Integral Backstepping Control for a PMLSM Using Adaptive RNNUO

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Abstract

Due to uncertainties exist in the applications of the a permanent magnet linear synchronous motor (PMLSM) servo drive which seriously influence the control performance, thus, an integral backstepping control system using adaptive recurrent neural network uncertainty observer (RNNUO) is proposed to increase the robustness of the PMLSM drive. First, the field-oriented mechanism is applied to formulate the dynamic equation of the PMLSM servo drive. Then, an integral backstepping approach is proposed to control the motion of PMLSM drive system. With proposed integral backstepping control system, the mover position of the PMLSM drive possesses the advantages of good transient control performance and robustness to uncertainties for the tracking of periodic reference trajectories. Moreover, to further increase the robustness of the PMLSM drive, an adaptive RNN uncertainty observer is proposed to estimate the required lumped uncertainty. The effectiveness of the proposed control scheme is verified by experimental results.

Keywords: permanent magnet synchronous motor, recurrent neural network, integral backstepping control

References

[1] I. Boldea and S. A. Nasar, Linear electric actuators and generators, London, Cambridge University Press, 1997.

[2] T. Egami, and T. Tsuchiya, “Disturbance suppression control with preview action of linear DC brushless motor,” IEEE Trans. Ind. Electron., vol. 42, pp. 494-500, Oct.1995.

[3] M. Sanada, S. Morimoto, and Y. Takeda, “Interior permanent magnet linear synchronous motor for high-performance drives,” IEEE Tran. Ind. Appl., vol. 33, pp. 966-972, July/Aug. 1997.

[4] M. Krstic and P. V. Kokotovic, “Adaptive nonlinear design with controller-identifier separation and swapping,” IEEE Trans. Automat. Contr., vol. 40, pp. 426-440, March 1995.

[5] M. Krstic, I. Kanellakopoulos, and P. V. Kokotovic, Nonlinear and adaptive control design. New York: Wiley, 1995.

[6] A. Stotsky, J. K. Hedrick, and P. P. Yip, “The use of sliding modes to simplify the backstepping control method,” Proc. of American Control Conf., pp. 1703–1708, June 1997.

[7] G. Bartolini, A. Ferrara, L. Giacomini, and E. Usai, “Properties of a combined adaptive/second-order sliding mode control algorithm for some classes of uncertain nonlinear systems,” IEEE Trans. Automat. Contr., vol. 45, pp. 1334–1341, July 2000.

[8] F. J. Lin, P. H. Shen, and S. P. Hsu, “Adaptive backstepping sliding mode control for linear induction motor drive,” IEE Proc., Electr. Power Appl., vol. 149, pp. 184–194, May 2002.

[9] C. C. Wang, N. S. Pai, H, T. Yau, “Chaos control in AFM system using sliding mode control by backstepping design, ” Communications in Nonlinear Science and Numerical Simulation, vol. 15, pp. 741-751, 2010.

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[10] C. L. Chen, C. C. Peng and H. T. Yau, "High-order sliding mode controller with backstepping design for aeroelastic systems," Communications in Nonlinear Science and Numerical Simulation, vol. 17, pp.1813-1823, 2012.
[11] T. W. S. Chow and Y. Fang, "A recurrent neural-network-based real-time learning control strategy applying to nonlinear systems with unknown dynamics," IEEE Trans. Ind. Electron., vol. 45, pp. 151-161, Feb. 1998.
[12] S.C. Sivakumar, W. Robertson, and W. J. Phillips, "On-line stabilization of block-diagonal recurrent neural networks," IEEE Trans. Neural Networks, vol. 10, pp. 167-175, Jan. 1999.
[13] M. A. Brdys and G. J. Kulawski, "Dynamic neural controllers for induction motor," IEEE Trans. Neural Networks, vol. 10, pp. 340-355, March 1999.
[14] H. Cardot, Recurrent neural networks for temporal data processing, InTech, Open Access Publisher, 2011.
[15] J. Martens and I. Sutskever, "Learning recurrent neural networks with Hessian-free optimization," in Proceedings of the28th International Conference on Machine Learning, Bellevue, Washington, USA, 2011.
[16] Q. Liu and J. Wang, "Finite-time convergent recurrent neural network with a hard-limiting activation function for constrained optimization with piecewise-linear objective functions," IEEE Trans. Neural Networks, vol. 22, pp. 601-613, April 2011.
[17] F. J. Lin, R. J. Wai, W. D. Chou and S. P. Hsu, "Adaptive backstepping control using recurrent neural network for linear induction motor drive," IEEE Trans. Ind. Electron., vol. 49, pp.134-146, Feb. 2002.
[18] C. H. Lin, A. J. Chen and Y. S. Tsai, "Adaptive backstepping control for synchronous reluctance motor drive using RNN uncertainty observer," IEEE Power Electronics Specialists Conf., pp. 542-547, Orlando, FL., June 2007.
[19] K. J. Astrom, and B. Wittenmark, Adaptive control, New York: Addison-Wesley, 1995.