PARTICLE SWARM OPTIMIZATION & GRAVITATIONAL SEARCH ALGORITHM IN SEQUENTIAL PROCESS PLANNING

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To my beloved mother and father

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ABSTRACT

The purpose of this study is to investigate the application of particle swarm optimization (PSO) and gravitational search algorithm (GSA) in assembly sequence planning problem, to look for the sequence which require the least assembly time. The problem model is an assembly process with 25 parts, which is a high dimension and also NP-hard problem. The study is focused on the comparison between both algorithms and investigation on which method perform better in term of convergence rate and the ability to escape local solution. In this study, the PSO are improved in term of random mechanism and GSA algorithms are improved in term of algorithm in order to improve convergence rate and overcome weak convergence respectively. The quality of randomness is also discussed. The simulation results show that PSO can find better optimum sequence than GSA does.

ABSTRAK

Tujuan kajian ini adalah untuk mengaji applikasi “particle swarm optimization” (PSO) dan “gravitational search algorithm” (GSA) dalam masalah merancang urutan pemasangan, untuk mencari urutan yang menpunyai masa tependek untuk dipasang. Masalah adalah terbentuk daripada 25 bahagian dan merupakan masalah NP-hard dan berdimensi tinggi. Kajian ini membanding kepeutusan daripada kedua-dua algoritma, dari segi kelajuan dan kebolehan untuk lari dari penyelesaian tempatan. Demi memperbaiki keupayaan PSO untuk lari daripada penyelesaian tempatan, cara rawk PSO telah diubasuai, dan untuk memperbaiki keupayan GSA untuk menumpu, algorithm GSA telah diubahsuai. Kualiti rawak juga dibincang dalam thesis ini. Keputusan dari simulasi menunjukkan PSO adalah lebih berkeupayaan untuk mencari peyelesaian yang lebih optimum daripada GSA.

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INTRODUCTION

1.1 Background

Assembly sequence planning (ASP) is one of the best-known production scheduling problems which has been proved to be strongly NP (non-deterministic)-hard problem (as shown in Figure 1.1). Most assembly operations are accomplished by robots for large scale automatic assembly. It is hard for robots to reorient and grasp tools frequently. The changes of assembly types, assembly tools and assembly orientation will increase the assembly instability and assembly costs, so the ASP is a widely researched problem.

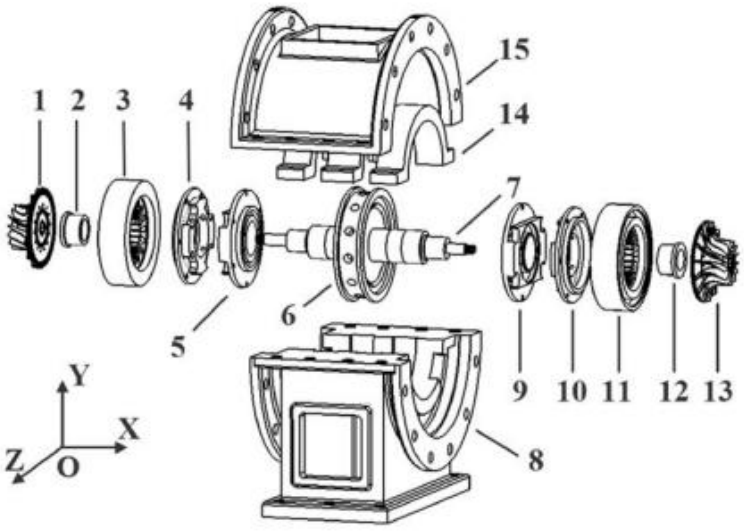

Figure 1.1 The Assembly of a Generator [5]

The exploded solid model of a generator assembly is shown in Figure. 1.1 The generator comprises 15 parts which are marked with numbers orderly. The assembly directions of all the parts are along the *X* and *Y* axes. Part 7 is viewed as the base part which has the most assembly relations with the other parts.

It is well known that the size of the search space of assembly sequence is exponentially proportional to the number of parts or components composing the whole product. The total assembly sequences are hard to be enumerated for products composed more than 20 parts even if the process constraints are considered. To meet the demands of product development, the efficient methods are urgently called to tackle the hard problem to generate the optimal or near-optimal assembly sequences.

Generic algorithm (GA), hybrid simulated annealing algorithm (SA), ant colony optimization (ACO), and other global optimization algorithms have also been applied successfully for ASP over the years. The intelligent optimization methods improve the efficiency of the process to search for feasible assembly sequences.

1.2 Problem Statement

The economic importance of assembly as manufacturing process has led to extensive efforts to improve the efficiency and cost effectiveness of assembly operations. By using intelligent algorithm, many results obtained are very encouraging to some extent. However, it was found that relatively little attention has been made at the ASP problem with PSO and GSA algorithms. This study proposes a modified PSO and GSA algorithm to solve ASP problem and analyzes the influence of parameter changes on ASP.

For this study, the problem model is made up of 25 parts and only part type and tool change is considered. The PSO and GSA algorithms are used to find the optimum sequence which has the least time to assemble the product under some constraint condition.

1.3 Objective

1. To generate optimal or near optimal assembly sequence based on PSO and GSA.

2. To determine which algorithm provide better solution.

1.4 Scope

The scopes of work for this project are as follows:

1. PSO and GSA are used as the computational tools of the development of the algorithms.
2. MATLAB is the platform for the design and algorithm development.
3. Part sequencing and assembly is used as the application for verification of algorithm.

1.5 Thesis Organization

Literature review for this project is covered in Chapter 2. Chapter 3 highlights the approaches and design used in this work. Chapter 4 contains the result and discussion. Conclusion is reviewed in Chapter 5. The last chapter, Chapter 6 discussed recommendation for future work.

REFERENCE

[1] Romeo MM, Lee H.S.L., Kazem A. *A genetic algorithm for the optimisation of assembly sequences*. Computers & Industrial Engineering 2006. 15(4):282–93.

[2] Laperriere L, Eimafaghy H GAPP: *a generative assembly process planner.* Journal of Manufacturing System 1996.

[3] Homem de Mello L, Lee S. *Computer-aided mechanical assembly planning*.London: Kluwer Academic Publishers 1991.

[4] Zha XF, Lim SY, Fok SC. *Integrated intelligent design and assembly planning:a survey.* International Journal of Advanced Manufacturing Technology 1998; 1–15.

[5] Wang Y, Liu JH. *Chaotic particle swarm optimization for assembly sequence planning 10.* Robotic and Computer-Intergrated Manufacturing 26 (2010) 212-222.

[6] Failli F, Dini G. *Ant colony systems in assembly planning: a new approach to sequence detection and optimization.* In: Proceedings of second CIRP international seminar on intelligent computation in manufacturing engineering. 2000. p. 227–32

[7] Wang JF, Liu JH. *Intelligent selective disassembly using the ant colony algorithm. Artificial intelligence for engineering design*. Analysis and Manufacturing 2003;17 (4):325–33.

[8] Cao P, Xiao R. *Assembly planning using a novel immune approach*. International Journal of Advanced Manufacturing Technology 2007; 31(7-8):770–82.

[9] Kennedy J, Eberhart R. *Particle swarm optimization*. In: Proceedings of the IEEE international conference on neural networks. 1995. p. 1942–8.

[10]Young-Keun Choi (2008),*An approach to multi-criteria assembly sequence planning using genetic algorithms*. Int J Adv Manuf Technol (2009) 42:180–188.

[11]Hong D, Cho H. *Generation of robotic assembly sequences using a simulated annealing*. In: Proceedings of the IEEE/RSJ international conference on intelligent robotic and systems. 1999. p. 1247–52.

[12]Guan Q, Liu JH, Zhong YF. *A concurrent hierarchical evolution approach to assembly process planning*. International Journal of Production Research 2002;40(14):3357–74.

[13]Smith GC, Smith SSF. *An enhanced genetic algorithm for automated assembly planning*. Robotics and Computer Integrated Manufacturing 2002; 18(5-6):355–64.

[14]Eberhart R, Shi Y. *Particle swarm optimization: developments, applications and resources.* In: Proceedings of the IEEE International Conference On Evolutionary Computation. 2001. p. 81–6.

[15]Kennedy J, Eberhart RC. *Swarm intelligence*. San Francisco: Morgan Kaufmann Publishers; 2001.

[16]Clerc M. *Particle swarm optimization*. London: ISTE; 2006.

[17]Liao C, Tseng C, Luarn P. *A discrete version of particle swarm optimization for flow shop scheduling problems*. Computers & Operations Research 2007; 34(10):3099–111.

[18]Schutte J, Koh B, et al. *Evaluation of a particle swarm algorithm for biomechanical optimization*. Journal of Biomechanical Engineering 2005; 127(3):465–74.

[19]Esmat Rashedi, Hossein Nezamabdi-pour, Saeid Saryazdi. *GSA: A Gravitational Search Algorithm. Information Sciences* 179 (2009) 2232-2248.