ABSTRACT

This dissertation undertakes a comprehensive exploration of switched model reference adaptive control (S-MRAC) strategies for parameter identification and control of switched multi-input multi-output (MIMO) linear systems and adaptive fault-tolerant methodologies applied to Euler-Lagrage (EL) systems. The primary objective is to enhance parameter convergence, tracking performance, and fault tolerant control for switched dynamical systems.

The investigation delves into the analysis of the memory augmentation and intermittent initial excitation (IIE) condition for switched linear systems. The study extends to compensating multiple actuator faults in EL systems through adaptive control techniques. The incorporation of memory augmentation and IIE condition proves instrumental in establishing globally exponential stability of overall error which includes tracking error and parameter estimation errors of all the subsystems for switched linear systems, a result not previously found in the literature. The absence of memory augmentation and/or non-satisfaction of the IIE condition limits stability outcomes to either Lyapunov stability or asymptotic stability. The IIE condition, a more generalized form of the initial excitation (IE) condition, is demonstrated to be less restrictive than the persistence of excitation (PE) condition for ensuring parameter convergence in adaptive systems. Memory augmentation also facilitates parameter learning during the inactive phase of subsystems, thereby enhancing overall tracking performance. A novel tunable and unified dwell time expression is derived, proving beneficial even when the reference signal is not sufficiently exciting.

The dissertation sequentially examines online adaptive identification, focusing on the accurate identification of switched system parameters. Subsequently, S-MRAC is proposed for a common reference model, and stability is analyzed using a common Lyapunov function. The analysis extends to a more general scenario wherein the reference model is also switched, employing multiple Lyapunov functions to assess the stability of overall error dynamics. The dissertation concludes with a dedicated exploration of adaptive actuator fault-tolerant control for the EL system, wherein single and multiple faults are compensated using adaptive control methods. Well-known projection operation in adaptive system literature is shown to compensate for the infinite number of actuator faults. Collectively, these contributions advance the field of adaptive control and fault-tolerant methodologies, offering a unified framework for the design and simulation of control systems in practical applications.