

# A guided-based genetic algorithm for solving assembly planning problems

張銀和、曾懷恩

E-mail: 9315397@mail.dyu.edu.tw

## ABSTRACT

Assembly planning refers to the task where planners arrange a specific assembly sequence according to the product design description as well as to their particular heuristics in putting together all the components of a product. Unlike traditional studies where the liaison graph goes with a genetic algorithm, an attempt is made to solve problems in assembly planning by using genetic algorithms (GAs) under the connector-based environment. The key point in this approach to assembly planning is to combine the connector concept and characteristics of a genetic algorithm using object-oriented programming. Because connectors serve as concept product building blocks in the design stage, more engineering features can be covered. With higher levels of information, the degree of complexity in assembly planning can be effectively reduced. Based upon the result of connector-based assembly planning model made by Tseng, Li and Chang (2004), the author proposed the so-called guide genetic algorithms to solve the massive constraints-oriented problems in assembly planning. The method of the traditional genetic algorithms is one kind of stochastic blind search procedure. Therefore, when the question constraints pattern is more complex, traditional GAs will create massive infeasible solutions. The procedure will reduce the GAs solution quality and the efficiency. In the mechanism of the guided GAs, initial population, crossover, mutation will be discuss in this research. Finally, a stapler, electric fan, and a laser printer were used as practical examples to demonstrate the possibility of such idea. Consequently, in terms of assembly planning, it is feasible to use the guided GAs to apply more complex product. This research also discovered that the efficiency of the guided GAs surpass the algorithms proposed by Tseng, Li and Chang (2004).

Keywords : Assembly Planning, Genetic Algorithms, Connector

## Table of Contents

封面內頁 簽名頁 授權書 i 中文摘要 v Abstract vi 誌謝 viii 目錄 ix 圖目錄 xii 表目錄 xiv 第一章 緒論 1 1.1 研究動機 1 1.2 研究目的 4 1.3 研究範圍與假設 6 1.4 研究方法 8 1.5 研究流程與架構 10 第二章 文獻探討 12 2.1 Connector-based的產品組裝模式 12 2.2 基因演算法應用於組裝規劃問題 17 第三章 引導式基因演算法 26 3.1 範例說明 28 3.2 Connector相關資訊建構 31 3.2.1 Connector相似矩陣S建構 31 3.2.2 Connector優先關係矩陣P建構 34 3.3 染色體編碼 34 3.4 結合二元樹(Binary tree)觀念產生初始母體 36 3.4.1 建構Connector-based二元樹 37 3.4.2 中序拜訪排序出可行組裝順序解 41 3.5 適應性函數(Fitness function) 42 3.6 引導式交配法(Guided crossover) 43 3.6.1 產生保留區間(Block) 43 3.6.2 染色體之基因碼交換 46 3.7 引導式突變法(Guided mutation) 50 3.8 選擇下一世代染色體 52 第四章 實例測試 55 4.1 釘書機範例探討 55 4.2 電風扇範例探討 56 4.3 印表機範例探討 60 4.3.1 初始母體對於基因演算法的影響 61 4.3.2 引導式基因演算法與基因演算法比較 64 4.4 結論 65 第五章 實驗設計 66 5.1 實驗參數設定 66 5.2 結果分析與討論 68 第六章 結論與建議 70 參考文獻 72 附錄一 76 附錄二 78

## REFERENCES

英文部分: Akagi, F., Osaki, H. and Kikuci, S., "The method of analysis of assembly work based on the fastener method" Bulletin of the JSME, 23 (184), pp.1670-1675, (1980). Baldwin, D. F., Abeel, T. E., Lui, M.-C. M., De Fazio, T. L. and Whitney, D. E., "An integrated computer aids for generating and evaluating assembly sequences for mechanical products" IEEE Transaction on Robotics and Automation, 7 (1), pp. 78-94. (1991). Bonneville, F., Perrard, C. and Henrioud, J. M., "A genetic algorithm to generate and evaluate assembly plans" Proceedings of the IEEE Symposium on Emerging Technology and Factory Automation, pp.231-239. (1995). Chen, S. F. and Liu, Y. J., "An adaptive genetic assembly-sequence planner" International Journal of Computer Integrated Manufacturing, 14(5), pp.489-500. (2001). Davis, L., "Applying adaptive algorithms to domains" In Proceedings of the International Joint Conference on Artificial Intelligence, pp.162-164, (1985). De Fazio T. L., and Whitney D. E., "Simplified Generation of all mechanical assembly sequence" IEEE Journal of Robotics and Automations, 3(6), pp. 640-658. (1987). Fujimoto, H. and Sebaaly, M. F., "A new sequence evolution approach to Assembly Planning" Journal of Manufacturing Science and Engineering, 122, pp.198-205 (2000). GEN, M. and CHENG, R., "Genetic Algorithms & Engineering Design" John Wiley & Sons, Inc, (1997). Goldberg, D., "Genetic algorithms in search optimization assembly machine learning" Reading, Ma: Addison-Wesley, (1989). Gottipolu, R. B. and Ghosh, K., "Representation and selection of assembly sequences in computer-aided assembly process planning" International Journal of Production, 35(12), pp.3447-3465. (1997). Holland, J. H., "Adaptation in natural and artificial systems" Cambridge, MA: MIT Press, (1975). Homem, D. E., Mello, L.

S. and Sanderson, A. C., "A correct and complete algorithm for the generation of mechanical assembly sequences" IEEE Transaction on Robotics and Automation, 7(2), pp.228-240. (1991). Louis, S. J. and Rawlins, J. E., "Using genetic algorithms to design structures" Technical Report (326), Department of computer Science, Indiana University, (1990). Nicola S., Roberto G. and David, R. W., "Concurrent assembly planning with genetic algorithms" Robotics and Computer Integrated Manufacturing, pp.65-72, (2000). Owen, T., "Assembly with Robots" Englewood Cliffs, New Jersey: Prentice-Hall (1985). Rembold, U., Blume, C. and Dillmann, R., "Computer-integrated manufacturing technology and systems" New York: Marcel Dekker (1985). Senin, N., Goppetti, R. and Wallace, D. R., "Concurrent assembly planning with genetic algorithms" Robotics and Computer Integrated Management, 16(4), pp.65-72. (2002). Smith, G. C. and Smith, S. F., "An enhanced genetic algorithm for automated assembly planning" Robotics and Computer Integrated Management, 18, pp.355-364. (2002). Smith, G. C. and Smith, S. F., "Automated initial population generation for genetic assembly planning" Computer Integrated Manufacturing, (16), pp.219-228, (2003). Tseng, H. E., "A method of connector-based approach for assembly planning" PHD dissertation, National Chiao Tung University in Industrial Engineering (1998). Tseng, H. E. and Li, R. K., "A novel means of generating assembly sequences using the connector concept" Journal of Intelligent Manufacturing, 10, pp. 423-435, (1999). Tseng H.-E., Li, J. D. and Chang Y. H., "Connector-based approach to assembly planning using genetic algorithms" INT. J. PROD. RES., 42, pp.2243-2261 (2004). Yin, Z. P., Ding, H., Li, H. X. and Xiong, Y. L., "A connector-based hierarchical approach to assembly sequence planning for mechanical assemblies" Computer-Aided Design, 35, pp.37-56. (2003). 中文部分: 張堂聖, 產品關連網路中模組化行程之探究, 碩士論文(2002). 黃國瑜 和 葉乃菁 編著, 資料結構, 文魁資訊股份有限公司(2001).