Abstract

This thesis focuses on the development of prescribed-time adaptive and optimal control techniques for a class of nonlinear systems. The research addresses the challenges associated with uncertain nonlinear dynamics, constrained feedback control, achieving consensus in uncertain nonlinear multi-agent systems and nonlinear optimal feedback control. The ultimate goal is to achieve convergence within a specified time frame.

The thesis begins by introducing the concept of prescribed-time adaptive backstepping control. The stability and convergence properties of this control scheme are analyzed, and theoretical proofs and simulations are provided to validate its effectiveness.

Next, the prescribed-time adaptive backstepping control methodology is extended to address the control challenges in a twin rotor helicopter system. A detailed controller design is developed, taking into account the specific dynamics of the helicopter. Simulations and comparative analyses are conducted to evaluate the performance of the proposed control strategy.

This thesis further focuses on the development and analysis of a prescribed-time constrained feedback control scheme to handle parameter uncertainties and input constraints in real-world systems, with a specific application to a twin rotor helicopter exhibiting uncertain dynamics. The proposed control approach is designed to achieve convergence within a prespecified time frame while considering the challenges associated with uncertainties and input constraints. The work rigorously analyzes the stability of the proposed control approach to ensure its adaptability to parameter variations. To validate its performance, numerical simulations and practical experiments are conducted. The results demonstrate the control scheme's ability to successfully handle parameter uncertainties, maintain stability, and adhere to the input constraints in a real-world application.

The thesis also addresses the application of prescribed-time adaptive control to DC-DC boost converters, which are widely used in power electronic systems. An adaptive estimator-based control strategy is proposed to regulate the output voltage of the boost converter within a prescribed time, considering uncertainties and variations in system parameters. The effectiveness of the proposed control approach is evaluated through theoretical analysis, simulation and experimental results.

Furthermore, the thesis investigates the achievement of prescribed-time adaptive neural consensus in uncertain nonlinear multi-agent systems. A novel consensus control approach is developed, combining adaptive control and neural networks, to achieve prescribed-time convergence and consensus among the agents. Theoretical analysis, simulation studies, and performance evaluations are provided to demonstrate the effectiveness of the proposed methodology.

Lastly, the thesis addresses the problem of prescribed-time optimal feedback control for nonlinear dynamical systems. Optimal nonlinear control techniques are employed to optimize a performance criterion subject to prescribed-time constraints. The theoretical developments, numerical methods, and experimental case studies presented in this thesis demonstrate the efficacy of the proposed prescribed-time optimal control methodology.