A Note on "A Hybrid Genetic Algorithm for the Dynamic Plant Layout Problem"

Jaydeep Balakrishnan[1]
Chun Hung Cheng[2]

[1] Operations Management Area
Haskayne School of Business
University of Calgary
Calgary, Alberta T2N 1N4
Canada
Ph: (403) 220 7844   Fax: (403) 210 3327   Email: Jaydeep.Balakrishnan@haskayne.ucalgary.ca

[2] Department of Systems Engineering and Engineering Management
The Chinese University of Hong Kong
Shatin, Hong Kong
PRC
Ph: +852 2609 8322   Fax: +852 2603 5505   Email: chcheng@se.cuhk.edu.hk

Published in the *International Journal of Production Economics*, 103, 1, 2006, pp 87-89.

A Note on "A Hybrid Genetic Algorithm for the Dynamic Plant Layout Problem"

Abstract

The dynamic plant layout problem (DPLP) deals with multi-period layout. Since a seminal work published in 1986 by Rosenblatt, many researchers have followed up with a number of solution methods. Among those, genetic algorithms and simulated annealing have been proposed. In this paper, we compare the performance of these algorithms in solving the DPLP.

Keywords: Dynamic layout, genetic algorithms, simulated annealing, algorithm comparison

1. Introduction

This paper provides an update on plant layouts based on multi-period planning horizons. During this horizon, the material handling flows between the different departments in the layout may change. This necessitates a more sophisticated approach than the static plant layout problem (SPLP) approach. The dynamic plant layout problem (DPLP) extends the SPLP by considering the changes in material handling flows over time and the costs of rearranging the layout.

Since the seminal work by Rosenblatt (1986), many researchers have been attracted to the problem and have developed a number of solution methods. Balakrishnan and Cheng (1998) provide a detailed review of these algorithms. However, their review does not cover recent genetic algorithms (GA), hybrid GA and simulated annealing (SA) based approaches since these appeared later. In this paper, we study their performance in solving the DPLP. This work is important in establishing a benchmark for future researchers in this area. The importance of this area has been emphasized by Benjaafer et al. (2002), in their layout review paper, where they identify dynamic layout as a research area for the next generation of factory layouts.

2. Recent Developments

Conway and Venkataramanan (1994) were the first to propose the use of GA in solving the DPLP. Their approach is reviewed in Balakrishnan and Cheng (1998). Balakrishnan and Cheng (2000) propose a unique GA that incorporates point-to-point crossover, mutation, and generational replacement to improve population diversity. They show that this GA performs better than Conway and Venkataramanan’s GA.

Baykasoglu and Gindy (2001) develop a simulated annealing algorithm (SA) for the DPLP. They show that their algorithm performs better than the GAs by Conway and Venkataramanan (1994), and Balakrishnan and Cheng (2000). The parameter settings in their SA algorithm involve determining the initial temperature (the probability that in the neighbourhood search, an inferior solution will be accepted), the rate at which the temperature decreases (the decrease in the acceptance probability of an inferior solution), and the number of iterations.

Balakrishnan et al. (2003), in work published in this journal, propose a hybrid GA approach. They attempt to use a dynamic programming based crossover to exploit the problem structure of the DPLP. The hybrid GA compares favourably with the traditional GA approaches but did not do as well as the SA approach for large problems. In an erratum, Baykasoglu and Gindy (2004) correct their computational results reported in Baykasoglu and Gindy (2001). The corrections occur in the 15 department and 30 department problems. With this correction, it appears that the SA does not provide as good results as the hybrid GA of Balakrishnan et al. (2003). This is explained below.

3. Comparison

The updated results from Baykasoglu and Gindy (2004), are compared to the hybrid GA results in Tables 1 through 4. Based on these updated results for the 15 and 30 department categories, the SA still does better than the CVGA on each and every problem. Further, it does as well or better than the NLGA on each and every problem. However, the GADP(U) outperforms the SA algorithm in each and every problem in these categories. In the 15 department category, the GADP (U) is at least 3.9% and 3.3% better on average in the 5 period and 10 period problems respectively. The differences range between 2.3% and 4.7% in these problems. In the 30 department category, the GADP (U) is 5.3% and 5.5% better on average in the 5 period and 10 period problems respectively. The differences range between 4% and 6.8% in these problems. Additionally, the GADP(R) outperforms the SA in every problem except one in the 15 and 30 department categories. It was previously shown (Balakrishnan et al., 2003) that the hybrid GA algorithm did better than the SA algorithm in the 6 department problems in general. Thus the hybrid GA algorithm appears to be very effective.

	Prob 1	Prob 2	Prob 3	Prob 4	Prob 5	Prob 6	Prob 7	Prob 8	Average
CVGA	504759	514718	516063	508532	515599	509384	512508	514839	512050.3
NLGA	511854	507694	518461	514242	512834	513763	512722	521116	514085.8
GADP (R)	493707	494476	506684	500826	502409	497382	494316	500779	498822.4
GADP (U)	484090	485352	489898	484625	489885	488640	489378	500779	489080.9
SA	501447	506236	512886	504956	509636	508215	508848	512320	508068.0

Table 1: Total costs for 15 department , 5 period problems

	Prob 1	Prob 2	Prob 3	Prob 4	Prob 5	Prob 6	Prob 7	Prob 8	Average
CVGA	1055536	1061940	1073603	1060034	1064692	1066370	1066617	1068216	1064626.0
NLGA	1047596	1037580	1056185	1026789	1033591	1028606	1043823	1048853	1040378.9
GADP (R)	1004806	1006790	1012482	1001795	1005988	1002871	1019645	1010772	1008143.6
GADP (U)	987887	980638	985886	976025	982778	973912	982872	987789	982223.4
SA	1017741	1016567	1021075	1007713	1010822	1007210	1013315	1019092	1014191.9

Table 2: Total costs for 15 department, 10 period problems

	Prob 1	Prob 2	Prob 3	Prob 4	Prob 5	Prob 6	Prob 7	Prob 8	Average
CVGA	632737	647585	642295	634626	639693	637620	640482	635776	638851.8
NLGA	611794	611873	611664	611766	604564	606010	607134	620183	610623.5
GADP (R)	603339	589834	592475	586064	580624	587797	588347	590451	589866.4
GADP (U)	578689	572232	578527	572057	559777	566792	567873	575720	571458.4
SA	604408	604370	603867	596901	591988	599862	600670	610474	601567.5

Table 3: Total costs for 30 department, 5 period problems

	Prob 1	Prob 2	Prob 3	Prob 4	Prob 5	Prob 6	Prob 7	Prob 8	Average
CVGA	1362513	1379640	1365024	1367130	1356860	1372513	1382799	1383610	1371261.1
NLGA	1228411	1231978	1231829	1227413	1215256	1221356	1212273	1245423	1226742.4
GADP (R)	1194084	1199001	1197253	1184422	1179673	1178091	1186145	1208436	1190888.1
GADP (U)	1169474	1168878	1166366	1154192	1133561	1145000	1145927	1168657	1156506.9
SA	1223124	1231151	1230520	1200613	1210892	1221356	1212273	1231408	1220167.1

Table 4: Total costs for 30 department, 10 period problems

References

1. Balakrishnan J. and Cheng C.H., 1998. Dynamic layout algorithms: a state-of-the-art survey, *Omega*, 26 (4), 507-521.

2. Balakrishnan J. and Cheng C.H., 2000. Genetic search and the dynamic layout problem: an improved algorithm, *Computers and Operations Research*, 27, 587-593.

3. Balakrishnan J., Cheng C.H., Conway D.G., and Lau E.C.M., 2003, "A hybrid genetic algorithm for dynamic layout", *International Journal of Production Economics*, 86, (2), 107-120.

4. Benjaafar, S. Heragu, S.S. and Irani, S.A., 2002. Next generation factory layouts: research challenges and recent progress, *Interfaces*, 32, (6), 58 -77.

5. Baykasoglu A., and Gindy N.N.Z., 2001. A simulated annealing algorithm for the dynamic layout problem, *Computers and Operations Research,* 28, 1403-1426.

6. Baykasoglu A., and Gindy N.N.Z., 2004. Erratum to "A simulated annealing algorithm for the dynamic layout problem", *Computers and Operations Research,* 31, 313-315.

7. Conway D.G., and Venkataramanan M.A., 1994. Genetic search and the dynamic facility layout problem, *Computers & Operations Research*, 21 (8), 955-960.

8. Rosenblatt M.J., 1986. The dynamics of plant layout, *Management Science*, 32, (1), 76-86.