A Study of PID Controller Design Based on Artificial Neural Network

黃聰謀、黃登淵

E-mail: 9314952@mail.dyu.edu.tw

ABSTRACT

This research is based on the applications of neural network, including function approximation and parameter tuning of PID controller. This research first focuses the application of backpropagation neural network on the function approximation. The learning rules including steepest descent method, steepest descent with momentum method, resilient backpropagation, conjugate gradient method, BFGS quasi-Newton method and Levenberg-Marquardt method are employed to investigate the capability of function approximation. However, convergence and mean square error (MSE) are also carefully compared when they are used to train the neural network. In addition, the effects of neuron number in the hidden layer on the function approximation are also studied. This research also applies the neural network to the off-line parameter tuning of PID controller. The error output and tracing signals of the control system will be fed to the neural network as its new input and target signals, respectively. Moreover, the neural network can calculate the parameters of PID controller based on the input and target information. The parameters of PID controller, i.e., Kp, Ki and Kd, are tuned repeatedly based on the error output of control system until MSE

Keywords : Backpropagation neural network, function approximation, self-tuning PID controller

Table of Contents

REFERENCES

[1] S. H. Huang, H. C. Zhang, " Neural networks in manufacturing: a survey, " IEEE CHMT int ' l Electronic manufacturing Technology Symposium pp. 177-188. Oct. 1993.
[2] M. M. Nelson, W. T. Illingworth, " A practical guide to neural nets, " Addison-Wesley Publishing company sixth printing, January 1994.
[3] L. M. Fu, " neural network in computer intelligence, " McGraw-Hill series in computer science international editions 1994.
[4] T. Masters, " Advanced algorithms for neural networks a C++ sourcebook , " John Wiley & Sons, Inc 1995.
[5] H. Demuth, M. Beale, " Neural network toolbox user ' s guide, " version 4, The Mathworks. Inc.
[6] S. Abe, " Neural network and fuzzy systems theory and application, " Klumer Academic publishers 1997.
[7] J. A. Freeman, D. M. Skapura, " Neural networks algorithms, application and programming Techniques, " Addison-Wesley Publishing Company Oct. 1991.
[8] A. Cichocki R. Unbehauen, " NN for optimization and signal procssing, " John Wiley & Sons Ltd. 1993.
[9] A. Paolo and V. Milutinovic, " neural network concepts, applications, and implementation volumn II, " Prentice Hall, Englewood Cliffs, New Jersey 07632. 1991.
[10] M. T. Hagan and H. B.Demuth, " Neural networks for control, " Proceeding of the ACC San Diego, California. June 1999.
[11] J. M. Zurada " Introduction to artificial neural systems. " West publishing company 1992.
[12] T. Hrycej, " Modular learning in neural network a modularized approach to neural network classification " John Wiley& Sons.1992.
[13] M. Zeidenberg " Neural networks in artificial intelligence, " EllisHorwood.
[14] A. Chaiyaratana A. M.S.Zalzala, " Time-optimal path planning and control using neural networks and a genetic algorithm, " The Journal of KNITNB., Vol. 12, No.3, Jul.-Sep. 2002.
[15] J. E. Dayhoff, " Neural network architectures: an introduction, " Van Nostrand Reinhold New York.
[16] K. Edwin, P. Chong, S. H. Zak, " An introduction to optimization second edition, " John Wiley & Sons, Inc. 2001.
[17] M. H. Fun, M. T. Hagan, " Levenberg-Marquardt training for modular networks, " IEEE trans. on N.N. pp. 468-472, May 1996.
[18] N. N. Schraudolph, T. Graepel, " Toward stochastic conjugate gradient methods ", Proc. 9th Intl. Conf. Neural Information Process Singapore 2002.
[19] M. T. Hagan, H. B. Demuth, M. Beale, " Neural network design, " Thomson Learning, 1996.
[20] S. I. Gallant, " Neural network learning and expert systems ", second printing A Bradford Book the MIT Press 1994.
[21] E. Barnard, " Optimization for Training Neural Nets, " IEEE Trans. on Neural Networks. Vol 3.No. 2. March 1992.
[22] L. Hasdofrr, " Gradient Optimization and Nonlinear Control, " John Wiley & Sons, 1976.
[23] K. Ogata, " Modern Control Engineering, " Englewood Cliff, NJ. Prentice Hall 1990.
[24] M. Sinha, P. K. Kalera, and K. Kumar, " Parameter estimation use compensatory neural networks, " Sadhana, Vol. 25, April 2000.
[25] B. C. Kuo, " Automatic Control Systems, " sixth edition, Prentice Hall international Editions 1991.
[26] F. L. Lewis, " Applied Optimal Control and Estimation, " Prentice Hall, 1992.
[27] A. S. Hodel, and Charles E. Hall, " Variable-Structure PID control to prevent Integrator windup, " ACC pp. 468-472, May 1995.
[28] T. Yamamoto, M. Kaneda, " Intelligent Tuning PID controllers, " IEEE Trans. on NN. pp.2610-2615 Jan.1995.
[29] W. Beilei, Z. Lin, " Neural network based online self-learning adaptive PID control, " Proceedings of the 3rd world congress on intelligent control and automation. pp. 908 Jun. 2000.
[30] K. Takao, T. Yamamoto, T. Hinamoto, " A design of model driven cascade PID controllers using a neural network, " IEEE Trans. on neural networks, pp.1547-1552 Sep, 2003.
[31] M. Kawafuku, M. Sasaki Shinya Kato, " Self-tuning PID control of a flexible micro-actuator using neural networks, " IEEE Trans. on neural networks, pp.3067-72, Jan 1998.

[32] T. Yamamoto, T. Oki, “ Design of a multivariable neural-net based PID controller, ” IEEE Trans.pp.1051-1056 Jun 1999.
[33] S. N. Balakrishnan, R. Weil “ Neuro-control A literature survey, ” Mathl. Comput. Modeling Vol.23, No. 1/2, pp. 101-117, 1998.
[34] D. N. Chorafas, “ New information technologies A Practitioner ’ s Guide, ” Van Nostrand Reinhold 1993.
[35] M. Chester, “ neural networks A tutorial, ” PTR prentice Hall Englewood Cliffs New Jersey 1995.
[36] D. F. Foresee, M. T. Hagan “ Gauss-Newton approximation to Bayesian Learning ”, IEEE Trans. on NN. No. 3, Oct. 1997.