

# Study of Principle and Applications of K+NN, a New Controller Structure, for Control System Design

黃志強、周鵬程

E-mail: 9607643@mail.dyu.edu.tw

## ABSTRACT

Soft computing includes artificial intelligence, expert systems, fuzzy logic, neural network (NN), particle swarm optimization and evolutionary computations. Use of those methodologies to improve computer algorithms can make computers smart enough to do some intelligent inferences for applications. Furthermore, the combination of soft computing technique and the conventional control can further improve the performance of the original control systems (controlled solely by its conventional controllers). Incorporating the soft computing technique to the control system design, a NN based K+NN assistor is provided to aid the original control systems so that improvement of transient responses becomes possible. Error signal and error rate are two inputs to this K+NN structure, NN will send out a control signal as the output. SE is the gain for error input, SDE is the gain for error rate input, and SU is the gain for NN output. These three important scaling factors dominant the design process of the K+NN assistor. K is the parallel gain between error signal and NN output. Finally, the combined output (NN and K) is in series with another gain called Ka constitutes the whole structure of a K+NN assistor. All necessary parameters for K+NN assistor can be found off-line by using PSO technique. If necessary, the parameters of the original controllers can quite well included together in PSO parameters finding. Lastly several examples are illustrated to prove the capability of using K+NN as an assistor/controller and as a plant modifier. K+NN can be a plant modifier, a stand-alone controller, or an assistor to the original controller. This effects can be found in this thesis.

Keywords : Neural Network 、 PID Controller 、 Fuzzy Logic 、 Particle Swarm Optimization

## Table of Contents

封面內頁 簽名頁 授權書 .....	iii	中文摘要 .....	iv	英文摘要 .....	v		
誌謝 .....	vi	目錄 .....	vii	圖目錄 .....	xi	表目錄 .....	
.....	xv	第一章 緒論 1.1 簡介 .....	1	1.2 文獻回顧 .....	2	1.3 研究方法 .....	2
.....	2	1.4 論文架構 .....	3	第二章 K+NN理論及架構 2.1 類神經網路的介紹 .....	4	2.1.1 神經元模型 .....	4
.....	4	2.1.1 神經元模型 .....	4	2.1.2 類神經網路架構 .....	6	2.1.2.1 單層類神經網路 .....	6
.....	6	2.1.2.2 多層類神經網路 .....	7	2.2 K+NN理論及架構 .....	8	2.2.1 K+NN架構 .....	8
.....	8	2.2.2 K+NN隱藏層結構 .....	9	2.2.3 K+NN用途 .....	13	2.3 K+NN曲面解 .....	13
析 .....	13	2.4 K+NN調整因子的角色 .....	15	2.5 K+NN參數與尋優法的關係 .....	15	2.5.1 .....	15
遺傳演算法 .....	15	2.5.2 物群智慧 .....	19	2.5.2.1 蟻群尋優法 .....	19	2.5.2.2 物群 .....	19
尋優法 .....	21	2.5.3 GA與PSO性能上之比較 .....	25	第三章 PID控制器介紹 3.1 PID控制器介紹 .....	26	3.2 PID控制理論及架構 .....	26
.....	26	3.2 PID控制理論及架構 .....	26	3.3 Ziegler-Nichols(ZN)調整法 .....	28	3.3.1 反應曲線 .....	28
法 .....	28	3.3.2 振盪法 .....	30	3.4 PID控制器應用範例 .....	31	第四章 模糊控制器 .....	31
介紹 4.1 Fuzzy介紹 .....	36	4.2 控制器架構 .....	40	4.2.1 模糊化 .....	41	4.2.2 .....	41
解模糊化 .....	42	4.2.3 知識庫 .....	43	4.2.4 模糊推論 .....	44	4.3 模糊控制器 .....	44
應用範例 .....	44	第五章 K+NN的應用實例 5.1 K+NN改善受控體的方法 .....	48	5.1.1 K+NN改良plant .....	48	5.1.2 PID調整K+NN modified plant .....	50
.....	48	5.1.2 PID調整K+NN modified plant .....	50	5.1.3 K+NN輔助PID調整原始plant .....	52	5.1.4 .....	52
K+NN輔助PID調整K+NN modified plant .....	54	5.2 K+NN當控制器使用範例 .....	56	5.2.1 K+NN當控制器與PID .....	56	5.2.1.1 受控體(一) .....	56
比較 .....	56	5.2.1.1 受控體(一) .....	56	5.2.1.2 受控體(一)以不同PID參數控制 .....	58	5.2.2 K+NN當 .....	58
控制器與PD比較 .....	59	5.3 K+NN當輔助器使用範例 .....	60	5.3.1 K+NN輔助PID控制器 .....	60	5.3.1.1 受控體(二) .....	61
61 5.3.1.1 受控體(二) .....	61	5.3.1.2 受控體(三) .....	64	5.3.1.3 受控體(四) .....	66	5.3.2 .....	66
K+NN輔助Fuzzy控制器 .....	68	5.3.2.1 對受控體(四)以Fuzzy 來控制 .....	68	5.3.2.2 受控體(五) .....	73	第六章 結論 6.1 結論 .....	82
73 第六章 結論 6.1 結論 .....	82	6.2 未來研究方向 .....	85	參考文獻 .....	85	附錄 .....	89
86 附錄 .....	89						

## REFERENCES

- [1] 周鵬程, “ 智慧型計算機概論-matlab 程式語言入門 ”, 全華科技 圖書股份有限公司(2004).
- [2] Pen Chen Chou, An Tzer Dzen and Song Chin Hsieh , “ Neural Assisted PID Controllers Design for Control Systems ” , Proceedings of the Fourth IASTED International Conference, Computational Intelligence, July (2005).
- [3] Pen Chen Chou and Son Chin Hsieh, “ Neural Assisted PI/PID Controller Design for a Motor Control System ” , IEEE CIMSA2005, July 20-22, Sicily, Italy (2005).
- [4] Pen Chen Chou , “ Design of a Robust Neural Controller for a Specified Plant using Genetic Algorithms Approach ” , IEEE International Symposium on Computational Intelligence for Measurement Systems and Applications, July (2003).
- [5] Pen Chen Chou and Jsen Jar Huwang , “ Design of PID Controllers using Genetic Algorithms Approach for low-damping, slow-varying Plants ” , IEEE International Symposium on Neural Networks (ISNN 2004),Dalian,China, August (2004).
- [6] 周鵬程, “ 類神經網路入門 ”, 全華科技圖書股份有限公司 (2004).
- [7] 羅華強, “ 類神經網路-MATLAB 的應用 ”, 清蔚科技(2001) [8] 張斐章, 張麗秋, 黃浩倫, “ 類神經網路理論與實務 ”, 東華書 局(2003)
- [9] L.C Hung, Y.C. Chung, “ An associate design of fuzzy logic with grey-neural predication in PID controller ” , 2002-ROC automatic control symposium, Taipei(2002) [10] L.Y. Lai, and M.Y. Lee , “ Fuzzy tuning of integrator outputs of PID controller for a dc motor system ” , Chung-Yuan J, Dec.(1993) ,Vol.XXII,126-137.
- [11] 黃志強,周鵬程, “ K+NN,暫態輔助器,一個新型智慧型控制器 ” , 大葉大學再生能源應用研討會(2007) [12] Pen Chen Chou, Tsi Chow Chang, and Tsi Chian Hwang , “ The Experience of using a Neural Assistor to Enhance the Transient Haracteristics of Well-Defined Control Systems ” , IEEE-CIMSA 2006, July (2006).
- [13] 謝松慶, “ 智慧型計算技術用於PI 控制器設計之研究 ”, 大葉大 學電機系碩士論文(2005).
- [14] 周鵬程, “ 遺傳演算法原理與應用-活用matlab ”, 全華科技圖書 股份有限公司(2001).
- [15] 蔡宜廷, 林裕鈞, 周鵬程, “ 利用模擬實驗尋求物群尋優法最 佳參數設定之研究 ”, 大葉大學再生能源應用研討會(2007) [16] 俞克維, “ 控制系統分析與設計 ”, 新文京開發股份有限公司 (2003) [17] 林芳蔚, “ 應用類神經網路於PID 控制器之設計研究 ”, 大葉大 學電機系碩士論文(2006).
- [18] 張碩, “ 自動控制系統 ”, 鼎茂圖書 (2001).
- [19] 王文俊, “ 認識Fuzzy ”, 全華科技圖書(2001) [20] Chin Teng Lin and C.S.George Lee , “ Neural Fuzzy Systems ” , Prentice-Hall (2003).
- [21] 張智星, 孫春在, 水谷英二, “ Neuro-Fuzzy AND Soft Computing ” , Prentice Hall (2004) [22] S.R. Vaishnav, Z.J. Khan , “ Design of PID &Fuzzy Logic Controller for Higher Order System ” , IMECS(2007) [23] Chuan Sheng Liu, Liang Rui Chen, Bing Ze Li, Shih Kai Chen, Zhao Syong Zeng, “ Improvement of the Twin Rotor MIMO System Tracking and Transient Response using Fuzzy Control Technology ” , ICIEA 2006 [24] 吳旭焜, “ 一簇非線性系統可變結構控制及其再雙旋轉翼系統 的應用 ”, 雲林科技大學,電機系碩士論文(2003)