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Event-Triggered Fault Detection Filtering of Fuzzy-Model-Based Systems with Prescribed Performance

Yao Wen[1,*], Xiaojie Su[2] and Yaoyao Tan[2]

[1]College of Automation, Chongqing University of Post and Telecommunication, Chongqing 400065, P. R. China
[2]College of Automation, Chongqing University, Chongqing 400044, P. R. China
*Corresponding author: wenyao@cqupt.edu.cn

Introduction

An event-triggered scheme considering network bandwidth utilization rate and fault occurrence probability is utilized, which can conserve communication resources and reduce computational burdens. The fault detection fuzzy filter is used as a residual generator, and the proposed event-based fault detection scheme is formulated as a fuzzy filtering problem. Moreover, the generated residual is robust against exogenous disturbances while being sensitive to system faults, and the resulting fault detection system has asymptotic stability with a specified property. The corresponding solvability conditions of the fault detection filter are constructed by converting the non-convex feasibility problem into the optimization problems. Finally, a numerical simulation is conducted to demonstrate the feasibility and validity.

Mathematical Formulas

The inferred fuzzy system can be obtained as

$$\dot{\mathrm{x}}(\mathrm{t}) = \sum_{i=1}^{\mathrm{r}} \mathrm{f}_i(\mathrm{x}(\mathrm{t}))\{A_i x(t) + B_i u(t) + C_i \omega(t) + C_{1i} f(t)\}$$

$$\mathrm{y}(\mathrm{t}) = \sum_{i=1}^{\mathrm{r}} \mathrm{f}_i(\mathrm{x}(\mathrm{t}))\{D_i x(t)\}$$

A new event-triggered condition is formulated as

$$\mathrm{e}^{\mathrm{T}}(\mathrm{t}_l)\Lambda_{\mathrm{i}}\mathrm{e}(\mathrm{t}_l) \le \delta_{\mathrm{x}}\delta_{\mathrm{y}}[y(t-\eta(t)) - \mathrm{e}(\mathrm{t}_l)]^T \Lambda_{\mathrm{i}}[y(t-\eta(t)) - \mathrm{e}(\mathrm{t}_l)]$$

The fault detection filter can be further described as

$$\dot{\mathrm{x}}_{\mathrm{f}}(\mathrm{t}) = \sum_{j=1}^{\mathrm{r}} \mathrm{f}_j(\mathrm{x}(\mathrm{t}_l))\{A_{fj} x_f(t) + B_{fj}[y(t-\eta(t)) - e(t_l)]\}$$

$$\mathrm{r}_{\mathrm{f}}(\mathrm{t}) = \sum_{j=1}^{\mathrm{r}} \mathrm{f}_j(\mathrm{x}(\mathrm{t}_l))\{C_{fj} x_f(t) + D_{fj}[y(t-\eta(t)) - e(t_l)]\}$$

Figures

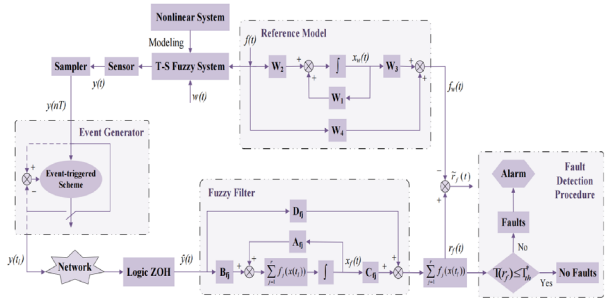

Figure 1. Diagram of fuzzy event-based fault detection system

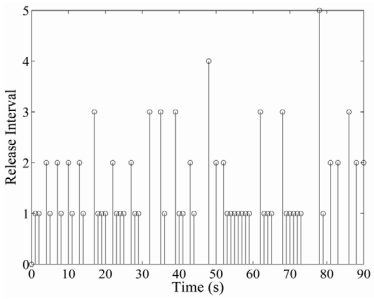

Figure 2. Release intervals and instants

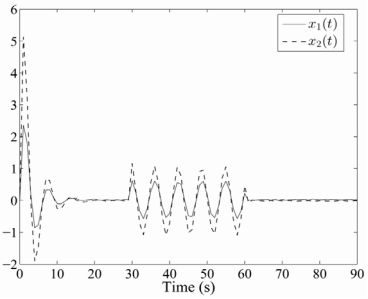

Figure 3. State responses of the systems

Methodologies

1) Each delay data is taken into account in the establishing of Lyapunov function, and the reciprocally convex approach is used to deal with the delay sub-interval information.
2) The decoupling problem of parameters existing in the nonlinear matrix inequality constraints is solved, and the non-convex feasibility problem in the fuzzy filter design is converted into the optimization problem.
3) A different event-based scheme considering network bandwidth utilization rate and fault occurrence probability is introduced to reduce the usage of limited network resources.

Conclusion

We solved the problem of fault detection in fuzzy dynamic systems with external perturbations and faults. A fuzzy filter was constructed to endow the resulting fault detection system with asymptotic stability and a specific H_∞ performance. In view of the limited number and unreliable nature of network links, we considered the transmission delay and used a flexible event-triggered strategy. Some sufficient conditions were included to guarantee the stability subject to a prescribed performance index. Moreover, feasible solutions of the fuzzy filter design problem were derived using the variation replacement technique. Finally, the effectiveness of developed design scheme was verified by conducting a numerical simulation.