

# 應用類神經網路於PID控制器之設計研究

黃聰謀、黃登淵

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

## 摘要

本論文以類神經網路之架構為基礎，首先探討倒傳遞神經網路在函數近似之模擬應用，文中採用最陡坡降法(Steepest descent method)、最陡坡降加慣量法(Steepest descent with momentum)、最速恢復倒傳遞法(Resilient backpropagation)、共軛梯度法(Conjugate gradient method)、BFGS 擬牛頓法(BFGS quasi-Newton method)與 LM 法(Levenberg-Marquardt method)等六種學習方法，以比較不同學習法則在函數近似之能力，同時也探討其對神經網路訓練之收斂速度與均方差之影響等。除此之外，隱藏層神經元數對函數近似之影響，也被提出討論，並給予適當建議。本論文同時將類神經網路應用於PID 控制器之離線(Off-line) 參數調整。首先利用控制系統輸出之誤差值與追蹤信號做為類神經網路之輸入值與學習目標值，以做為調整PID 控制器參數之依據。PID 控制器參數之調整則以輸出誤差為調整權重，透過迭代計算至滿足均方誤差設定值

關鍵詞：倒傳遞類神經網路、函數近似，自調式PID 控制器

## 目錄

封面內頁 簽名頁 授權書.....	iii	中文摘要.....	.....
.....v 英文摘要.....	.....	.....vi 誌謝.....	.....
.....vii 目錄.....	.....	.....viii 圖目錄.....	.....
.....xii 表目錄.....	.....	.....xv 縮略詞.....	.....
.....xvi 第一章 序論 1.1 研究背景.....	1	1.2 研究動機.....	1
.....2 1.3 文獻回顧.....	2	1.4 研究目的.....	2
.....3 1.5 論文大綱.....	3	.....5	5
.....6 第二章 神經網路的基本觀念.....	6	2.1 人工神經網路的簡短歷史.....	7
.....9 2.2 基本的觀念和模型.....	9	2.3 神經元的基本結構.....	.....
.....9 2.4 神經元的參數.....	10	2.5 轉移函數的類型.....	.....
.....11 2.6 神經網路結構.....	14	2.6.1 向量輸入的神經原.....	.....
.....15 2.6.2 單一層神經元網路.....	15	2.6.3 多層神經元網路.....	.....
.....16 2.6.4 多層網路的優點.....	17	2.6.5 應用多層網路到實際問題之步驟.....	.....
.....18 2.7 ADALINE 學習法.....	19	2.7.1 ADALINE 學習規則.....	.....
.....19 2.7.2 MADALINE 學習規則.....	19	2.8 神經網路型式.....	.....
.....21 2.8.1 前饋網路.....	21	2.8.2 回授網路.....	.....
.....22 2.8.3 蜂巢狀網路.....	20	2.9 多層網路的近似能力.....	.....
.....22 2.9.1 神經網路之函數近似.....	24	2.10 網路的結構.....	.....
.....25 2.10.1 決定隱藏層數.....	25	2.10.2 決定隱藏神經元數.....	.....
.....26 第三章 神經網路的學習法.....	29	3.1 神經網路的學習法的形式.....	.....
.....29 3.1.1 漸增的訓練.....	30	3.1.2 批次的訓練.....	.....
.....30 3.2 學習類型.....	30	3.2.1 非監督式學習法.....	.....
.....31 3.2.2 監督式學習法.....	32	3.2.3 增強式學習.....	.....
.....32 3.3 倒傳遞的觀念.....	33	3.4 倒傳遞學習法.....	.....
.....34 3.4.1 倒傳遞神經網路的利益和限制.....	34	3.4.2 局部最小值(Local minimum).....	.....
.....35 3.4.3 如何處理局部最小值.....	36	3.5 最陡坡降法.....	.....
.....36 3.5.1 決定訓練停止的參數.....	37	3.6 最陡坡降加慣性量法.....	.....
.....39 3.7 最速恢復傳遞法.....	40	3.8 共軛梯度法.....	.....
.....40 3.9 BFGS 擬牛頓法(Quasi-Newton).....	41	3.10 Levenberg Marquardt法.....	.....
.....42 3.11 結果與討論.....	43	3.12 學習法則之討論.....	.....
.....46 第四章 神經網路的應用.....	49	4.1 歸納推演(Generalization).....	.....
.....49 4.1.1 改良歸納推演的過度配適.....	49	4.2 類神經網路之應用實例(一).....	.....

.....50	4.2.1 類神經網路之應用實例(二).....	51	第五章 控制系統.....
.....52	5.1 控制系統的歷史檢討.....	52	5.2 PID 控制器的觀念.....
.....53	5.2.1 PD 控制器設計.....	55	5.2.2 PI 控制器的設計.....
.....55	5.2.3 PID 控制器的設計.....	56	5.3 PID 控制器參數調整法.....
.....56	5.4 Ziegler-Nichols 參數調整法.....	59	5.4.1 Ziegler-Nichols第一法 ( First method.).....
.....59	5.4.2 Ziegler-Nichols 第二法( Second method.).....	61	5.5 類神經網路控制架構.....
.....61	5.5.1 離散化(Discretization).....	64	5.6 電腦模擬結果(Computer simulated result).....
.....65	第六章 結論.....	72	6.1 未來展望.....
.....73	參考文獻(References).....	74	

## 參考文獻

- [1] S. H. Huang, H. C. Zhang, " Neural networks in manufacturing: a survey, " IEEE CHMT int ' I 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.