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Sensor Working Mode Replacement-Based Faulty Performance Self-Recovery Control Strategy for Nonlinear System with Sensor Failures

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Abstract. To meet the fine, high-quality production tasks, the structure of automatic control system is becoming more and more compact and complex, the insufficient preventive maintenance measures together with the complex and changeable operating environment of sensors make the controlled system face potential security risks and is prone to multi-sensor failures. Meanwhile, the manual maintenance of faulty sensors is laborious, and most control schemes based on analytic redundancy technology become inapplicable due to the presence of false output measurement signals when the sensors fail partially or completely. Hence, it is necessary to formulate a sensor working mode replacement-based performance self-recovery control strategy for the nonlinear system regulation against sensor failures. To give a solution, a switching function-based working mode replacement scheme is designed to automatically activate different sensor working modes such that the impact of the faulty sensors can be reduced, in which the total failure patterns and working modes of multiple sensors are divided, and the mode replacement indication about correntropy criterion is established for delivering an indication of mode maintenance or replacement. A prescribed-time performance function and an error transformation dynamic are constructed simultaneously for the guaranteed performance technology, which compensates for the continuous performance deterioration caused by the delayed working mode replacement and drives the system output tracking error to accommodate the user-defined asymmetric performance constraints, which effectively suppresses the faulty performance attenuation and improve the convergence rate and accuracy. Then, a reliable performance self-recovery control strategy with multi-sensor working mode replacement is exploited to alleviate the sensor failure impact, which promotes the failure tolerance and the system performance realization for energy-efficient and secure wastewater treatment. The complete theoretical analysis of system stability and extensive studies on a practical industrial dissolved oxygen system of wastewater treatment are provided to validate that the proposed strategy can guarantee the automatic working mode replacement and desired control performance while mitigating the failure detriment.

Keywords: Nonlinear System, mode replacement, self-recovery control, performance guarantee, sensor failure

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