

Xia, Xianzhong; Li, Renfa; An, Jiyao

On delay-fractional-dependent stability criteria for Takagi-Sugeno fuzzy systems with interval delay. (English) [Zbl 1407.93207](#)

Math. Probl. Eng. 2014, Article ID 370382, 13 p. (2014).

Summary: This paper investigates stability program of Takagi-Sugeno fuzzy systems with interval time-varying delay via a variable delay decomposition approach. By developing a delay decomposition approach, both lower and upper bound information of the delayed plant states can be taken into full consideration; two novel delay-fractional-dependent stability criteria are obtained based on the direct Lyapunov method allied with an appropriate and variable Lyapunov-Krasovskii functional choice and with two different bounding techniques to estimate some integral terms in the time-derivative of the Lyapunov-Krasovskii functional. The first stability criterion is derived by utilizing the suitable and generalized integral inequalities, while the second stability condition is obtained by employing a scalar inequality, without any direct approximation. Particularly, the proposed results differ from previous ones since the positiveness of the Lyapunov-Krasovskii functional is guaranteed by new relaxed conditions. When applying these two stability criteria to check the stability of a T-S fuzzy system, it is shown through some numerical examples that the first stability condition can provide a larger maximum allowable delay bound than the second stability criterion, and both stability criteria yield less conservative than the existing ones.

#### MSC:

[93C42](#) Fuzzy control/observation systems

[93D05](#) Lyapunov and other classical stabilities (Lagrange, Poisson,  $L^p$ ,  $l^p$ , etc.) in control theory

[34K20](#) Stability theory of functional-differential equations

[34K36](#) Fuzzy functional-differential equations

Full Text: [DOI](#)

#### References:

- [1] Gu, K.; Kharitonov, V. L.; Chen, J., Stability of Time-Delay Systems, (2003), Basel, Switzerland: Birkhäuser, Basel, Switzerland · [Zbl 1039.34067](#)
- [2] Takagi, T.; Sugeno, M., Fuzzy identification of systems and its applications to modeling and control, IEEE Transactions on Systems, Man and Cybernetics, 15, 1, 116-132, (1985) · [Zbl 0576.93021](#)
- [3] Cao, Y.-Y.; Frank, P. M., Stability analysis and synthesis of nonlinear time-delay systems via linear Takagi-Sugeno fuzzy models, Fuzzy Sets and Systems, 124, 2, 213-229, (2001) · [Zbl 1002.93051](#)
- [4] Tanaka, K.; Wang, H. O., Fuzzy Control Systems Design and Analysis: A Linear Matrix Inequality Approach, (2001), New York, NY, USA: John Wiley & Sons, New York, NY, USA
- [5] Li, L.; Liu, X.; Chai, T., New approaches on  $H_\infty$  control of T-S fuzzy systems with interval time-varying delay, Fuzzy Sets and Systems, 160, 12, 1669-1688, (2009) · [Zbl 1175.93127](#)
- [6] Lien, C. H.; Yu, K. W.; Chen, W. D.; Wan, Z. L.; Chung, Y. J., Stability criteria for uncertain Takagi-Sugeno fuzzy systems with interval time-varying delay, IET Control Theory & Applications, 1, 3, 764-769, (2007)
- [7] Tian, E.; Yue, D.; Zhang, Y., Delay-dependent robust  $H_\infty$  control for T-S fuzzy system with interval time-varying delay, Fuzzy Sets and Systems, 160, 12, 1708-1719, (2009) · [Zbl 1175.93134](#)
- [8] Peng, C.; Wen, L.-Y.; Yang, J.-Q., On delay-dependent robust stability criteria for uncertain T-S fuzzy systems with interval time-varying delay, International Journal of Fuzzy Systems, 13, 1, 35-44, (2011)
- [9] Peng, C.; Fei, M.-R., An improved result on the stability of uncertain T-S fuzzy systems with interval time-varying delay, Fuzzy Sets and Systems, 212, 97-109, (2013) · [Zbl 1285.93054](#)
- [10] Souza, F. O.; Campos, V. C. S.; Palhares, R. M., On delay-dependent stability conditions for Takagi-Sugeno fuzzy systems · [Zbl 1290.93130](#)
- [11] Souza, F. O.; Mozelli, L. A.; Palhares, R. M., On stability and stabilization of T-S fuzzy time-delayed systems, IEEE Transactions on Fuzzy Systems, 17, 6, 1450-1455, (2009)
- [12] An, J. Y.; Wen, G. L., Improved stability criteria for time-varying delayed T-S fuzzy systems via delay partitioning approach, Fuzzy Sets and Systems, 185, 1, 83-94, (2011) · [Zbl 1237.93156](#)

- [13] Peng, C.; Han, Q.-L., Delay-range-dependent robust stabilization for uncertain T-S fuzzy control systems with interval time-varying delays, *Information Sciences*, 181, 19, 4287-4299, (2011) · [Zbl 1242.93067](#)
- [14] An, J. Y.; Li, T.; Wen, G. L.; Li, R. F., New stability conditions for uncertain T-S Fuzzy systems with interval time-varying delay, *International Journal of Control, Automation and Systems*, 10, 3, 490-497, (2012)
- [15] Chadli, M.; Guerra, T. M., LMI solution for robust static output feedback control of Takagi-Sugeno fuzzy models, *IEEE Transactions on Fuzzy Systems*, 20, 6, 1160-1165, (2012)
- [16] Zhu, X.-L.; Yang, G.-H., Jensen integral inequality approach to stability analysis of continuous-time systems with time-varying delay, *IET Control Theory and Applications*, 2, 6, 524-534, (2008)
- [17] Mozelli, L. A.; Palhares, R. M.; Souza, F. O.; Mendes, E. M. A. M., Reducing conservativeness in recent stability conditions of TS fuzzy systems, *Automatica*, 45, 6, 1580-1583, (2009) · [Zbl 1166.93344](#)
- [18] Yang, Z.; Yang, Y.-P., New delay-dependent stability analysis and synthesis of T-S fuzzy systems with time-varying delay, *International Journal of Robust and Nonlinear Control*, 20, 3, 313-322, (2010) · [Zbl 1185.93071](#)
- [19] Chadli, M.; Abdo, A.; Ding, S. X.,  $H_{\infty}$  /  $H_2$  fault detection filter design for discrete-time Takagi-Sugeno fuzzy system, *Automatica*, 49, 7, 1996-2005, (2013) · [Zbl 1364.93420](#)
- [20] Saifia, D.; Chadli, M.; Labiod, S.; Karimi, H. R.,  $H_{\infty}$  fuzzy control of DC-DC converters with input constraint, *Mathematical Problems in Engineering*, 2012, (2012) · [Zbl 1264.93054](#)
- [21] Aouaouda, S.; Chadli, M.; Cocquemot, V.; Tarek Khadir, M., Multi-objective  $H_{\infty}$  /  $H_2$  faults detection observer design for Takagi-Sugeno fuzzy systems with unmeasurable premise variables: descriptor approach, *International Journal of Adaptive Control and Signal Processing*, 27, 12, 1031-1047, (2012) · [Zbl 1282.93153](#)
- [22] Aouaouda, S.; Chadli, M.; Tarek Khadir, M.; Bouarar, T., Robust fault tolerant tracking controller design for unknown inputs T-S models with unmeasurable premise variables, *Journal of Process Control*, 22, 5, 861-872, (2012)
- [23] Chadli, M.; Karimi, H. R., Robust observer design for unknown inputs Takagi-Sugeno models, *IEEE Transactions on Fuzzy Systems*, 21, 1, 158-164, (2013)
- [24] Zhang, X.-M.; Wu, M.; She, J.-H.; He, Y., Delay-dependent stabilization of linear systems with time-varying state and input delays, *Automatica*, 41, 8, 1405-1412, (2005) · [Zbl 1093.93024](#)
- [25] Chen, B.; Liu, X.; Tong, S., New delay-dependent stabilization conditions of T-S fuzzy systems with constant delay, *Fuzzy Sets and Systems*, 158, 20, 2209-2224, (2007) · [Zbl 1122.93048](#)
- [26] Liu, F.; Wu, M.; He, Y.; Yokoyama, R., New delay-dependent stability criteria for T-S fuzzy systems with time-varying delay, *Fuzzy Sets and Systems*, 161, 15, 2033-2042, (2010) · [Zbl 1194.93117](#)
- [27] Han, Q.-L.; Gu, K., Stability of linear systems with time-varying delay: a generalized discretized lyapunov functional approach, *Asian Journal of Control*, 3, 3, 170-180, (2001)
- [28] Liu, P.-L., Delay-range-dependent stability criteria for Takagi-Sugeno fuzzy systems with fast time-varying delays, *Journal of Applied Mathematics*, 2012, (2012) · [Zbl 1251.93073](#)
- [29] Zhao, Y.; Gao, H.; Lam, J.; Du, B., Stability and stabilization of delayed T-S fuzzy systems: a delay partitioning approach, *IEEE Transactions on Fuzzy Systems*, 17, 4, 750-762, (2009)
- [30] Sun, J.; Liu, G. P.; Chen, J.; Rees, D., Improved delay-range-dependent stability criteria for linear systems with time-varying delays, *Automatica*, 46, 2, 466-470, (2010) · [Zbl 1205.93139](#)
- [31] Briat, C., Convergence and equivalence results for the Jensen's inequality-application to time-delay and sampled-data systems, *IEEE Transactions on Automatic Control*, 56, 7, 1660-1665, (2011) · [Zbl 1368.26020](#)
- [32] Wu, Y.; Wu, Y.; Chen, Y., Mean square exponential stability of uncertain stochastic neural networks with time-varying delay, *Neurocomputing*, 72, 10-12, 2379-2384, (2009)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.