Stabilization of Uncertain Dynamical Systems: An Artificial Delay Approach

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by

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Chapter 6

Conclusions and Future Scopes

6.1 Contributions

The study presented in this entire work considers the non-availability of all the state's information and uncertainty occurring in control theory. In this context, three problems have been examined. The first two problems are related to the general nonlinear systems, and the last one is on the general linear MASs. In the nonlinear systems, diffeomorphism and change of variables are applied to get it into the linear system form. Once the linear system is achieved, the proposed control is applied to stabilize the systems. In the general linear MASs, the leader-follower and leaderless consensus is performed using the delayed output feedback control method. Examples have been presented to describe the applications on practical systems. The issues occurring due to the non-availability of all the states and uncertainty have been solved using delayed partial state feedback and delayed output feedback.

The work presented in this thesis highlights the advantages of applying delay-based partial state feedback and output feedback to the nonlinear system and general linear system problems. The proposed control design is simple and straightforward for implementation purpose. A novel Lyapunov-Krasovskii functional is constructed, which leads to LMIs, that yields a feasible solution for small delays. In order to do a comparative analysis, the proposed work are compared with existing works, and results confirm the significance of the proposed approach.

In this work, first a multiple delayed partial state feedback sliding mode control is proposed for the uncertain nonlinear systems. A delayed sliding surface is designed based

on the partial state information. Asymptotic stabilization of the uncertain nonlinear systems is achieved.

Next, a delayed output feedback sliding mode control is proposed for the uncertain nonlinear systems. A delayed sliding surface with an exponential term is designed based on the output information, which relaxes the reaching phase and made sliding surface convergence insensitive to disturbances from the very beginning. Further, robust stability analysis is presented.

Finally, a distributed delayed output feedback control is proposed for uncertain general linear multi-agent systems. Leader-follower and leaderless consensus problem is studied based on the directed communication graph. It has been confirmed that the tracking errors is asymptotically converging to zero in the absence of disturbances and uniformly bounded in the presence of disturbances.

6.2 Future Scope

The stabilization of the uncertain systems is a mature field, but an immense scope is still available in this direction. We recommend some advancements in this area. The outcomes of this thesis may be further investigated in the following research directions:

- In network-based control, the plant and controller are separated by the communication network. Thus the introduction of the delay in feedback may enhance the system performance. We can improve and extend our work to the stabilization of the network-based control system.

- In MASs, multiple objects work together to achieve a common objective. MASs are of two types - homogeneous and heterogeneous. Homogeneous MASs are widely studied in the literature based on delayed output feedback, but the study of heterogeneous MASs using delayed output feedback is not yet explored. So our next focus will be on filling this gap, under fixed and switching directed topologies.

- The partial differential equations (PDEs) govern classes of systems. Thus, the study of PDE handling systems is essential to stabilize these classes of systems. In future, the proposed approach applies to PDE-based systems.

- In literature, stabilization of fractional-order time-delay systems is extensively studied. However, by delayed output feedback, stabilization of fractional time-delay system is still an open area.

- Many practical systems belong to discrete-time in nature. Therefore, control of discrete-time systems is an essential and challenging task. In future, we will try our approach to discrete-time systems and will stabilize the class of discrete-time systems.

- In order to relax the requirement of upper bound of unknown perturbation, we can apply adaptive delayed feedback approach to stabilize uncertain dynamical systems.