scheme that weakening the effect of the interconnections via feedback can stabilize the local dynamic, in the case of known interconnections and communication delays.

• In the case of unknown interconnections the proposed adaptive control scheme guarantees tracking errors that are small in the mean square sense provided the interconnections can be weakened and the time delays are relatively small.

• Further work includes application of the proposed schemes to actual networks and exploration of cases with more and different uncertainties.

Known Interconnections

• Proposed Controller:

$$u_i(t) = -K_i x_i(t) + L_i r_i(t) - \sum_{j=1}^{N} K_{ij} x_j(t - \tau_{ij}) \quad (3)$$

- $K_i$, $L_i$ so that $A_{m,i} - B_i K_i$, $B_i L_i = B_{m,i}$
- $K_{ij} = \arg\min \|A_{ij} - B_i K_i\|$ with $W_{ij} = A_{ij} - B_i K_i$

• $\tau_{ij}$ can be calculated by solving the system of LMIs above.

• The computational burden for each adaptive controller depends on the number of neighbors that the respective subsystem has.

• The controllers do not know the delays. All they need is for them to be sufficiently small.

Unknown Interconnections

• Proposed Controller:

$$u_i(t) = -K_i x_i(t) + L_i r_i(t) - \sum_{j=1}^{N} K_{ij} x_j(t - \tau_{ij}) \quad (3)$$

- $K_i$, $L_i$ so that $A_{m,i} - B_i K_i$, $B_i L_i = B_{m,i}$
- $K_{ij} = \arg\min \|A_{ij} - B_i K_i\|$ with $W_{ij} = A_{ij} - B_i K_i$

• $\tau_{ij}$ depend on the unknown parameters and cannot be calculated.

• The adaptive controllers do not know the delays. All they need is for them to be sufficiently small.