Abstract

Adaptive observer design deals with online estimation of states using input-output information of a dynamical system in the presence of parametric uncertainty in the dynamics. It works with the principle of simultaneous estimation of states and the uncertain parameters using suitable online estimation algorithms to ensure stability of the estimation error dynamics. Conventional adaptive observers rely on the richness of input-output signals to satisfy the persistence of excitation (PE) condition for parameter convergence. The PE condition is restrictive since it demands sufficient energy of the signal for the entire time span and the condition depends on the future behavior of the signal, which poses difficulty in online verification.

Existing adaptive observer algorithms rely on the PE condition for the convergence of unknown parameters to zero. To enforce the PE condition, it is required that the external auxiliary signal should sustain significant richness for the entire time of operation. Hence, PE is stringent in the sense that it is not always realizable, and it is often impractical to monitor online whether a signal will remain PE as the condition relies on the future behavior of the signal. Therefore, relaxing the PE condition is a long-standing area of research in adaptive control and estimation. In addition, the persistent energy demands of PE may cause damage to many real-world systems, e.g., aircraft systems etc.

For adaptive control problems, several authors proposed a two-layer filter based new adaptive control architectures, which guarantee parameter convergence under the milder condition of initial excitation (IE). The IE condition requires that the regressor has sufficient energy in the initial time window of finite length, which is less restrictive than the PE condition, where the regressor is required to have sufficient energy for the entire time span. Further, the IE condition can be verified online and may be ensured by injecting a transient dither-like signal.

This dissertation presents an IE-based adaptive observer architecture that ensures parameter convergence in the absence of PE. A switched estimator based on a double-layered filter architecture is used which by virtue of switching captures the necessary information (about unknown parameters) from the transient cycles and uses it for future references in the absence of PE.