Abstract

A system is said to have a delay when the rate of variation in the system state depends on past states. Such a system is called a time-delay system. Delays frequently appear in real-world engineering systems. They are often a source of instability, poor performance of systems and significantly increase the difficulty of stability analysis and control design. On the other hand, it has a stabilizing effect. In other words, the employment of small time-delay in the control law stabilizes some unstable dynamical systems. This thesis work is on utilizing such stabilizing impact of time-delay.

Another major concern deal with in this work is the unmeasurable states. In many practical applications, we do not have complete state information, only partial state information, or, in more limited cases, just measured state information is available. Therefore, we have to estimate the unmeasurable states and use the observer-based or dynamic output feedback controller in these circumstances. But due to the involvement of the observer dynamics, the closed-loop system complexity is increased. An alternative approach that relaxes the complexity is defined as artificial delay-based feedback stabilization.

First, a multiple delayed partial state feedback sliding mode control for uncertain nonlinear systems is proposed in this work. An output-based delayed sliding surface is designed. Subsequently, a novel Lyapunov-Krasovskii functional is constructed, leading to the Linear Matrix Inequalities (LMIs) criterion, which yields a feasible solution for small delays. The efficacy of the proposed theory is demonstrated on a ball and wheel system.

Next, delayed output feedback sliding mode control is proposed for uncertain nonlinear systems. A delayed sliding surface with a decreasing exponential term is presented based on the output. The decreasing exponential term is used to achieve a sliding surface from the very initial time. A novel Lyapunov-Krasovskii functional is constructed, leading to the Linear Matrix Inequalities (LMIs) criterion, which yields a feasible solu-

tion for small delays. Finally, the proposed method's efficacy is demonstrated through a Translation Oscillator Rotating Actuator (TORA) system.

Finally, a distributed delayed output feedback control to the consensus problem of uncertain multi-agent systems (MASs) is developed, where only the agent output is used for feedback. The consensus problem of the leader-follower and leaderless systems is presented on the directed communication graph. Using distributed delayed output feedback control, the consensus is achieved for both problems. It has been shown that in the absence of external disturbances, the tracking errors are asymptotically converging to zero, and in the presence of disturbances, tracking errors are uniformly bounded. Numerical results demonstrate the effectiveness of the proposed techniques.