A Distributed Robust Adaptive Control for a class of Nonlinearly Coupled Hierarchical Systems with Actuator Faults

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Abstract: This talk proposes an approach to address the control challenges posed by a fault induced uncertainty in both dynamics and control input effectiveness for a class of hierarchical nonlinear system. The nonlinear system has two layers in which the high-level dynamics is coupled with low level subsystems through a nonlinear function Such nonlinearity in the coupling makes the problem challenging as it is not an invertible function In other words, if the nonlinear function is designed as the control input for the high level dynamics, the individual low level outputs cannot be obtained from it. In addition, both the high-level dynamics and the low-level subsystems have multiplicative uncertainty in their control input effectiveness, but the former is due to an exogenous signal and the latter is due to the time varying actuator faults.

To address this problem, a distributed robust adaptive controller is designed. For the low level subsystems, an adaptive mechanism estimates fast time varying parameters, and then a splitting mechanism is designed to distribute the control input automatically among subsystems in response to the faults. The splitter works in a way that faulty subsystems receive less control inputs and healthy ones receive more inputs such that the overall control input effectiveness is preserved, and then a distributed state feedback controller is designed to recover the system from the faults. In the high-level dynamics, a nonlinear $\mathcal{L}_2$ gain-based controller is designed to reject the exogenous disturbance The resulting analysis guarantees a robust tracking of the high-level reference command signal.