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EDITORIAL

IEEE ACCESS SPECIAL SECTION: RECENT ADVANCES IN FAULT DIAGNOSIS AND FAULT-TOLERANT CONTROL OF AEROSPACE ENGINEERING SYSTEMS

With the rapid development of automation technologies, aerospace engineering systems, including aircraft, satellite, and spacecraft, have become increasingly susceptible to system/component malfunctions. Failure to take appropriate responses to even relatively minor defects can result in highly destructive events. A conventional feedback control design may result in an unsatisfactory performance or even instability in the event of malfunctions. Because of this, fault diagnosis (FD) and fault-tolerant control (FTC) technologies that can ensure the safety of handicapped systems have attracted significant interest. FTC design and relevant techniques have provided a flexible framework for dealing with these challenges since the 1970s. There has been significant progress since the 1970s by the active research community, through symposiums and seminars, as well as the vast number of publications on the subject. The research illustrates that FD and FTC are effective and applicable in many engineering plants, especially for aerospace engineering systems. However, it still remains a challenging research area in applications relating to aircraft, spacecraft, and satellites.

The main objective of this Special Section is to create a platform for scientists, engineers, and practitioners to present their latest theoretical and technological advancements in the field of advanced FD and FTC design methods for aerospace engineering systems (AESs). The main topics include experimental and analytical investigations on fatigue and fracture of system components, fault detection and diagnosis for AESs, sensors and measurements for AESs, fault-tolerant control/reliable control, remaining life assessment and health management, self-healing, self-organizing, self-adaptive, automatic recovery, optimization theory for fault-tolerant control design for AESs, integration design of fault diagnosis and fault-tolerant control, novel control, guidance, navigation methodologies, and innovative control algorithms (such as robust control, adaptive control, and intelligent control). The Special Section received a total of 54 submissions, and all submitted articles were carefully reviewed after a rigorous review process. We selected 12 articles covering the subject from different perspectives, i.e., 22.2% of all the submitted articles. The contents of those accepted articles are briefly summarized below.

In the article, "Adaptive sliding mode control for spacecraft autonomous rendezvous with elliptical orbits and thruster faults," by Liu *et al.* the problem of spacecraft autonomous rendezvous control for elliptical target orbits with external disturbance and thruster faults was investigated. By estimating the thruster faults and external disturbance online, an adaptive sliding mode-based fault tolerant control scheme was designed to achieve the rendezvous control with the effects of the thruster faults and external disturbances eliminated. A simulation example was provided to verify the effectiveness of the approach.

In the article, "A rapid solving method to large airline disruption problems caused by airports closure," by Wu *et al.* a new and rapid recovery scheduling approach was developed to deal with large dimension airline disruption problems. This was achieved by applying the fixed-point iterative method for integer programming and the feasible flight lines. Moreover, the numerical results validated the application potential of the proposed distributed approach.

In the article, "Adaptive backstepping-based neural network control for hypersonic reentry vehicle with input constraints," by Ma *et al.* the attitude tracking control problem of hypersonic reentry vehicles was addressed. The control-oriented model of the hypersonic reentry vehicles is formulated with mismatched and matched lumped uncertainties including the multiple aerodynamic uncertainties, external disturbances, and actuator saturation. An adaptive NN disturbance observer was developed to estimate the lumped disturbances. Then, a backstepping-based control approach was designed to guarantee that the tracking errors were uniformly ultimately bounded. Several simulations were investigated to show the effectiveness of the proposed control scheme.

In the article, "Anti-radiation performance assessment of satellite units based on the Weiner process," Zhou *et al.* investigated the anti-radiation reinforcement index of the selected electronic components to ensure that the satellite has enough anti-radiation adaptability. A performance degradation model based on the Wiener process was constructed to characterize the law of the unit anti-radiation performance changes along with the total radiation dose levels.

In the article, "Global stabilization for a class of genuinely nonlinear systems with a time-varying power: An interval homogeneous domination approach," Chen *et al.* addressed the problem of global state feedback stabilization for a class of genuinely nonlinear systems with a time-varying power. A new design method called interval homogeneous domination approach was proposed to delicately design a state feedback control law that renders the nonlinear systems globally asymptotically stable. The key feature of the proposed scheme is that it provided a distinct perspective to solve the stabilization problem for the nonlinear systems with a time-varying power.

In the article, "Self-healing control for attitude system of hypersonic flight vehicle with body flap faults," by Wang *et al.* a mathematical model for a hypersonic flight vehicle system with actuator faults was established. A fault-tolerant attitude control approach was then developed to handle the body-flap faults. The stability of the closed-loop system ensured by the proposed approach was proved by using the Lyapunov stability theory. Moreover, simulation results were also presented to validate that the system output can track the desired command even under fault situations.

In the article, "Centrifugal blower of stratospheric airship," Sun *et al.* developed a novel stratospheric blower for the airship to keep its shape and realize the desired performance, while landing safely from a 20-km altitude. It was shown that the designed stratospheric blower met the requirements of a semi-rigid airship 160 m in length. The blower made the airship land safely with an efficiency of 77% in the stratosphere. Additionally, the sensitivity of different geometric parameters to the efficiency was further analyzed.

In the article, "Robust fault tolerant control for discrete-time dynamic systems with applications to aero engineering systems," Liu *et al.* presented an estimator-based fault tolerant control approach for both discrete-time linear and discrete-time Lipschitz nonlinear systems in the presence of simultaneous actuator/sensor faults, partially decoupled unknown input disturbances, and sensor noises. The closed-loop system was governed by the proposed approach to be input-to-state stable with the robustness performance guaranteed. The proposed scheme was applied to a jet engine system and a flight control system for simulation validation.

In the article, "Nonlinear fault-tolerant control for hypersonic flight vehicle with multi-sensor faults," by Chen *et al.* the problems of fault tolerant control and fault diagnosis were studied for hypersonic flight vehicles. The fault in an altitude system was estimated by synthesizing a backstepping sliding-mode observer with a good estimation performance. The estimation results were then used to design a nonlinear fault tolerant controller to compensate for the multi-sensor faults. The stability of the closed-loop system was proved. Numerical simulation was further presented to validate the performance of the proposed approach.

In the article, "A continuous finite-time output feedback control scheme and its application in quadrotor UAVs," Tian *et al*. presented a continuous output feedback control scheme for double integrator systems with non-vanishing perturbation. No explicit state observer or disturbance observer was designed. The geometric homogeneity technique and Lyapunov stability theory were integrated to ensure the global finite-time stability of the closed-loop system. The proposed approach was then extended to the control of multi-input multi-output systems. Moreover, the approach was successfully applied to achieve the quadrotor unmanned aerial vehicles control.

In the article, "A fault diagnosis method for on load tap changer of aerospace power grid based on the current detection," Li *et al.* investigated the real-time monitoring and fault diagnosis problem of on load tap changer (OLTC) of a power transformer in the aerospace power grid. A novel fault diagnosis method was designed for OLTC based on the current detection in the process of switching. Through on-line acquisition of current waveform in the switching process, the empirical mode decomposition and the Hilbert–Huang transform were used to calculate normalized time-frequency spectrum, and extract fault characteristic quantity. Then, the comprehensive diagnosis of the running state of the equipment, and identification of the early fault characteristics were achieved. Experimental results were presented to prove that the designed fault diagnosis instrument effectively monitored the working condition of OLTC during the switching process and diagnosed its fault.

In the last article, "A generalized minor component extraction algorithm and its analysis," by Li *et al.* the generalized minor component analysis (GMCA) and the Hebbian-rule-based algorithm were combined to present a novel GMCA approach. This new approach can ensure good convergence speed, self-stabilizing property, and multiple generalized minor component extraction in sequence. A theoretical analysis verified these properties via matrix theory and the deterministic discrete-time method. Numerical simulations were conducted to further demonstrate the advantages of the proposed algorithm.

Finally, it should be pointed out that the selected topics and articles are not a comprehensive representation of the area of this Special Section on advances in fault diagnosis and fault-tolerant control of aerospace engineering systems. However, they represent the rich and multifaceted knowledge that we have the pleasure of sharing with readers. The guest editors gratefully thank all the authors who submitted papers for consideration to the Special Section as well as the reviewers for their time and detailed reviews. They are also grateful to the Editor-in-Chief, Prof. Derek Abbott, of IEEE ACCESS, the Managing Editor, and the Editorial Office staff, for giving us the opportunity to edit this Special Section on "Recent advances in fault diagnosis and fault-tolerant control of aerospace engineering systems," and for their valuable guidance and encouragement.

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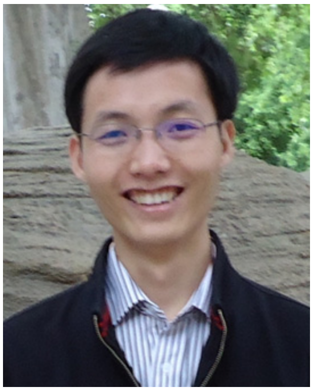

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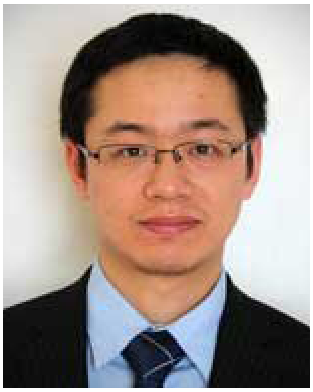

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