Preface

Many practical control systems are subject to possible malfunctions which may cause significant performance degradation and even instability of the system. To improve reliability, performance, and safety of dynamical systems, fault diagnosis techniques are receiving considerable attention both in research and applications and have been the subjects of intensive investigations. Fault detection, which acts as the first step of the fault diagnosis, is a binary decision process determining whether a fault has occurred or not. Fault isolation is to determine the location of the faulty component, while fault estimation is to online identify the size of the occurred fault. Compared with the problems of fault detection and isolation, fault estimation is more challenging. In this book, observer-fault estimation techniques are further investigated and new results related to fault estimation are presented.

In Chap. 1, the background of fault estimation is given and motivations of our studies are presented in detail.

In Chap. 2, the design of a multi-constrained full-order fault estimation observer (FFEO) with finite-frequency specifications is studied for continuous-time systems. By constructing an augmented system, a multi-constrained FFEO in finite-frequency domain is proposed to achieve fault estimation. Meanwhile, the presented FFEO can avoid the overdesign problem generated by the entire frequency domain by the generalized Kalman–Yakubovich–Popov (KYP) lemma. Furthermore, by introducing slack variables, improved results on FFEO design in different frequency domains are obtained such that different Lyapunov matrices can be separately designed for each constraint.

In Chap. 3, a framework of fault estimation observer design in finite-frequency domain is proposed for discrete-time systems, including FFEO and reduced-order fault estimation observer (RFEO). A FFEO in finite-frequency domain is designed to achieve fault estimation by using the generalized KYP lemma to reduce conservatism generated by the entire frequency domain. Then, a RFEO is constructed, which results in a new fault estimator to realize fault estimation using current output information. Furthermore, improved results on FFEO and RFEO design with finite-frequency specifications are obtained.

In Chap. 4, the problem of fault estimation observer design with finite-frequency specifications is addressed for discrete-time Takagi-Sugeno fuzzy systems. Then fuzzy unknown input observer-based fault estimation is investigated for discrete-time T-S fuzzy systems.

In Chap. 5, the issue of fault estimation observer design with finite-time convergence specification is studied for continuous-time dynamic systems subject to external disturbances. The unknown input observer is constructed to achieve accurate estimation of the occurred fault and to guarantee robustness against the disturbance. Then a pole placement-based fault estimation observer is constructed using time-delay design such that the fault estimation error converges to zero in finite time. Meanwhile, the proposed fault estimator with finite-time convergence specification does not contain discontinuous sign function.

In Chap. 6, a novel adjustable parameter-based fault estimation design is addressed for continuous-time/discrete-time dynamic systems. First, a fault estimation observer with adjustable parameter is constructed to online identify the size of occurred faults. The fault estimation design not only possesses a wider application compared with adaptive observers, but also uses the current output information to enhance fault estimation performance. Then a multi-constrained approach is proposed to determine gain matrices of fault estimation observer. Moreover, fault estimation results with the slack-variable technique are obtained to further reduce the conservatism.

In Chap. 7, the distributed fault estimation observer (DFEO) is studied based on H_∞ and H_2 strategies for discrete-time multi-agent systems (MAS). For each agent, a fault estimation observer is designed using relative output estimation errors. By denoting global estimation error vectors, the global error dynamics is constructed for MAS. Then the existence condition of the presented DFEO is further discussed.

In Chap. 8, under the directed communication topology, an adaptive observer-based DFEO is studied for MAS. First, a corresponding fault estimation observer is constructed based on relative output estimation errors. To consider DFEO design from an overall perspective, the whole error dynamics is obtained by defining global error vectors. Then an adaptive technique-based DFEO design is proposed for MAS with directed communication topologies.

In Chap. 9, an adjustable parameter-based DFEO is proposed for MAS with directed communication topologies to improve the accuracy of fault estimation. Based on H_∞ and H_2 with pole placement, multi-constrained design is given to calculate gain matrices of DFEO.

In summary, conclusions are presented in Chap. 10.

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