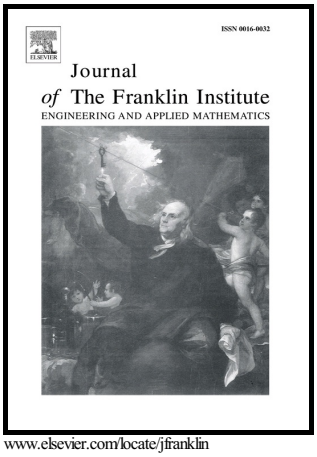

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Robust Finite-Time Fault Estimation for Stochastic Nonlinear Systems with Brownian Motions

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Abstract: Motivated by real-time monitoring and fault diagnosis for complex systems, the presented paper aims to develop effective fault estimation techniques for stochastic nonlinear systems subject to partially decoupled unknown input disturbances and Brownian motions. The challenges of the research is how to ensure the robustness of the proposed fault estimation techniques against stochastic Brownian perturbations and additive process disturbances, and provide a rigorous mathematical proof of the finite-time input-to-stabilization of the estimation error dynamics. In this paper, stochastic input-to-state stability and finite-time stochastic input-to-state stability of stochastic nonlinear systems are firstly investigated based on Lyapunov theory, leading to a simple and straightforward criterion. By integrating augmented system approach, unknown input observer technique, finite-time stochastic input-to-state stability theory, a highly-novel fault estimation technique is proposed. The convergence of the estimation error with respect to un-decoupled unknown inputs and Brownian perturbation is proven by using the derived stochastic input-to-state stability and finite-time stochastic input-to-state stability theorems. Based on linear matrix inequality technique, the robust observer gains can be obtained in order to achieve both stability and robustness of the error dynamic. Finally, the effectiveness of the proposed fault estimation techniques is demonstrated by the detailed simulation studies using a robotic system and a numerical example.

Keywords: Finite-time stochastic input-to-state stability; stochastic nonlinear system; Brownian motions; unknown input observer; robust fault estimation.

1. Introduction

Nowadays, industrial systems are becoming more complex with more sophistical control strategies utilized. Since a single linear model, which is only valid within a neighbourhood of the operating point, cannot be effectively used for modelling complicated dynamics, nonlinear systems are becoming more popular to describe