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Linear and Fuzzy Control Extensions of the Symmetrical Optimum Method

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Abstract: This paper deals with theoretical and applicative aspects concerning two extensions of the Symmetrical Optimum method (SO-m) for controller design focusing on speed and position control in mechatronics systems. The methods, introduced by the authors and called the Extended form of the Symmetrical Optimum method (ESO-m) and the Double parameterization of the Symmetrical Optimum method (2p-SO-m), are briefly presented. Due to the large applicability of the methods the authors elaborate and present some extensions to controllers with non-homogenous information processing with respect to the inputs and to fuzzy control solutions applications. Since the classical control algorithms are present in their different forms in a lot of practical applications (for example, in the electrical driving systems) the highlighted aspects are of permanent actuality.

Keywords: Double parameterization of the Symmetrical Optimum method, Extended form of the Symmetrical Optimum method, fuzzy control, mechatronics systems, non-homogenous dynamics.

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REFERENCES

Abiyev, R.H. and Kaynak, O. (2010). Type 2 fuzzy neural structure for identification and control of time-varying plants. *IEEE Transactions on Industrial Electronics*, 57 (12), 4147-4159.

Åström, K.J. and Hägglund, T. (1995). *PID Controllers Theory: Design and Tuning*. Instrument Society of America, Research Triangle Park, NC.

Bin, L. and David, J. H. (2010). Uniform stability and ISS of discrete-time impulsive hybrid systems. *Nonlinear Analysis: Hybrid Systems*, 4 (2), 319-333.

Cuesta, F. and Ollero, A. (2002). Stability analysis of fuzzy reactive navigation. *Preprints of 15th World Congress of IFAC (b'02)*, Barcelona, Spain, paper 1799, 6 pp.

Blažič, S., Matko, D., and Škrjanc I. (2010). Adaptive law with a new leakage term. *IET Control Theory and Applications*, 4 (9), 1533-1542.

Dimirovski, G.M. (2005). Fuzzy-Petri-net reasoning supervisory controller and estimating states of Markov chain models. *Computers and Artificial Intelligence*, 24 (6), 563-576.

Dimirovski, G.M. (2008). Complexity versus integrity solution in adaptive fuzzy-neural inference models. *International Journal of Intelligent Systems*, 23 (5), 556-573.

Dong, J. and Yang, G.-H. (2009). Dynamic output feedback H_∞ control synthesis for discrete-tme T-S fuzzy systems via switching fuzzy controllers. *Fuzzy Sets and Systems*, 160 (4), 482-499.

Föllinger, O. (1985). *Regelungstechnik*. Elitera Verlag, Berlin.

Galichet, S. and Foulloy, L. (1995). Fuzzy controllers: synthesis and equivalences. *IEEE Transactions on Fuzzy Systems*, 3 (2), 140-148.

Guerra, T-M., Kruszewski, A., and Lauber, J. (2009). Discrete Tagaki-Sugeno models for control: Where are we?. *Annual Reviews in Control*, 33 (1), 37-47.

Haber, R.E., del Toro, R.M., and Gajate, A. (2010). Optimal fuzzy control system using the cross-entropy method. A case study of a drilling process. *Information Sciences*, 180 (4), 2777-2792.

Haber, R.E., Haber-Haber, R., Jiménez, A., and Galán, R. (2009). An optimal fuzzy control system in a network environment based on simulated annealing. An application to a drilling process. *Applied Soft Computing*, 9 (3), 889-895.

Hládek, D., Vaščák, J., and Sinčák, P. (2009). Multi-robot control system for pursuit-evasion problem. *Journal of Electrical Engineering*, 60 (3), 143-148.

Horváth, L. Rudas, I.J. (2004). *Modeling and Problem Solving Methods for Engineers*. Academic Press, Elsevier, Burlington, MA.

Hušek, P. (2008). Stability margin for linear systems with fuzzy parametric uncertainty. *Proceedings of 10th Pacific Rim International Conference on Artificial Intelligence (PRICAI 2008)*, Hanoi, Vietnam, 708-717.

Isserman, R. (2005). *Mechatronic Systems. Fundamentals*. Springer-Verlag, Berlin, Heidelberg, New York.

Johanyák, Z.C. (2010). Fuzzy rule interpolation based on subsethood values. *Proceedings of 2010 IEEE Intenerational Conference on Systems Man, and Cybernetics (SMC 2010)*, Istanbul, Turkey, 2387-2393.

Kessler, C. (1958a). Das symetrische Optimum. *Regelungstechnik*, 6 (11), 395-400.

Kessler, C. (1958b). Das symetrische Optimum. *Regelungstechnik*, 6 (12), 432-436.

Kim, D.W. and Lee, H.J. (2009). Stability connection between sampled-data fuzzy control systems with quantization and their approximate discrete-time model. *Automatica*, 45 (6), 1518-1523.

Kóczy, L.T. (1996). Fuzzy if-then rule models and their transformation into one another. *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans*, 26 (5), 621-637.

Loron, L. (1997). Tuning of PID controllers by the non-symmetrical optimum method. *Automatica*, 33 (1), 103-107.

Petres, Z., Baranyi, P., Korondi, P., and Hashimoto, H. (2007). Trajectory tracking by TP model transformation: Case study of a benchmark problem. *IEEE Transactions on Industrial Electronics*, 54 (3), 1654-1663.

Precup, R.-E. and Hellendoorn, H. (2011), A survey on industrial applications of fuzzy control. *Computers in Industry*, 62 (3), 213-226.

Precup, R.-E. and Preitl, S. (1999). Development of some fuzzy controllers with non-homogenous dynamics with respect to the input channels meant for a class of systems. *Proceedings of European Control Conference (ECC'99)*, Karlsruhe, Germany, paper index F56, 6 pp.

Precup, R.-E., Preitl, S., Balas, M., and Balas, V. (2004). Fuzzy controllers for tire slip control in anti-lock braking systems. *Proceedings of IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2004)*, Budapest, Hungary, 3, 1317-1322.

Precup, R.-E., Preitl, S., Petriu, E.M., Tar, J.K., Tomescu, M.-L., and Pozna, C. (2009). Generic two-degree-of-freedom linear and fuzzy controllers for integral processes. *Journal of The Franklin Institute*, 346 (10), 988-1003.

Preitl, S. and Precup, R.-E. (1996). On the algorithmic design of a class of control systems based on providing the symmetry of open-loop Bode plots. *Scientific Bulletin of the "Politehnica" University of Timişoara, Series Automation and Computer Science*, 41(55) (2), 47-55.

Preitl, S. and Precup, R.-E. (1999). An extension of tuning relations after symmetrical optimum method for PI and PID controllers. *Automatica*, 35 (10), 1731-1736.

Preitl, S. and Precup, R.-E. (2000). Cross optimization aspects concerning the extended symmetrical optimum method. *Preprints of PID'00 IFAC Workshop*, Terrassa, Spain, 254-259.

Preitl, S. and Precup, R.-E. (2004). Development of TS fuzzy controllers with dynamics for low order benchmarks with time variable parameters. *Proceedings of 5th International Symposium of Hungarian Researchers on Computational Intelligence*, Budapest, Hungary, 239-248.

Preitl, S., Preitl, Z., and Precup, R.-E. (2002). Low cost fuzzy controllers for classes of second-order systems. *Preprints of 15th World Congress of IFAC (b'02)*, Barcelona, Spain, paper index 416, 6 pp.

Preitl, Z. (2001). PI and PID controller tuning method for a class of systems. *Proceedings of 7th Symposium on Automatic Control and Computer Science*, Iasi, Romania, 4 pp.

Preitl, Z. (2005). Improving disturbance rejection by means of a double parameterization of the symmetrical optimum method. *Scientific Bulletin of the "Politehnica" University of Timişoara, Series Automation and Computer Science*, 50(64) (1), 25-34.

Preitl, Z. (2008). *Model Based Design Methods for Speed Control. Applications*. Editura Politehnica, Timisoara.

Qi, R. and Brdys, M.A. (2008). Stable indirect adaptive control based on discrete-time T-S fuzzy model. *Fuzzy Sets and Systems*, 159(8), 900-925.

Sala, A., Guerra, T.M., and Babuška, R. (2005). Perspectives of fuzzy systems and control. *Fuzzy Sets and Systems*, 156 (3), 432-444.

Tanner, H.G. and Kyriakopoulos, K.J. (2002). Discontinuous backstepping for stabilization of non-holonomic mobile robots. *Proceedings of 2002 IEEE International Conference on Robotics and Automation (ICRA 2002)*, Washington, DC, USA, 3948-3953.

Tsourveloudis, N.C., Valvanis, K.P., and Hebert, T. (2001). Autonomous vehicle navigation utilizing electro-static potential fields and fuzzy logic. *IEEE Transactions on Robotics and Automation,* 17 (4), 490-497.

Sugeno, M. (1999). On stability of fuzzy systems expressed by fuzzy rules with singleton consequents. *IEEE Transactions on Fuzzy Systems*, 7 (2), 201-224.

Wuxi, S. (2008). Indirect adaptive fuzzy control for a class of nonlinear discrete-time systems. *Journal of Systems Engineering and Electronics*, 19 (6), 1203-1207.

Xie, X. P. and Zhang, H.-G. (2010). Stabilization of discrete-time 2-D T-S fuzzy systems based on new relaxed conditions. *Acta Automatica Sinica*, 36 (2), 267-273.

Yoneyama, J. (2008). H_∞ output feedback control for fuzzy systems with immeasurable premise variables: Discrete-time case. *Applied Soft Computing*, 8 (2), 949-958.