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APPLICATION OF A BANK OF KALMAN FILTERS AND A ROBUST KALMAN FILTER FOR AIRCRAFT ENGINE SENSOR/ACTUATOR FAULT DIAGNOSIS

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Abstract. *In this paper, A Robust Kalman filter and a bank of Kalman filters are applied in fault detection and isolation (FDI) of sensor and actuator for aircraft gas turbine engine. A bank of Kalman filters is used to detect and isolate sensor fault, each of Kalman filter is designed based on a specific hypothesis for detecting a specific sensor fault. In the event that a fault does occur, all filters except the one using the correct hypothesis will produce large estimation errors, from which a specific fault is isolated. When the Kalman filter is used, failures in the sensors and actuators affect the characteristics of the residual signals of the Kalman filter. While a Robust Kalman filter is used, the decision statistics changes regardless the faults in the sensors or in the actuators, because it is sensitive to sensor fault and insensitive to actuator fault. The proposed FDI approach above, which was previously discussed in literature to distinguish the sensor and actuator fault as an effective approach, is applied to a nonlinear engine simulation in this paper, and the evaluation results show that this approach to detect and isolate sensor and actuator faults is demonstrated.*
Keywords: Aerospace propulsion system, Fault detection and isolation (FDI), Kalman filter, Sensor and actuator fault

1. **Introduction.** Fault detection and isolation (FDI) logic plays a crucial role in enhancing the safety and reliability, and reducing the operating cost of aircraft propulsion systems. However, achieving the FDI task with high reliability is a challenging problem [1]. For this purpose, various approaches have been proposed in the literature [2-4].

Firstly, two different fault detection algorithms, namely multiple hypotheses testing and neural networks that analyze the sensor residuals generated with an extended Kalman filter (EKF) based on an un-faulted engine model were developed and implemented by Randal et al. [5]. These two algorithms have complementary performance, which is exploited in a fusion algorithm to enhance the overall detection & classification performance. An observer-based robust sensor fault detection approach was applied to a jet engine simulation by Patton and Chen [6]. Merrill, Delaat, and Bruton used a bank of Kalman filters for aircraft engine sensor FDI [7]. This study successfully improved control loop tolerance to sensor failures, which were considered the most likely engine failures to happen under the harsh operating environment. In this study, the actuator failure was not considered. An actuator failure may cause a false alarm or missed detection if not considered. In the study done by Kobayashi and Simon [8,9], a fault detection and isolation (FDI) system which utilizes a bank of Kalman filters is developed for aircraft engine sensor and actuator FDI in conjunction with the detection of component faults. In the meantime, a set of parameters that indicate engine component performance is estimated