COMBINING GA AND MCDM METHODS TO SOLVE SMTWTP WITH SEQUENTIAL DEPENDENT SETUP TIMES

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ABSTRACT

This study is to solve a single machine total weighted tardiness scheduling problem (SMTWTP) considering the sequential dependent setup times. AHP (Analytic Hierarchy Process) is considered as a prior rule that evaluate the qualitative and quantitative factors simultaneously then assign the weights to each job. Compared with different prior rules by GA (Genetic Algorithm) computation, the results show that the proposed method is efficient to find the minimal time of optimal solution and practical in business applications.

INTRODUCTION

Scheduling is a business manufacturing process which concerned with the allocation of limited resources to tasks in time, customers satisfaction, and cost. If the firm's tasks worked overtime, it makes huge damage and has to compensate for that. Therefore, the area of scheduling problem has grown considerably, and there is an extensive literature available on this subject. However, most research in this field assumes that each job has the same weight, or decided the importance of jobs arbitrarily [1] [2]. Moreover, most of research objectives at present consider manufacturing performance factors lack of concerning about the qualitative factors such as the customers' needs and business strategy. Our purpose is to minimize the total weighted tardiness time (considering the sequential dependent setup time) on a single machine which called total weighted tardiness scheduling problem (SMTWTP). Analytic Hierarchy Process (AHP) evaluates the qualitative and quantitative factors simultaneously to assign the weights to each job. Then it is considered as a prior rule to compared different prior rules by the computation of Genetic Algorithm (GA).

LITERATURE REVIEW & METHODOLOGIES

The traditional operation research method like Branch and Bound (B&B) algorithm [3] can find the optimal solution. With the problems getting extensive, it is limited by computational times and computer storage requirements. Therefore, there has been much progress on the design and analysis of heuristic algorithms such as Genetic Algorithm (GA) and Tabu Search (TS) for solving the real-world optimization problems [4]. In addition, most research on this problem only concerns quantitative factors lacking for adopting qualitative ones and often neglects the condition of setup time.

Problem of scheduling on a single machine to minimize total weighted tardiness of jobs can be described as follows: A set of n jobs are available for processing at time zero on a continuously available machine. Each job has a processing time p_j a due date d_j, and a setup time a_{ij} which is incurred when job *i* immediately follows job *j*. Assumes all the processing times, due dates and setup times are non-negative, let q is a sequence of the jobs ($q_0 = q_0, q_1, ..., q_n$), where q_j denotes the index of the j_{th} job in sequence, and $q_0 = 0$. The due date of the j_{th} job in sequence is denoted as d_{sj} and the processing time of the j_{th} job in sequence is denoted as p_{sj}. Thus, the completion time of the j_{th} job in sequence is given as $C_{qj} = \sum_{k=1}^{j} (a_{qk-1} + p_{qk})$ .The tardiness of the j_{th} job in sequence is given as $T_{qi} = \max(C_{qj} - d_{qj}, 0)$. The objective is to minimize the total weighted tardiness of jobs, $\sum_{j=1}^{n} w_i T_{qj}$. In spite of the fact that a majority of the literature deals with problems without sequence dependent setups, setups are important in a majority of practical situations, and must be accounted for in the design of algorithms for scheduling problems.

We used AHP to solve multiple criteria weight planning problems. In the Multiple criteria decision making (MCDM) methods, AHP is a common and simple weighting method. Since its invention has been an approach at the hands of decision makers and researchers. It is one of the most widely used in many outstanding works and published. These applications of AHP in different fields include such as planning, selecting a best alternative, resource allocations, resolving conflict, optimization, and numerical extensions of AHP. It is an Eigenvalue approach to the pair-wise comparisons, and also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from 1/9 for 'least valued than', to 1 for 'equal', and to 9 for 'absolutely more important than' covering the entire spectrum of the comparison. AHP helps to incorporate a group consensus. Generally, this consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution.

In this research, we studied the total weighted tardiness scheduling problem to minimize the tardiness time, and applied GA to solve the best scheduling sequence. The initial solution will use the weights which AHP computed, and then compared with other four prior rules. These rules include Weighted Shortest Processing Time (WSPT), Shortest Processing Time (SPT), Earliness Due Date (EDD), Longest Processing Time (LPT), and Ranking rule. The GA has some essential steps during the computed process stated with detail as follows: (a) coding, (b) parametric to set, (c) initial population, (d) fitness, (e) selection, (f) crossover, (g) mutation, and (h) replacement.

EXPERIMENTS AND RESULTS

10-job problem is selected as computational example to proof this model. To calculate the relative important qualitative factors as the profit, historical trades, the market shared the potential order for goods, and the required materials according to the AHP. To sum of all the factors as the weights assign to each job. The finding is shown in Table 1.

Table 1. Total weight of each job

	Profit	Historical trades	The market shared	The potential order for goods	The required materials	Total
1	0.1554	0.0852	0.1839	0.0414	0	0.4659
2	0.0792	0.0598	0.0497	0.056	1.00	1.2447
3	0.175	0.17	0.0712	0.1349	1.00	1.5511
4	0.1363	0.2454	0.1452	0.2403	1.00	1.7672
5	0.0762	0.0598	0.0232	0.054	0	0.2132

6	0.0656	0.0416	0.0878	0.0869	0.90	1.1819
7	0.0635	0.17	0.0372	0.1349	0	0.4056
8	0.0605	0.0328	0.2515	0.0328	1.00	1.3776
9	0.1085	0.1094	0.1145	0.1913	1.00	1.5237
10	0.0798	0.026	0.0358	0.0275	0.65	0.8191

We tested the five prior rules and the AHP-GA under the same parameters (crossover = 0.4 and mutation = 0.006) as the initial solution, and computed by GA to hit the minimal total weighted tardiness time (3942.61) by compared with the generation and the computational time. The finding shows in Table 2. The outcomes showed that the AHP-GA only needs 300 generations and one second computed time.

Table 2. The results of different prior rules

Prior rule	EDD	SPT	WSPT	LPT	Ranking	AHP
Initial sol.	8265.95	6349.81	5626.21	7161.71	7009.09	6000.48
Best sol.	3942.61	3942.61	3942.61	3942.61	3942.61	3942.61
Generations	554	904	415	970	896	300
Time(sec.)	1	2	1	2	2	1

CONCLUSIONS

Most scheduling research of multiple objectives at present, only consider manufacturing performance factor. The AHP-GA considers both the qualitative and quantitative factors, and then it can hit the best solution rapidly. Therefore, the contributions of the method we proposed are as follows: (a) in the scheduling research we first use the AHP to estimate the weight and the sequence of jobs can get the good initial solution; (b) After testing AHP and finding out AHP might be a good prior rule; (c) Combined AHP with GA concerns both the qualitative and quantitative factors that conforms to the real business environment, and has a efficient performance which is superior to other rules. The limitation of AHP is that the inner factors must be independent, but in a real business some factors are dependent, so the future work might consider: (a) considering the Analytic Network Process (ANP) to estimate the weight; (b) mixing Fuzzy theory and ANP as FANP to have the qualitative factors more objective; (c) extending the experiment size or the complexity for the further studies.

REFERENCES

[1] Nearchou, A. C. Solving the single machine total weighted tardiness scheduling problem using a hybrid simulated annealing algorithm. *Industrial Informatics, 2004. INDIN '04. 2004 2nd IEEE International Conference on*, 2004, 513-516.

[2] Gupta, S. R. and Smith, J. S. Algorithms for single machine total tardiness scheduling with sequence dependent setups. *European Journal of Operational Research*, In Press, Corrected Proof, 2005.

[3] Tavakkoli-Moghaddam, R., Moslehi, G., Vasei, M. and Azaron, A. A branch-and-bound algorithm for a single machine sequencing to minimize the sum of maximum earliness and tardiness with idle insert. *Applied Mathematics and Computation*, 2006, *174*, 388-408.

[4] Chang, P. C., Hsieh, J. C. and Liu, C. H. A case-injected genetic algorithm for single machine scheduling problems with release time. *International Journal of Production Economics*, 2006, *103*, 551-564.