Topics in Control: Control of Multiagent Systems

Courseworks
Winter 2020

Problem 1: Consider a network of 5 agents described as

$$\dot{x}_i(t) = u_i(t), i = 1, 2, 3, 4, 5, \tag{1}$$

where the agents are randomly initialized between $[-1\ 1]$.

a) Design and simulate a control strategy for the control inputs $u_i(t), i = 1, 2, 3, 4, 5$, such that the agents states converge to a common value. First assume that the agents are in interaction under the leader-follower communication topology depicted in Fig. 1, and then they are in interaction under the leaderless communication topology depicted in Fig. 2.

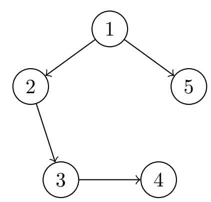

Figure 1: The leader-follower communication topology of the multiagent system in Question 1.

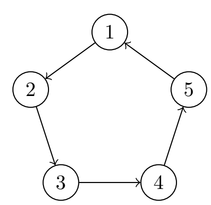

Figure 2: The leaderless communication topology of the multiagent system in Question 1.

b) Assume that due to faults in the actuators of Agent 2, $u_2 = 0$ for $t > 1$. Repeat the simulation scenario of Part (a) in this case, and discuss and conclude your observations.

c) In the experiment of Part (b), analytically obtain the states of the agents when $t \to \infty$.

Problem 2: Consider a leaderless network of 9 agents when the network communication topology is depicted in Fig. 3.

a) Show that the network communication topology has sufficient conditions to achieve consensus (no simulation is required).

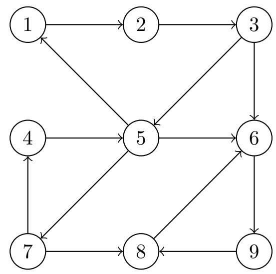

Figure 3: The network topology of the multiagent system in Question 2.

b) According to the network communication topology and without computation of the network Laplacian matrix, discus which agents can affect the final consensus value?

Problem 3: Consider a leader-follower network of 4 agents described as

$$\dot{x}_i(t) = u_i(t), i = 1, 2, 3, 4,$$

where the followers are randomly initialized between $[-1\ 1]$, and the network topology is depicted in Fig. 4.

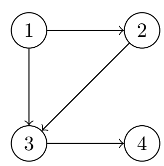

Figure 4: The network topology of the multiagent system in Question 3.

a) For $x_1(t) = 0$, design a control strategy such that the followers follow the leader, and verify your answer by simulation test. Then, for the same control law, increase $x_1(t)$ as $0, 0.1, 0.1\sin(2t), 0.5\sin(2t), 0.5\sin(0.2t)$ and discus your observations.

b) For your experiments in Part (a), analytically find the bound/maximum of $|x_1(t) - x_i(t)|, i = 2, 3, 4$ when $t \to \infty$.

Problem 4: Consider a network of 4 agents described as

$$\begin{aligned}\dot{x}_i(t) &= u_{xi}(t),\\ \dot{y}_i(t) &= u_{yi}(t), i = 1, 2, 3, 4.\end{aligned}$$

a) Design a communication topology along with a control strategy for the control input $(u_{xi}(t), u_{yi}(t)), i = 1, 2, 3, 4$, such that the agents reach a square formation with the side of 1 and with the center of the average of the initial positions of the agents.

b) By assuming that the agents initial positions are $[1\ 0]$, $[-1\ 2]$, $[3\ 1]$, and $[1\ 1]$, verify the accuracy of your design in Part (a) by simulation test.

c) Modify the designed control strategy of Part (a) such that the formation is moving with the desired velocity $[1, 1]$. Considering the initial conditions given in Part (b), verify the accuracy of your design by simulation test.

Note: In all the questions, assume that $a_{ij} = 1$ if there is an edge form Node j to Node i.

In the case of questions or ambiguities, feel free to send email to h.rezaee@imperial.ac.uk.

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