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Extended Dissipative Filter for Delayed T-S Fuzzy Network of Stochastic System with Packet Loss

Rizwan Ullah,[1,2] Yina Li[1]*, Muhammad Shamrooz Aslam[3]* & Andong Sheng[1]

[1]School of Automation, Nanjing University of Science and Technology, 210 094, PR China
[2]COMSATS University Islamabad, Attock Campus 43600, Pakistan
[3]School of Automation, Guangxi University of Science and Technology, Liuzhou 545 006, China

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This research investigates a time-varying delay-based adaptive event-triggered dissipative filtering problem for the interval type-2 (IT-2) Takagi-Sugeno (T-S) fuzzy networked stochastic system. The concept of extended dissipativity is used to solve the H_∞, $L_2 - L_\infty$ and dissipative performances for (IT-2) T-S fuzzy stochastic systems in a unified manner. Data packet failures and latency difficulties are taken into account while designing fuzzy filters. An adaptive event-triggered mechanism is presented to efficiently control network resources and minimise excessive continuous monitoring while assuring the system's efficiency with extended dissipativity. A new adaptive event triggering scheme is proposed which depends on the dynamic error rather than pre-determined constant threshold. A new fuzzy stochastic Lyapunov-Krasovskii Functional (LKF) using fuzzy matrices with higher order integrals is built based on the Lyapunov stability principle for mode-dependent filters. Solvability of such LKF leads to the formation of appropriate conditions in the form of linear matrix inequalities, ensuring that the resulting error mechanism is stable. In order to highlight the utility and perfection of the proposed technique, an example is presented.

Keywords: Adaptive event-triggered scheme, Delayed fuzzy filters, Extended dissipativity, IT–2 T-S fuzzy systems

Introduction

Takagi-Sugeno (T-S) Fuzzy systems are the combination of information of human expert's knowledge with measurements and mathematical models. The expert knowledge provides the basis for the mathematical formulation of different nonlinear dynamical systems.[1] The Type-1 Takagi-Sugeno fuzzy systems have significance in a wide range of practical fields, such as active queue management, inverted pendulumand mechanical system.[2–4] There's always a risk that unknown system parameters will lead to uncertain grades of membership function, limiting the use of Type-1 fuzzy sets. Interval Type-2 (IT–2) fuzzy systems are being considered as a solution to this problem in several studies.[5–7] Several nonlinear behaviors are intrinsically occurring in many physical systems, such as time-varying state constraints, rapidly changing subsystem interconnections, stochastic variations, and so on.[8]

The aforementioned literature, on the other hand, is focused on continuous sampling, which causes network resources to be overloaded. Event-based sampling was proposed to make use of the most of the bandwidth.[9–16] The feedback stabilising controller design problem was also investigated earlier using an event-triggered scheme.[9] Similarly switching approach was suggested to decrease network load by lowering the quantity of data points.[15] The event-triggered sampling and time delays described were used to address the filtering problem for networked systems.[14] The event-triggered dissipative T-S fuzzy filtering problems were investigated.[16] In addition, an adaptive law was proposed for the selection of the threshold of the event-triggered scheme in order to improve network resource utilisation in terms of computing and transmission resource by many studies.[17–20] A new aperiodic adaptive event-triggered communication mechanism is proposed to reduce transmission load by combining event-triggered communication with aperiodic sampled data in Li *et al*. and Wang *et al*. where adaptively updated event-triggered scheme with H_∞ output tracking performance, the asymptotic stability of the considered Networked Control Systems (NCSs) is calculated.[18,19] In Yan *et al*., the authors looked at an Adaptive Event-Triggered Scheme (AETS) for a nonlinear networked interconnected control system.[20]

*Authors for Correspondence
E-mail: liyinya@njust.edu.cn; shamroz_aslam@yahoo.com

Cooperative control strategies for multiagent systems and wireless sensor networks were proposed that can result of the event–triggered filtering for Network Stochastic Systems (NSSs).[21–27] In Zhao *et al*. the issue event-triggered dissipative filtering for networked semi-NSSs is being studied.[22] The event-triggered network-based H_∞ filtering problem for discrete time singular stochastic systems is discussed.[23] The quantization and recognition of the negative effects of packet loss on channel performance, as well as event-triggered control with imperfect transmission between the event-generator and filter, are discussed.[24,25] In Li *et al*. the authors investigated the issue for IT–2 fuzzy NSSs with event-triggered filtering, but designing an adaptive event triggered mechanism along with other performance indicators for IT–2 NSSs remains a challenge.[26] The asymptotic stability conditions for the NSSs with dissipative asynchronous filtering problems based on type-1 fuzzy are investigated without consideration of uncertain parameters and exploitation of network resources.[27] Uncertain parameters and restricted bandwidth can have a negative impact on the system's efficiency. As a consequence, these concerns are of practical importance. To the best of the author's knowledge, the adaptive event-triggered dissipative filter design problem for IT-2 fuzzy. NSSs has not been properly considered with time-varying delays, and hence remains open and demanding.

In the above-mentioned articles, the researchers looked into the filter design problems time delays.[12,22] The time delays component is inherent in the state of the filter, causing delay in the measurement of input signal of the filter from the plant in networked control system.[28] The filter that holds the state and input delays will be more significant to study. Unfortunately, this intriguing topic has not been widely researched for IT–2 *NSSs*, which is still challenging. It is one of the motives behind this research. A new type of LKF is also being implemented termed fuzzy stochastic *LKF*, which has dual membership function characteristics while also taking into account the transition rate of a stochastic system. Such functionalities, we believe, include extra system model information and hence aid to reduce the conservatism of IT-2 Stochastic System. The H_∞ filtering problem for T-S fuzzy systems has been investigated using fuzzy LKF, implemented by Zhang *et al*.[29] It is worth noting that only the integral terms are common in this LKF, Zhang *et al*.[29] and the non-integral term is dependent on membership functions. The LKF, as implemented in Lin *et al*.[30] is used to analyse the stochastic switch system's filtering problem, in which all integral and non-integral terms are dependent on Transition Rates (TRs). This could lead to more significant restrictions. The additional attention is placed on generalising fuzzy and stochastic LKFs by including membership-function dependent and transition-rates dependent integral terms.[29,30]

Based on the above discussions, this work is devoted to investigating the extended dissipative filter for delayed T-S Fuzzy networked stochastic system with packet loss. A new type of fuzzy filters involving the state and input delays with Packet loss is considered for the nonlinear stochastic systems, which are modeled by the IT–2 fuzzy technique.[27,31] A novel procedure has been developed with respect to the existing methods to study the extended dissipative filter based on the comprehensive performance index, which allows us to consider the H_∞, $L_2 - L_\infty$ and dissipativity in a uniform way.[24,32]

To efficiently utilize the network resources an adaptive event-triggering scheme is proposed, as compared with the existing research.[9,22] The designed adaptive event-triggering scheme is generalized with practical significance, by ensuring the desired performance of the filtering error while minimising network load. The new fuzzy stochastic LKF using fuzzy matrices with higher order integrals is created for the mode-dependent filters, producing less conservative results.

Problem Statement

System Model

Consider the following delayed networked stochastic system, which is represented using the IT-2 fuzzy technique, as illustrated in Fig. 1.

Plant Rulei: If $\nu_1(x(t))$is $\widetilde{M}_{i1}, \nu_2(x(t))$is $\widetilde{M}_{i2}$, ..., and $\nu_p(x(t))$ is $\widetilde{M}_{ip},\ldots$, we have

$$\begin{cases} \dot{x}(t) &= A_{\sigma(t)i}x(t) + A_{d_1\sigma(t)i}x(t-d_1(t)) + B_{\sigma(t)i}\omega(t), \\ y(t) &= C_{\sigma(t)i}x(t) + D_{\sigma(t)i}\omega(t), \\ z(t) &= E_{\sigma(t)i}x(t) + E_{d_1\sigma(t)i}x(t-d_1(t)) + F_{\sigma(t)i}\omega(t), \\ x(t) &= \bar{\psi}(t), t \in [-\bar{d}_1, 0] \end{cases} \quad \ldots(1)$$

where, $\nu_j(x(t))(j = 1,2,\cdots,p)$ presents the premise variable; $\widetilde{M}_{ik}(i \in \mathfrak{T} = 1,2,\cdots,r; k = 1,2,\cdots,p)$ is the $IT-2$ fuzzy set with *r* rules $x(t) \in \Re^{n_x}$ and $y(t) \in \Re^{n_y}$ are the system state vector and the output vector;

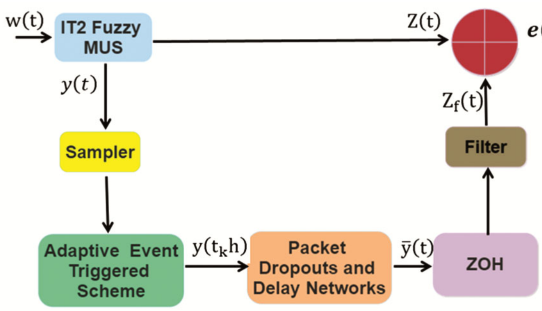

Fig. 1 — A typical filtering for fuzzy NMJSs with the adaptive event-triggered mechanism

$\omega(t) \in \Re^{n_\omega}$ is the exogenous disturbance that belongs to $l_2[0,\infty)$;

$z(t) \in \Re^{n_z}$ is the signal to be estimated;

$\bar{\phi}(t)$ is a continuous vector-valued initial function on $[-\bar{d}_1, 0]$

$\bar{d}_1(t) > 0$ is the state delay of the system

$A_{\sigma(t)i}, A_{d_1\sigma(t)i}, B_{\sigma(t)i}, C_{\sigma(t)i}, D_{\sigma(t)i}, E_{\sigma(t)i}, E_{d_1\sigma(t)i}, F_{\sigma(t)i}$ are properly dimensioned matrices of system parameters

σ_t shows a homogeneous Markov–jump process with finite states within a set M = 1, 2,⋯, N, and follows the probability matrix of transitions

$\Psi = \{\pi_{\mathfrak{d}\mathfrak{w}}\}$ based on the outcomes of

$$Pr\{\sigma(t+\Delta t) = \mathfrak{m} | \sigma(t) = \mathfrak{d}\} = \begin{cases} \pi_{\mathfrak{d}\mathfrak{w}} + o(\Delta t), \mathfrak{d} \neq \mathfrak{w}, \\ 1 + \pi_{\mathfrak{d}\mathfrak{w}} + o(\Delta t), \mathfrak{d} = \mathfrak{w} \end{cases} \quad \ldots(2)$$

where, $lim_{\Delta t \to 0}\left(\frac{o(\Delta t)}{\Delta t}\right) = 0, (\Delta t > 0)$,

$\pi_{\mathfrak{d}\mathfrak{w}} \geq 0$ represents the transition rate from mode $\mathfrak{d}$ to $\mathfrak{w}$ at time $(t+\Delta t)$ if $\mathfrak{d} \neq \mathfrak{w}$ and $\pi_{\mathfrak{d}\mathfrak{d}} = -\sum_{\mathfrak{w} \in M, \mathfrak{w} \neq \mathfrak{d}} \pi_{\mathfrak{d}\mathfrak{w}}$.

New Event-triggered Scheme Under the Miss-measurement Concept

In order to save network resources, the following is a new adaptive event-triggered scheme

$$\hat{e}_k^T(t)\Omega_1\hat{e}_k(t) \geq \mathrm{v}(t)y^T(t_k h)\Omega_2 y(t_k h) \quad \ldots(3)$$

where, $\hat{e}_k(t) = y(t_k h) - y(i_k h)$, Ω_1 and Ω_2 are positive scalars. Moreover, $\mathrm{v}(t)$ is a function satisfying

$$\dot{\mathrm{v}}(t) = \frac{1}{\mathrm{v}(t)}\left[\frac{1}{\mathrm{v}(t)} - \varphi\right] e_k^T(t)\Omega_1 e_k(t) \quad \ldots(4)$$

After that, the initial value of *v*(*t*) can be chosen, and φ, is a positive scalar. The sampling period is assumed to be h. The next transmission instant $t_{(k+1)}$ h according to system (3), is

$$t_{k+1}h = t_k h + min_{lblue \leq 1}$$

$$\{lh | e_k^T(t)\Omega_1 e_k(t) \geq \mathrm{v}(t)y^T(t_k h)\Omega_2 y(t_k h)\}$$

where, $e_k(t) = y(t_k h) - y(t_k h + lh)$.

Asynchronous Fuzzy Filter

The delayed fuzzy asynchronous filter described below is intended to predict the unknown signal produced by the original system.

Filter

Rule

j: If $\theta_1(x(t))$ is $\tilde{N}_{j1}, \theta_2(x(t))$ is $\tilde{N}_{j2}, \cdots$, and $\theta q(x(t))$ is $\tilde{N}_{jq}$, we have

$$\begin{cases} \dot{x}_f(t) &= A_{\mathfrak{d}fj}x_f(t) + A_{d_2\mathfrak{d}fj}x_f(t - d_2(t)) + B_{\mathfrak{d}fj}y_f(t), \\ z_f(t) &= E_{\mathfrak{d}fj}x_f(t) + E_{d_2\mathfrak{d}fj}x_f(t - d_2(t)) + F_{\mathfrak{d}fj}y_f(t), \\ x_f(t) &= \bar{\psi}_f(t), t \in [-\bar{d}_2, 0] \end{cases} \quad \ldots(5)$$

where,

$x_f(t) \in \Re^{nx}$ represents the filter state vector,
$y_f(t) \in \Re^{ny}$ represents the input, and
$z_f(t) \in \Re^{nz}$ represents the estimation of $z(t)$.

The initial condition is $\bar{\psi}_f(t)$, and the delay in the filter state is $d_2(t)$.

The filter matrices are $\mathbb{A}_{\mathfrak{d}fj}, \mathbb{A}_{d_2\mathfrak{d}fj}, \mathbb{B}_{\mathfrak{d}fj}, \mathbb{E}_{\mathfrak{d}fj}, \mathbb{E}_{d_2\mathfrak{d}fj}$ and $\mathbb{F}_{\mathfrak{d}fj}$. $\tilde{N}_{jb}$ represents the IT − 2 fuzzy set, with $j \in \zeta = 1,2,\cdots,r$.

The premise variable is $\theta_b(x(t))(b = 1,2,\cdots,q)$ and the number of fuzzy sets is q. The following is a representation of the fuzzy filter:

$$\begin{cases} \dot{x}_f(t) = \sum_{j=1}^{r} \bar{\lambda}_j(x(t))[A_{\mathfrak{d}fj}x_f(t) + A_{d_2\mathfrak{d}fj}x_f(t - d_2(t)) + B_{\mathfrak{d}fj}y_f(t)], \\ z_f(t) = \sum_{j=1}^{r} \bar{\lambda}_j(x(t))[E_{\mathfrak{d}fj}x_f(t) + E_{d_2\mathfrak{d}fj}x_f(t - d_2(t)) + F_{\mathfrak{d}fj}y_f(t)], \end{cases} \quad \ldots(6)$$

where,

$$\bar{\lambda}_j(x(t)) = l_j^U(x(t))\bar{\lambda}_j^U(x(t)) + l_j^L(x(t))\bar{\lambda}_j^L(x(t)) \geq 0$$

$$\textstyle\sum_{j=1}^{r} \bar{\lambda}_j(x(t)) = 1, 0 \leq l_j^L(x(t)), l_j^U(x(t)) \leq 1$$

and

$$l_j^L(x(t)) + l_j^U(x(t)) = 1.$$

In the next part, certain assumptions were made as follows

Assumption 1: Given matrices $\exists_0, \exists_1, \exists_2$, and $\exists_3$ fulfills the following conditions*:*

- $\exists_0 = \exists_0^T, \exists_1 = \exists_1^T$ and $\exists_3 = \exists_3^T$
- $\exists_0 \geq 0$ and $\exists_1 \leq 0$
- $(\| \exists_1 \| + \| \exists_2 \|) \, \| \exists_0 \| = 0$

Assumption 2: Time varying delays $d_u(t), u = 1,2$, satisfy:
$0 \leq d_u(t) \leq \bar{d}_u, \dot{d}_u(t) \leq \mu_u$
where, $\bar{d}_u > 0$ *and* μ_u are prescribed constant scalars.

Definition 1 Consider the matrices $\exists_0$, $\exists_1, \exists_2$, and $\exists_3$ which all satisfy Assumption 1. If there exists a scalar ρ such that the following inequality holds for any $t_f \geq 0$ and all $\widetilde{\omega}(t) \in l_2[0, \infty]$ resulting system (13) is said to be extended dissipative.

$$\Xi\left[\int_0^{t_f} \mathbb{J}(t)dt\right] - \sup_{0 \leq t \leq t_f} \Xi[\delta(t)^T \exists_0 \delta(t)] \geq \rho \qquad \ldots(7)$$

where,

$$\mathbb{J}(t) = \delta(t)^T \exists_1 \delta(t) + 2\delta(t)^T \exists_2 \widetilde{\omega}(t) + \widetilde{\omega}(t)^T \exists_3 \widetilde{\omega}(t).$$

Without jeopardising generality, we can assume that $\exists_0 = \tilde{\exists}_0^T \tilde{\exists}_0, \exists_1 = -\tilde{\exists}_1^T \tilde{\exists}_1$

Lemma 1 (Seuret and Gouaisbaut Zhang *et al.*[33]) The following inequality applies for a given positive and symmetric matrix

$\boldsymbol{G} > 0$ with appropriate dimension and various signal x over $[\mathfrak{a}, \mathfrak{b}] \to \mathbb{R}_n$:

$$-\int_{\mathfrak{a}}^{\mathfrak{b}} \dot{x}^T(\alpha)\mathbf{G}\dot{x}(\alpha)d\alpha \leq -\frac{1}{\mathfrak{b} - \mathfrak{a}} \begin{bmatrix} \dot{x}(\mathfrak{b}) \\ \dot{x}(\mathfrak{a}) \\ \nu \end{bmatrix}^T \begin{bmatrix} \grave{}a_1\mathbf{G} & \grave{}a_2\mathbf{G} & \grave{}a_3\mathbf{G} \\ \star & \grave{}a_1\mathbf{G} & \grave{}a_3\mathbf{G} \\ \star & \star & \grave{}a_4\mathbf{G} \end{bmatrix} \begin{bmatrix} \dot{x}(\mathfrak{b}) \\ \dot{x}(\mathfrak{a}) \\ \nu \end{bmatrix}$$

where,

$$(\grave{}a_1, \grave{}a_2, \grave{}a_3, \grave{}a_4) = (\frac{\pi^2}{4} + 1, \frac{\pi^2}{4} - 1, -\frac{\pi^2}{2}, \pi^2)$$

and $\nu = -\frac{1}{\mathfrak{b}-\mathfrak{a}} \int_{\mathfrak{a}}^{\mathfrak{b}} x(\alpha)d\alpha$

Main Results

Stability and extended dissipative performance requirements for error systems are first described in Zhang and Chen.[13] In the following section, we'll discuss delayed filter architecture.

Theorem 1$\tau_M, \varrho_ł, ł = 0, 1, 2, 3$ are positive constants. The filtering error system is therefore extended dissipative[13] for any time-varying delays
$d_u(t) u = 1,2$ satisfies Assumption 2 if matrices exist.
$\mathbb{G} > 0, P_{\mathfrak{d}i} > 0, Q_{k\mathfrak{d}i} > 0, R_{k\mathfrak{d}i} > 0, Z_{u\mathfrak{d}i} > 0, \begin{bmatrix} Z_{u\mathfrak{d}i} & G_u \\ \maltese & Z_{u\mathfrak{d}i} \end{bmatrix} > 0, G_u, Z_{3\mathfrak{d}i}, \Omega_u > 0 \; k = 1,2,3 \; and \; u = 1,2 \; such \; that \; \mathcal{Q}_i < 0, \mathcal{R}_i < 0, and \; \mathcal{Z}_i < 0$, *as well as the following inequalities, hold:*

$$\mathbb{G} - P_{\mathfrak{d}i} < 0 \qquad \ldots(8)$$

$$\begin{bmatrix} -\varrho_0\mathbb{G} & 0 & 0 & 0 & \tilde{E}_{\mathfrak{d}ij}^T \tilde{\exists}_0^T \\ \maltese & -\varrho_1\mathbb{G} & 0 & 0 & \tilde{E}_{\mathfrak{d}ij}^{1T} \tilde{\exists}_0^T \\ \maltese & \maltese & -\varrho_2\mathbb{G} & 0 & \tilde{E}_{\mathfrak{d}ij}^{2T} \tilde{\exists}_0^T \\ \maltese & \maltese & \maltese & -\varrho_3\mathbb{G} & \tilde{F}_{\mathfrak{d}ij}^T \tilde{\exists}_0^T \\ \maltese & \maltese & \maltese & \maltese & -I \end{bmatrix} < 0 \qquad \ldots(9)$$

$$\begin{bmatrix} \mathrm{F}_{ij} & \Gamma_{ij}^T & \psi_i^1 & \mathcal{A}_{ij}^T P_{\mathfrak{d}i} & \mathcal{E}_{ij}^T \tilde{\exists}_1^T \\ \maltese & -\exists_3 + J_2^T D_{\mathfrak{d}i}^T \Omega_2 D_{\mathfrak{d}i} J_2 & 0 & \tilde{B}_{\widetilde{\omega}}^T P_{\mathfrak{d}i} & \tilde{F}_{\widetilde{\omega}\mathfrak{d}ij} \tilde{\exists}_1^T \\ \maltese & \maltese & \psi_i^2 & 0 & 0 \\ \maltese & \maltese & \maltese & \mathbb{Z}_i - 2P_{\mathfrak{d}i} & 0 \\ \maltese & \maltese & \maltese & \maltese & -I \end{bmatrix} < 0 \qquad \ldots(10)$$

where,

$\mathrm{F}_{ij} = [(1,1) = (\dot{P}_{\mathfrak{d}i} + \mathrm{sym}\{P_{\mathfrak{d}i}\tilde{A}_{\mathfrak{d}ij}^1\} + \sum_{k=1}^3 \{Q_{k\mathfrak{d}i} + R_{k\mathfrak{d}i} + \bar{d}_k S_k\} - \grave{}a_1 Z_{3\mathfrak{d}i}),$

$(1,2) = P_{\mathfrak{d}i}\tilde{A}_{\mathfrak{d}ij}^1 - Z_{1\mathfrak{d}i} - G_1, (1,3) = G_1$

$(1,4) = P_{\mathfrak{d}i}\tilde{A}_{\mathfrak{d}ij}^2 - Z_{2\mathfrak{d}i} - G_2, (1,5) = G_2,$

$(1,6) = P_{\mathfrak{d}i}\tilde{B}_{\mathfrak{d}ij} - \grave{}a_1 Z_{3\mathfrak{d}i}, (1,8) = P_{\mathfrak{d}i}\tilde{B}_{e\mathfrak{d}ij}$

$(2,2) = (1 - \mu_1)Q_{1\mathfrak{d}i} - 2Z_{1\mathfrak{d}i} + \mathrm{sym}\{G_1\},$

$(2,3) = Z_{1\mathfrak{d}i} - G_1, (3,3) = -Z_{1\mathfrak{d}i} - R_{1\mathfrak{d}i}$

$(4,4) = (1 - \mu_2)Q_{2\mathfrak{d}i} - 2Z_{2\mathfrak{d}i} + \mathrm{sym}\{G_2\},$

$(4,5) = Z_{2\mathfrak{d}i} - G_2, (5,5) = -Z_{2\mathfrak{d}i} - R_{2\mathfrak{d}i}$

$(6,6) = J_1^T C_{\mathfrak{d}i}^T \Omega_2 C_{\mathfrak{d}i} J_1 - 2\grave{}a_1 Z_{3\mathfrak{d}i},$

$(6,7) = -\grave{}a_2 Z_{3\mathfrak{d}i}, (6,8) = J_1^T C_{\mathfrak{d}i}^T \Omega_2$

$(7,7) = -\grave{}a_1 Z_{3\mathfrak{d}i}, (8,8) = -(\varphi\Omega_1 - \Omega_2)]$

$$\Gamma_{ij} = \begin{bmatrix} (-\exists_2^T \tilde{E}_{\mathfrak{d}ij} + \tilde{B}_{\widetilde{\omega}\mathfrak{d}ij}^T P_{\mathfrak{d}i}) & -\exists_2^T \tilde{E}_{\mathfrak{d}ij}^1 & 0 & -\exists_2^T \tilde{E}_{\mathfrak{d}ij}^2 \\ 0 & (-\exists_2^T \tilde{F}_{\mathfrak{d}ij} + J_1^T C_{\mathfrak{d}i}^T \Omega_2 D_{\mathfrak{d}i} J_2) 0 & (-\exists_2^T \tilde{B}_{e\mathfrak{d}ij} + \Omega_2 D_{\mathfrak{d}i} J_2) \end{bmatrix}$$

$$\mathcal{A}_{ij} = \begin{bmatrix} \tilde{A}_{\mathfrak{d}ij} & \tilde{A}_{\mathfrak{d}ij}^1 & 0 & \tilde{A}_{\mathfrak{d}ij}^2 & 0 & \tilde{B}_{\mathfrak{d}ij} & 0 & \tilde{B}_{e\mathfrak{d}ij} \end{bmatrix},$$

$$\mathcal{E}_{ij} = \begin{bmatrix} \tilde{E}_{\mathfrak{d}ij} & \tilde{E}_{\mathfrak{d}ij}^1 & 0 & \tilde{E}_{\mathfrak{d}ij}^2 & 0 & \tilde{F}_{\mathfrak{d}ij} & 0 & \tilde{F}_{e\mathfrak{d}ij} \end{bmatrix}$$

$$\psi_i^1 = \begin{bmatrix} \psi_i^a & \psi_i^b \end{bmatrix},$$

$$\psi_i^a = \mathrm{col}\begin{bmatrix} \underbrace{0 \cdots 0}_{5} & -\grave{}a_3 Z_{3\mathfrak{d}i} & -\grave{}a_3 Z_{3\mathfrak{d}i} & 0 \end{bmatrix}$$

ψ_i^b = "col" $\left[-`a_3Z_{3\mathfrak{d}i} \quad \underbrace{0\cdots0}_{4} \quad -`a_3Z_{3\mathfrak{d}i} \quad 0 \quad 0\right]$

ψ_i^2 = "diag" $\{-`a_4Z_{3\mathfrak{d}i}, -`a_4Z_{3\mathfrak{d}i}\}$

Proof: Due to the limitation of pages, the authors omitted the proof section.

Assumption 3: *There are real constant scalars* β_i *with the property that* $\bar{h}_i \le \beta_i, i = 1,\cdots,r.$

The Delayed Filter Design

As some of the matrixes above are not convex items, the Matlab toolbox does not yet allow the extraction of the filter parameter matrices based on the extended dissipative conditions. As a result, a mechanism is presented for designing filters in which the parameters fulfill linear matrix inequalities *(LMIs)*.

Theorem 2

$\tau_M, \varrho_{ł}, ł = 0, 1, 2, 3$ are positive constants. The filtering error system (13) is the next ended dissipative[13] for any time-varying delay $sd_u(t)u = 1{,}2$ satisfies the Assumption 2, if there exist matrices

$\mathbb{G} > 0, P_{\mathfrak{d}i} > 0, Q_{k\mathfrak{d}i} > 0, R_{k\mathfrak{d}i} > 0,$
$Z_{u\mathfrak{d}i} > 0, G_u, Z_{3\mathfrak{d}i}, \Omega_u > 0$ *such that* $\mathfrak{L}_0, \mathfrak{L}_k, \mathfrak{K}_k, \mathcal{O}_k,$
$\hat{A}_{\mathfrak{d}fj}, \hat{A}_{d_2\mathfrak{d}fj}, \hat{B}_{\mathfrak{d}fj}, \hat{E}_{\mathfrak{d}fj}, \hat{E}_{d_2\mathfrak{d}fj}, \hat{F}_{\mathfrak{d}fj},$

$$\begin{bmatrix} Z_{u\mathfrak{d}i} & G_u \\ \maltese & Z_{u\mathfrak{d}i} \end{bmatrix} > 0, \textit{and } k = 1,2,3 \textit{ and } u = 1,2 \textit{ and}$$

the following inequalities apply:

$$\mathbb{G} - \text{Ꮧ}_i < 0, \begin{bmatrix} Z_{u\mathfrak{d}i} & G_u \\ \maltese & Z_{u\mathfrak{d}i} \end{bmatrix} > 0, (P_{\mathfrak{d}i} + \mathfrak{L}_0) > 0 \quad \ldots(11)$$

$$\begin{cases} \sum_{i=1}^{r} \beta_i \left(\sum_{\mathfrak{w}=1}^{N} \pi_{\mathfrak{d}\mathfrak{w}} (Q_{k\mathfrak{d}i} + R_{k\mathfrak{d}i} + \mathfrak{L}_k) \right) - S_k < 0 \\ (Q_{k\mathfrak{d}i} + R_{k\mathfrak{d}i} + \mathfrak{L}_k) > 0 \end{cases} \quad \ldots(12)$$

$$\begin{cases} \sum_{i=1}^{r} \beta_i (\sum_{\mathfrak{w}=1}^{N} \pi_{\mathfrak{d}\mathfrak{w}} (R_{k\mathfrak{d}i} + \mathfrak{K}_k)) - S_k < 0 \\ (R_{k\mathfrak{d}i} + \mathfrak{K}_k) > 0 \end{cases} \quad \ldots(13)$$

$$\begin{cases} \sum_{i=1}^{r} \beta_i (\sum_{\mathfrak{w}=1}^{N} \pi_{\mathfrak{d}\mathfrak{w}} (Z_{k\mathfrak{d}i} + \mathfrak{O}_k)) - \bar{d}_k^{-1} W_k < 0 \\ (Z_{k\mathfrak{d}i} + \mathfrak{O}_k) > 0 \end{cases} \quad \ldots(14)$$

$$\perp_{ij} + \perp_{ji} < 0, i \le j \quad \ldots(15)$$

$$\top_{ij} + \top_{ji} < 0, i \le j \quad \ldots(16)$$

where,

$$\perp_{ij} = \begin{bmatrix} -\varrho_0\mathbb{G} & 0 & 0 & 0 & \bar{\mathcal{E}}_{\mathfrak{d}ij}\mathfrak{Z}_0^T \\ \maltese & -\varrho_1\mathbb{G} & 0 & 0 & \bar{\mathcal{E}}_{\mathfrak{d}ij}^1\mathfrak{Z}_0^T \\ \maltese & \maltese & -\varrho_2\mathbb{G} & 0 & \bar{\mathcal{E}}_{d\mathfrak{d}ij}^{2T}\mathfrak{Z}_0^T \\ \maltese & \maltese & \maltese & -\varrho_3\mathbb{G} & \bar{F}_{\mathfrak{d}ij}^T\mathfrak{Z}_0^T \\ \maltese & \maltese & \maltese & \maltese & -I \end{bmatrix}$$

$$\top_{ij} = \begin{bmatrix} \bar{\text{F}}_{ij} & \bar{\Gamma}_{ij}^T & \psi_i^1 & \bar{\mathcal{A}}_{ij}^T & \bar{\mathcal{E}}_{ij}^T\mathfrak{Z}_1^T \\ \maltese & -\exists_3 + J_2^T D_{\mathfrak{d}i}^T \Omega_2 D_{\mathfrak{d}i} J_2 & 0 & \bar{B}_{\bar{\omega}\mathfrak{d}ij}^T & \bar{F}_{\mathfrak{d}ij}^T\mathfrak{Z}_1^T \\ \maltese & \maltese & \psi_i^2 & 0 & 0 \\ \maltese & \maltese & \maltese & \mathbb{Z}_i - 2\text{Ꮧ}_i & 0 \\ \maltese & \maltese & \maltese & \maltese & -I \end{bmatrix}$$

where,

$$\bar{\text{F}}_{ij} = [(\bar{1},\bar{1}) = \sum_{i=1}^{r} \left(\begin{bmatrix} I \\ 0 \end{bmatrix} \beta_i (\sum_{\mathfrak{w}=1}^{N} \pi_{\mathfrak{d}\mathfrak{w}} (P_{\mathfrak{d}i} + \mathfrak{L}_0)) \begin{bmatrix} I & 0 \end{bmatrix} \right) + \text{"sym"}\{\bar{A}_{\mathfrak{d}ij}\} + \sum_{k=1}^{3} \{Q_{k\mathfrak{d}i} + R_{k\mathfrak{d}i} + \bar{d}_k S_k\} - `a_1 Z_{3\mathfrak{d}i}$$

$(\bar{1},\bar{2}) = \bar{A}_{\mathfrak{d}ij}^1 - Z_{1\mathfrak{d}i} - G_1,$

$(\bar{1},\bar{4}) = \bar{A}_{\mathfrak{d}ij}^2 - Z_{2\mathfrak{d}i} - G_2,$

$(\bar{1},\bar{6}) = \bar{B}_{\mathfrak{d}ij} - `a_1 Z_{3\mathfrak{d}i},$

$(\bar{1},\bar{8}) = \bar{B}_{e\mathfrak{d}ij}, \text{Ꮧ}_i = \begin{bmatrix} P_{1\mathfrak{d}i} & -P_{2\mathfrak{d}i} \\ -P_{2\mathfrak{d}i} & P_{2\mathfrak{d}i} \end{bmatrix}$

$$\Gamma_{ij} = \begin{bmatrix} (-\exists_2^T \bar{\mathcal{E}}_{ij} + \bar{B}_{\mathfrak{d}ij}) & -\exists_2^T \bar{E}_{\mathfrak{d}ij}^1 & 0 & -\exists_2^T \bar{E}_{\mathfrak{d}ij}^2 \\ 0 & (-\exists_2^T \bar{F}_{\mathfrak{d}ij} + J_1^T C_{\mathfrak{d}i}^T \Omega_2 D_{\mathfrak{d}i} J_2) 0 & & (-\exists_2^T \bar{B}_{e\mathfrak{d}ij} + \Omega_2 D_{\mathfrak{d}i} J_2) \end{bmatrix}$$

$\bar{\mathcal{A}}_{ij} = \begin{bmatrix} \bar{A}_{\mathfrak{d}ij} & \bar{A}_{\mathfrak{d}ij}^1 & 0 & \bar{A}_{\mathfrak{d}ij}^2 & 0 & \bar{B}_{\mathfrak{d}ij} & 0 & \bar{B}_{e\mathfrak{d}ij} \end{bmatrix},$

$\mathcal{E}_{ij} = \begin{bmatrix} \bar{E}_{\mathfrak{d}ij} & \bar{E}_{\mathfrak{d}ij}^1 & 0 & \bar{E}_{\mathfrak{d}ij}^2 & 0 & \bar{F}_{\mathfrak{d}ij} & 0 & \bar{F}_{e\mathfrak{d}ij} \end{bmatrix}$

$\bar{A}_{\mathfrak{d}ij} = \begin{bmatrix} P_{1\mathfrak{d}i}A_{\mathfrak{d}i} & -\hat{A}_{\mathfrak{d}fj} \\ -P_{1\mathfrak{d}i}A_{\mathfrak{d}i} & \hat{A}_{\mathfrak{d}fj} \end{bmatrix},$

$\bar{A}_{\mathfrak{d}ij}^1 = \begin{bmatrix} P_{1\mathfrak{d}i}A_{d_1\mathfrak{d}i} & 0 \\ -P_{2\mathfrak{d}i}A_{d_1\mathfrak{d}i} & 0 \end{bmatrix},$

$\bar{A}_{\mathfrak{d}ij}^2 = \begin{bmatrix} 0 & \hat{A}_{d_2\mathfrak{d}fj} \\ 0 & \hat{A}_{d_2\mathfrak{d}fj} \end{bmatrix}$

]

$\bar{B}_{1\mathfrak{d}ij} = \begin{bmatrix} -\hat{B}_{\mathfrak{d}fj}C_{\mathfrak{d}i} & 0 \\ \hat{B}_{\mathfrak{d}fj}C_{\mathfrak{d}i} & 0 \end{bmatrix},$

$\bar{B}_{2\mathfrak{d}ij} = \begin{bmatrix} -\tilde{\Xi}\hat{B}_{\mathfrak{d}fj}C_{\mathfrak{d}i} & 0 \\ \tilde{\Xi}\hat{B}_{\mathfrak{d}fj}C_{\mathfrak{d}i} & \tilde{\Xi}\hat{B}_{\mathfrak{d}fj}C_{\mathfrak{d}i} \end{bmatrix},$

$\bar{B}_{1e\mathfrak{d}ij} = \begin{bmatrix} -\hat{B}_{\mathfrak{d}fj} \\ \hat{B}_{\mathfrak{d}fj} \end{bmatrix}$

$$\bar{B}_{1\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} 0 & -\tilde{\Xi}\hat{B}_{\mathfrak{d}fj}D_{\mathfrak{d}i} \\ 0 & \tilde{\Xi}\hat{B}_{\mathfrak{d}fj}D_{\mathfrak{d}i} \end{bmatrix},$$

$$\bar{B}_{2\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} P_{1\mathfrak{d}i}B_{\mathfrak{d}i} & -\hat{B}_{\mathfrak{d}fj}D_{\mathfrak{d}i} \\ -P_{2\mathfrak{d}i}B_{\mathfrak{d}i} & \hat{B}_{\mathfrak{d}fj}D_{\mathfrak{d}i} \end{bmatrix},$$

$$\bar{B}_{2e\mathfrak{d}ij} = \begin{bmatrix} -\tilde{\Xi}\hat{B}_{\mathfrak{d}fj} \\ \tilde{\Xi}\hat{B}_{\mathfrak{d}fj} \end{bmatrix}$$

$$\bar{\mathcal{E}}_{ij} = \begin{bmatrix} E_{\mathfrak{d}i}^T \\ -\hat{E}_{\mathfrak{d}fj} \end{bmatrix}, \bar{\mathcal{E}}_{ij}^1 = \begin{bmatrix} E_{d_1\mathfrak{d}i}^T \\ 0 \end{bmatrix}, \bar{\mathcal{E}}_{ij}^2 = \begin{bmatrix} 0 \\ -\hat{E}_{d_2\mathfrak{d}fi}^T \end{bmatrix},$$

$$\bar{F}_{1\mathfrak{d}ij} = \begin{bmatrix} -C_{\mathfrak{d}i}^T\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix}, \bar{F}_{2\mathfrak{d}ij} = \begin{bmatrix} -\Xi C_{\mathfrak{d}i}^T\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix}$$

$$\bar{F}_{1e\mathfrak{d}ij} = \begin{bmatrix} -\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix}, \bar{F}_{2e\mathfrak{d}ij} = \begin{bmatrix} -\Xi\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix},$$

$$\bar{F}_{1\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} -D_{\mathfrak{d}i}^T\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix}, \bar{F}_{2\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} -\Xi D_{\mathfrak{d}i}^T\hat{F}_{\mathfrak{d}fj}^T \\ 0 \end{bmatrix}$$

$$\bar{B}_{\mathfrak{d}ij} = \begin{bmatrix} f\bar{B}_{1\mathfrak{d}ij} & \bar{B}_{2\mathfrak{d}ij} \end{bmatrix}, \bar{B}_{e\mathfrak{d}ij} = \begin{bmatrix} f\bar{B}_{1e\mathfrak{d}ij} & \bar{B}_{2e\mathfrak{d}ij} \end{bmatrix},$$

$$\bar{B}_{\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} f\bar{B}_{1\bar{\omega}\mathfrak{d}ij} & \bar{B}_{2\bar{\omega}\mathfrak{d}ij} \end{bmatrix}$$

$$\bar{F}_{\mathfrak{d}ij} = \begin{bmatrix} f\bar{F}_{1\mathfrak{d}ij} & \bar{F}_{2\mathfrak{d}ij} \end{bmatrix},$$

$$\bar{F}_{e\mathfrak{d}ij} = \begin{bmatrix} f\bar{F}_{1e\mathfrak{d}ij} & \bar{F}_{2e\mathfrak{d}ij} \end{bmatrix},$$

$$\bar{F}_{\bar{\omega}\mathfrak{d}ij} = \begin{bmatrix} f\bar{F}_{1\bar{\omega}\mathfrak{d}ij} & \bar{F}_{2\bar{\omega}\mathfrak{d}ij} \end{bmatrix}$$

The remaining parameters are identical to those provided in this section's Theorem 1.

Proof: Due to the limitation of pages, the authors omitted the proof section.

A Numerical Example

We present a tunnel diode model to demonstrate the use of adaptive event-triggered control and to verify the theoretical results presented in this paper. The IT type-2 fuzzy plant of tunnel diode circuits can be demonstrated using two jump modes and two fuzzy rules Li *et al.*[26], Park *et al.*[34]

$$\begin{cases} \dot{x}(t) = \sum_{i=1}^{r} \bar{h}_i(x(t))[A_{\mathfrak{d}i}x(t) + A_{d_1\mathfrak{d}i}x(t-d_1(t)) + B_{\mathfrak{d}i}\omega(t)], \\ y(t) = \sum_{i=1}^{r} \bar{h}_i(x(t))[C_{\mathfrak{d}i}x(t) + D_{\mathfrak{d}i}\omega(t)], \\ z(t) = \sum_{i=1}^{r} \bar{h}_i(x(t))[E_{\mathfrak{d}i}x(t) + E_{d_1\mathfrak{d}i}x(t-d_1(t)) + F_{\mathfrak{d}i}\omega(t)], \end{cases} \quad \ldots(17)$$

and the systems matrices are given by:

$$\begin{bmatrix} A_{11} & A_{12} & A_{d_111} & A_{d_112} \\ A_{21} & A_{22} & A_{d_121} & A_{d_122} \end{bmatrix} = \begin{bmatrix} -0.1 & 50 & -13.6 & 50 & 0.5 & 0.6 & -4.5 & 5 \\ -1 & -10 & -1 & -10 & -0.1 & -0.8 & -3.9 & -5 \\ -0.11 & 50.1 & -4.5 & 50 & 0.2 & 0.9 & -3.5 & 2.1 \\ -1 & -10 & -1 & -10 & -0.3 & -0.2 & 0.3 & 0 \end{bmatrix}$$

$$\begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} = \begin{bmatrix} 0.95 & 0 & 1 & 0 \\ 1.1 & 0 & 0.1 & 0 \end{bmatrix}, D_{11} = D_{12} = D_{21} = D_{22} = 1$$

$$\begin{bmatrix} E_{11} & E_{12} & E_{d_111} & E_{d_112} \\ E_{21} & E_{22} & E_{d_121} & E_{d_122} \end{bmatrix} = \begin{bmatrix} 0.9 & 0 & 1 & 0 & 0.1 & 0 & 0.6 & 0 \\ 1.1 & 0 & 1.2 & 0 & 0.5 & 0 & 0.2 & 0 \end{bmatrix}$$

$$\begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix} = \begin{bmatrix} 1 & 0.9 \\ 1.1 & 1.2 \end{bmatrix}$$

Let's consider the matrix of mode transmission probabilities as follows:

$$\pi = \begin{bmatrix} -0.3 & 0.3 \\ 0.4 & -0.4 \end{bmatrix}$$

In the original system and filter as mentioned, membership is the same as in the original system Li *et al.*[26] Moreover, we choose an initial adaptive event â€ "triggered parameter $(\upsilon_0, \varphi) = (0.25, 0.15)$. we consider the time delay to be a function of:

$$d_i(t) = \frac{\bar{d}_i + \bar{d}_i \sin(2\mu_i t/\bar{d}_i)}{2}, i = 1,2$$

where, $(\bar{d}_1, \bar{d}_2) = (0.75, 1.15)$ and $(\mu_1, \mu_2) = (0.35, 0.45)$. Based on this evidence, the assumption 2 is satisfied. It is further assumed that the external disturbance takes the following form:

$$\omega(t) = \begin{cases} 0.25\sin(3t^2 + 0.8) + 0.2, & 2.5 \le t \le 6 \\ 0, & \text{"otherwise"} \end{cases}$$

By selecting the initial condition as

$\bar{\phi} = [-0.1, 0.1]^T$ and $\bar{\phi}_f = [0.1, -0.1]^T$.

The algorithms are subsequently demonstrated in 3 cases to demonstrate their effectiveness. H_∞ fuzzy filters, dissipative fuzzy filters, and $L_2 - L_\infty$ fuzzy filters will be discussed. Our approach to address the LMI criteria in Theorem 2 imply that

$(\beta_1, \beta_2) = 100$ and $(\varrho_0, \varrho_1, \varrho_2, \varrho_3) = 0.25$.

Case-A:

***H_∞* filtering**: Suppose $\exists_0 = 0, \exists_1 = -1, \exists_2 = 0$ and $\exists_3 = \gamma^2$, where $\gamma = 3.5$ with $(\bar{\Xi}, \tau_M) = (0.45, 0.70)$. The LMIs (11)–(16) are then determined to be feasible, and the viable solutions to those LMIs are derived as follows:

$$\begin{bmatrix} A_{f11} & A_{f12} \\ A_{f21} & A_{f22} \end{bmatrix} = \begin{bmatrix} -3.3255 & -63.6208 & -1.2046 & 0.5466 \\ 1.9570 & -4.8250 & -0.0242 & -0.5301 \\ 1.2046 & -0.5467 & -16.0080 & -43.0674 \\ 0.0242 & 0.5301 & 3.4775 & -9.4193 \end{bmatrix} \begin{bmatrix} A_{d_2f11} & A_{d_2f12} \\ A_{d_2f21} & A_{d_2f22} \end{bmatrix} = \begin{bmatrix} 0.3823 & 0.1068 & -0.2263 & -0.0214 \\ 0.0622 & 0.3012 & -0.0766 & -0.4578 \\ 0.2263 & 0.0214 & -0.4138 & 0.5057 \\ 0.0766 & 0.4578 & -0.0327 & -0.2044 \end{bmatrix}$$

$$\begin{bmatrix} B_{f11} & B_{f12} \\ B_{f21} & B_{f22} \end{bmatrix} = \begin{bmatrix} 17.0842 & 15.1481 \\ -1.5722 & -14.2351 \\ -3.7507 & -1.7278 \\ 14.2405 & 2.0690 \end{bmatrix}$$

$$\begin{bmatrix} E_{f11} & E_{f12} \\ E_{f21} & E_{f22} \end{bmatrix} = \begin{bmatrix} -0.0879 & 0.0098 & -0.0647 & -0.1994 \\ -0.0879 & 0.0098 & -0.0647 & -0.1994 \end{bmatrix}$$

$$\begin{bmatrix} E_{d_2f11} & E_{d_2f12} \\ E_{d_2f21} & E_{d_2f22} \end{bmatrix} = \begin{bmatrix} -0.0835 & 0.0093 & -0.0614 & -0.1895 \\ -0.0835 & 0.0093 & -0.0614 & -0.1895 \end{bmatrix}$$

$$\begin{bmatrix} F_{f11} & F_{f12} \\ F_{f21} & F_{f22} \end{bmatrix} = \begin{bmatrix} 0.0064 & 0.0293 \\ 0.0079 & -0.0387 \end{bmatrix}, \begin{bmatrix} \Omega_1 & \Omega_2 \end{bmatrix} = \begin{bmatrix} 6.1286 & 1.1523 \end{bmatrix}$$

The system modes are also explained in Fig. 2. A filtering system's estimation of its state is shown in Figs 3(a) & 3(b). By looking at the graph, it can be observed that the system reaches a point of no return, demonstrating the effectiveness of the H_∞ filter. As shown in Fig. 3(c)the event-triggering schemes represent the instants and intervals when they are released.

Case-B: Dissipative filtering: Suppose $\exists_0 = 0, \exists_1 = -1, \exists_2 = 1$ and $\exists_3 = \gamma$, where $\gamma = 3.5$ with $(\bar{\Xi}, \tau_M) = (0.45, 0.60)$. The LMIs (11)–(16) are then discovered to be feasible, and the viable solutions to those LMIs are obtained as follows:

$$\begin{bmatrix} A_{f11} & A_{f12} \\ A_{f21} & A_{f22} \end{bmatrix} = \begin{bmatrix} -27.1246 & -5.1841 & 3.1767 & 0.5210 \\ 15.6361 & -37.5486 & 0.2443 & 4.8081 \\ -3.1777 & -0.5289 & -12.6618 & -33.6916 \\ -0.2439 & -4.8094 & 28.8825 & -73.4679 \end{bmatrix}$$

$$\begin{bmatrix} A_{d_2f11} & A_{d_2f12} \\ A_{d_2f21} & A_{d_2f22} \end{bmatrix} = \begin{bmatrix} 0.3473 & -0.0518 & -0.1998 & -0.0054 \\ 0.0624 & 0.1081 & -0.0143 & -0.4451 \\ -0.2113 & -0.0064 & -0.3364 & -0.1805 \\ -0.0097 & -0.2429 & 0.0303 & -0.3429 \end{bmatrix}$$

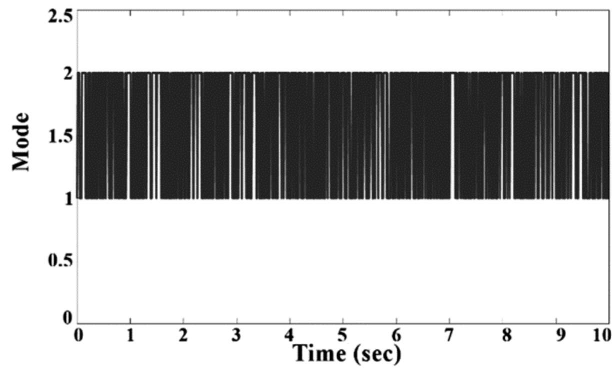

Fig. 2 — Stochastic process

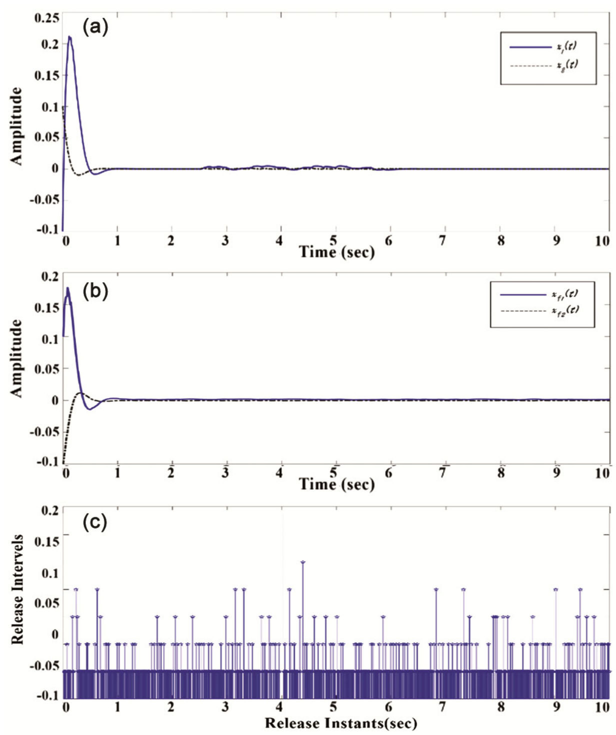

Fig. 3 — State estimation and triggering response

$$\begin{bmatrix} B_{f11} & B_{f12} \\ B_{f21} & B_{f22} \end{bmatrix} = \begin{bmatrix} 13.5566 & 12.8712 \\ -12.8265 & -11.7979 \\ -30.3966 & -13.6101 \\ 11.7511 & 17.1649 \end{bmatrix}$$

$$\begin{bmatrix} E_{f11} & E_{f12} \\ E_{f21} & E_{f22} \end{bmatrix} = \begin{bmatrix} 0.6080 & 0.1317 & 5.5281 & 3.5540 \\ 0.7184 & 0.2457 & 6.1834 & 2.7889 \end{bmatrix}$$

$$\begin{bmatrix} E_{d_2f11} & E_{d_2f12} \\ E_{d_2f21} & E_{d_2f22} \end{bmatrix} = \begin{bmatrix} 0.1021 & -0.4027 & -0.4699 & -0.0696 \\ 0.0127 & -0.0501 & -0.2643 & -0.0391 \end{bmatrix}$$

$$\begin{bmatrix} F_{f11} & F_{f12} \\ F_{f21} & F_{f22} \end{bmatrix} = \begin{bmatrix} 0.2909 & 0.5300 \\ 0.3117 & -0.2581 \end{bmatrix}, \begin{bmatrix} \Omega_1 & \Omega_2 \end{bmatrix} = \begin{bmatrix} 5.5687 & 2.3524 \end{bmatrix}$$

According to Fig. 4 (a), the filtering error approaches zero at the end of the filtering system. In Fig. 4 (b), we illustrate the images created by $\nu(t)$. Our simulations indicate that adaptive event-activated filtering can reduce the communication load in the channel as well as satisfy the system performance and metrics are shown in Table.1.

Case-C:

$L_2 - L_\infty$ filtering: **Case − C**: **$L_2 - L_\infty$ filtering**: Suppose $\exists_0 = 1, \exists_1 = 0, \exists_2 = 0$ and $\exists_3 = \gamma^2$, where, $\gamma = 3.5$ with $(\bar{\Xi}, \tau_M) = (0.25, 0.80)$. The LMIs (11)–(16) are then shown to be feasible, and the viable solutions to those LMIs are obtained as follows:

$$\begin{bmatrix} A_{f11} & A_{f12} \\ A_{f21} & A_{f22} \end{bmatrix} = \begin{bmatrix} -0.0501 & -1.1527 & -0.1436 & -9.0479 \\ 0.0323 & -0.0292 & 0.5314 & -1.1757 \\ -1.4264 & -8.6855 & -2.3913 & -6.1878 \\ 0.6909 & -0.7069 & 0.7023 & -1.6966 \end{bmatrix}$$

$$\begin{bmatrix} A_{d_2f11} & A_{d_2f12} \\ A_{d_2f21} & A_{d_2f22} \end{bmatrix} = \begin{bmatrix} 0.1020 & 0.0350 & -0.1482 & 0.0017 \\ 0.0097 & -0.0071 & -0.0056 & -0.0214 \\ -0.2113 & -0.0064 & -0.3364 & -0.1805 \\ -0.0097 & -0.2429 & 0.0303 & -0.3429 \end{bmatrix}$$

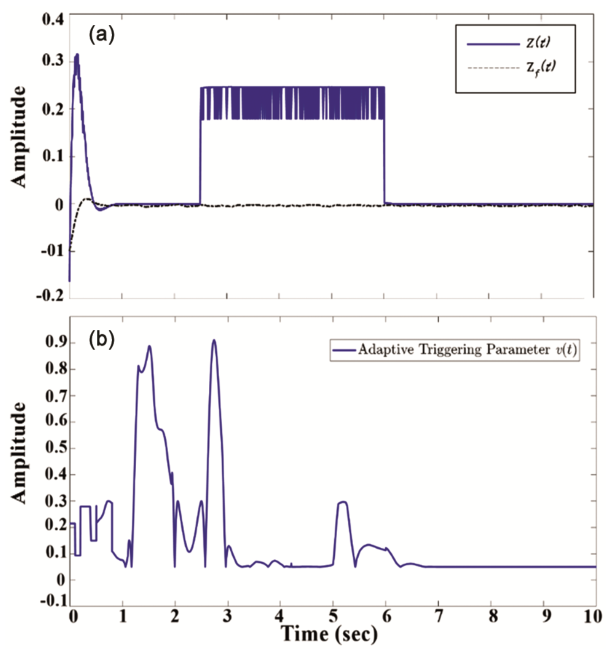

Fig. 4 — States response and adaptiver triggereing

$$\begin{bmatrix} B_{f11} & B_{f12} \\ B_{f21} & B_{f22} \end{bmatrix} = \begin{bmatrix} 2.4723 & 1.0331 \\ -0.2999 & -2.4963 \\ 0.8171 & -24.5827 \\ 2.5630 & -38.5398 \end{bmatrix}$$

$$\begin{bmatrix} E_{f11} & E_{f12} \\ E_{f21} & E_{f22} \end{bmatrix} = \begin{bmatrix} -0.6435 & 0.0754 & 4.0693 & 1.2125 \\ -0.8379 & -0.08514 & -2.4663 & 0.3205 \end{bmatrix}$$

$$\begin{bmatrix} E_{d_2f11} & E_{d_2f12} \\ E_{d_2f21} & E_{d_2f22} \end{bmatrix} = \begin{bmatrix} -0.0322 & 0.0038 & 0.2035 & 0.0606 \\ 0.2035 & 0.0606 & -0.4319 & 0.0347 \end{bmatrix}$$

$$\begin{bmatrix} F_{f11} & F_{f12} \\ F_{f21} & F_{f22} \end{bmatrix} = \begin{bmatrix} -0.7134 & 0.867400 \\ 0.0243 & -0.3618 \end{bmatrix}, \begin{bmatrix} \Omega_1 & \Omega_2 \end{bmatrix} = \begin{bmatrix} 3.4903 & 1.8278 \end{bmatrix}$$

The stochastic data missing in the error system is presented in Fig. 5(a)with the probability $\bar{\Xi} = 0.25$. The Fig. 5(b)demonstrates the estimating response $\delta(t)$of the error system that satisfies the $L_2 - L_\infty$ performance and summarized in Table 2.

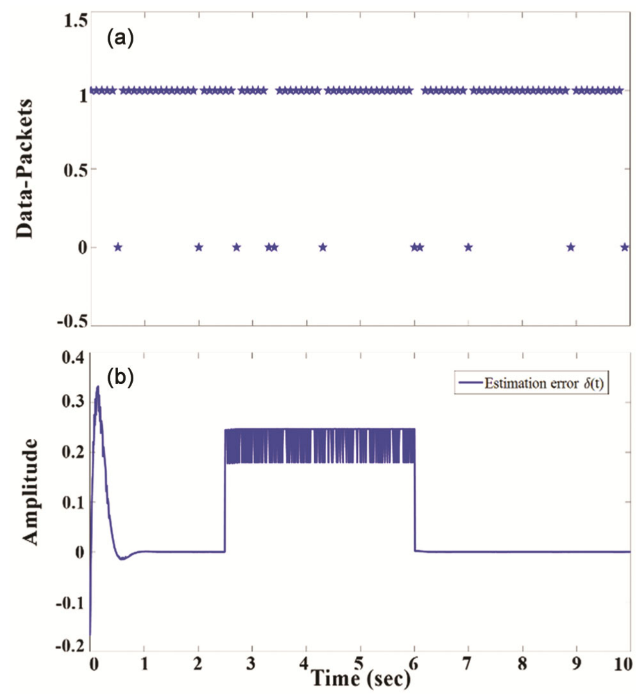

Fig. 5 — Packet loss with estimation error

Table 1 — Obtained H_∞ filtering performance for different τ_M

$black\tau_M$	0.1	0.2	0.3	0.4	0.5
Lu *et al.*[35]	0.3653	0.3662	0.3698	0.3701	0.3714
Theorem 2	0.1752	0.1783	0.1814	0.1837	0.1950

Table 2 — Obtained $L_2 - L_\infty$ filtering performance for different τ_M

τ_M	0.25	0.50	0.65	0.70	0.85
Theorem 3	10^{-3}	10^{-3}	10^{-3}	10^{-2}	10^{-2}

Conclusions

We investigated the dissipative filtering issues for the IT-2 fuzzy NMJSs employing an adaptive event-triggered strategy with time-varying delays. Also, $H_\infty, L_2 - L_\infty$, dissipativity and fuzzy filtering are explored. To cope with networked induced delay, the usual Seuret and Gouaisbaut lemma are applied. Additionally, two key elements are taken into account: packet loss and delay in filter state. The adaptive event-triggered strategy is used to minimise communication energy consumption while maintaining the system's extended dissipative performance. To demonstrate the algorithms' use, a tunnel diode circuit was employed. The computation complexity of the proposed algorithm is not effective, which will be investigated carefully in future. The proposed strategy will be expanded in future work to encompass a broader range of situations. Multi-agent systems with saturation of actuators or switching topologies.

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