The Robust Neural Network Control Theorem Apply to Manipulator Tracking

黃睿祥、陳昭雄

E-mail: 9419866@mail.dyu.edu.tw

ABSTRACT

The two-link robot manipulators are typical nonlinear and MIMO systems. They are usually used as experimentation equipment to verify the effectiveness of the proposed control theory. This paper presents a new robust neural network controller for robot manipulators, whose dynamic models are poorly understood. A neural network system is used to model the unknown nonlinearities of the robot dynamic systems. Then, a control law is constructed based on this neural-network model for the robot tracking problems. By using a robust adaptive control technique, an adaptive law is presented for tuning all parameters of the neural network system, including the output weights, the widths and the centers, thereby reducing the approximation error. Global stability of the overall control scheme is guaranteed in the sense of Lyapunov, and the tracking errors converge to the required precision. Finally, Simulations and experiments performed on a practical two-link robot manipulator demonstrate the effectiveness of our scheme.

Keywords : adaptation control ; nonlinear system ; neural network

Table of Contents

中文摘要 v ABSTRACT vi 誌謝 vii 目錄 viii 表目錄 xiv 第一章 緒論 1 1.1 研究動機 1 1.2 研究目的 2 1.3 文獻回顧 2 1.4 文章內容簡介 4 第二章 機械臂硬體架構 6 2.1兩軸機械臂系統硬體架構 6 2.2 Lagrange運動方程式 13 2.3 兩軸機械臂數學模型 15 第三章 路徑規劃 18 3.1 運動學 18 3.2 順向運動學 19 3.3 逆向運動學 22 3.4 機械手臂工作空間 24 3.5 程式的撰寫 25 3.6 機械臂路徑之規劃 26 第四章 強健類神經控制器之設計 34 4.1 類神經網路理論 34 4.2 人工神經元 35 4.3 類神經網路架構 38 4.4 機械臂控制問題描述 40 4.6 多連桿機器手臂的適應性RBFN控制器 45 第五章 控制系統模擬 53 5.1 PD控制器 53 5.2強健類神經網路控制器 61 第六章 實驗 70 第七章 結論 81 7.1 結論 81 7.2 未來展望 81 參考文獻 82

REFERENCES

[1] J. R. Noriega, and H. Wang, “A direct adaptive neural-network control for unknown nonlinear systems and its application, ” IEEE Transactions on Neural Networks, vol. 9, no. 1, pp. 27-34, 1998.

[2] F. J. Lin, W. J. Hwang, and R. J. Wai, “Ultrasonic motor servo drive with on-line trained neural network model-following controller, ” IEE Proceedings- Electric Power Applications, vol. 145, no. 2, pp. 105-110, 1998.

[3] H. D. Patino, R. Carelli, and B. R. Kuchen, “Neural networks for advanced control of robot manipulators, ” IEEE Transactions on Neural Networks, vol. 13, no. 2, pp. 343-354, 2002.

[4] F. Sun, Z. Sun, and P. Y. Woo, “Neural networks-based adaptive controller design of robotic manipulators with an observer, ” IEEETransactions on Neural Networks, vol. 12, no. 1, pp. 54-67, 2001.

[5] S. J. Huang, and J. S. Lee, “A stable self-organizing fuzzy controller for robotic motion control, ” IEEE Transactions on Industrial Electronics, vol. 47, no. 2, pp. 421-428, 2000.

[6] B. K. Yoo, and W. C. Ham, “Adaptive control of robot manipulator using fuzzy compensator, ” IEEE Transactions on Fuzzy Systems, vol. 8, no. 2, pp. 186-199, 2000.

[7] 鄭佳弘, “非線性多變數系統之適應性模糊最佳控制器設計”, 碩士論文, 國立台灣大學, 電機工程學系, 2002.

[8] 廖義銘, “應用模糊理論於機械手臂混合式位置/力量控制之研究”, 碩士論文, 國立台灣科技大學, 電機工程學系, 2000.

[9] Andreja Rojko and Karel Jezernik, “Adaptive Fuzzy Sliding Mode Motion Control of Robot Manipulator, ” University of Maribor, copyright IFAC, 2002.

[10] L. Behera and K.K. Anand, “Guaranteed tracking and regulatory performance of nonlinear dynamic systems using fuzzy neural networks, ” IEE Proc.-Control Theory Appl. , vol. 146, pp. 484-491. 1999.

[11] C.J. Chien, “A sampled-data iterative learning control using fuzzy network design, ” Internat. J. Control, vol. 73, pp. 902-913. 2000.

[12] C. T. Lin and C.S.G. Lee, “Neural network-based fuzzy logic control and decision system, ” IEEE Trans. Comput, vol.40, pp. 1320-1336. 1991.

[13] 謝冠雲, “多軸機械臂之力量控制與定位追蹤”, 碩士論文, 元智大學, 電機工程學系, 2002.

[14] 陳芳雄, “機械手臂之非線性遞回步階控制設計”, 碩士論文, 暨南國際大學, 電機工程學系, 2004.

[15] 沈奇聰，“平面雙機械臂之順滑控制法”，碩士論文，國立中興大學，機械工程學系， 2003.
[16] 張斐章、張麗秋、黃浩倫，“類神經網路理論與實務”，東華書局， 2003.
[17] Z. Qu and D.M. Dawson,“ Robust tracking control of robot manipulators, ” Piscataway, NJ:IEEE, 1996.
[18] J. Park and I.W. Sandberg,“ Universal approximation using radial basis-function networks, ” Neural Computation, vol. 3, pp 246-257, 1991.
[19] R.M. Sanner and J.-J. E. Slotine,“ Gaussian networks for direct adaptive control, ” IEEE Transactions on Neural Networks, vol.3, no. 6, pp 837-863, 1992.
[20] H. Han, C.Y. Su, and Y. Stepanenko,“ Adaptive control of a class of nonlinear systems with nonlinearly parameterized fuzzy approximators, ” IEEE Transactions on fuzzy systems, vol.9, no. 2, pp 315-323, 2001.
[21] R. C. HIBBELER，“ Engineering Mechanics:Dynamics, ”， Prentice Hall， 1997.