Proposition of Selection Operation in a Genetic Algorithm for a Job Shop Rescheduling Problem

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Abstract. This paper deals with a two-objective rescheduling problem in a job shop for alteration of due date. One objective of this problem is to minimize the total tardiness, and the other is to minimize the difference of schedule. A genetic algorithm is proposed, and a new selection operation is particularly introduced to obtain the Pareto optimal solutions in the problem. At every generation in the proposed method, two solutions are picked up as the parents. While one of them is picked up from the population, the other is picked up from the archive solution set. Then, two solutions are selected from these parents and four children generated by means of the crossover and the mutation operation. The candidates selected are not only solutions close to the Pareto-optimal front but also solutions with a smaller value of the total tardiness, because the initial solutions are around the solution in which the total tardiness is zero. For this purpose, the solution space is ranked on the basis of the archive solutions. It is confirmed from the computational result that the proposed method outperforms other methods.

1 Introduction

Although many researchers have so far proposed various methods for solving scheduling problems in manufacturing systems, most studies deal with the determination of a schedule for conventional problems in which the condition is given in advance. However, in real manufacturing systems, alteration of problem condition such as change of due date and addition of job often obliges to revise a schedule worked out previously. Vieira et al. [1] presented definition appropriate for most applications of such rescheduling manufacturing systems, and reviewed various methods to solve the rescheduling problems. Moreover, genetic algorithms (GAs) [2] were also applied to some rescheduling problems [3, 4, 5]. The GA is an appropriate method to solve rescheduling problems, because diversity of population in the GA is useful in tracking change of problem condition [6].

The aim of most of these methods is to optimize only an original objective function, say the total tardiness. Consequently, the schedule obtained by such a method may be very different from that before the alteration. The difference of schedule incurs time and costs in re-preparing the processing for the case where

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the problem condition is altered after preparation of processing. As studies considering the schedule difference, Watatani and Fujii [7] defined a problem in which the objective function is a weighted sum of the makespan and the schedule difference, and applied the simulated annealing method to this problem. Abumaizar and Svestka [8] considered a problem for a breakdown of machine, and obtained a schedule with a small difference by rescheduling only the operations affected by the breakdown of machine.

This paper deals with a job shop rescheduling problem of minimizing both the total tardiness and the schedule difference in the case where the due dates of some jobs are altered, and a GA is proposed for obtaining the Pareto optimal solutions. Although a GA with a selection operation was applied to this problem [9] as a preliminary study, it is ineffective in instances with many jobs. In addition, the weight between the objective functions must be given in advance. In order to overcome these disadvantages, a new selection operation is proposed in this paper. In this operation, the solution space is ranked to select not only solutions close to the Pareto-optimal front but also solutions with a smaller value of the total tardiness.

The rest of the paper is organized as follows. Section 2 describes the rescheduling problem as well as the conventional scheduling problem before the alteration. Next, Section 3 presents the GA proposed for the rescheduling problem, and describes the new selection operation. The computational results can be found in Section 4, and the effectiveness of the proposed GA is investigated. Finally, Section 5 concludes the paper.

2 Problem Statement

2.1 Conventional Problem

At the beginning, a conventional problem P^* before alteration is described. In P^*, a set of I kinds of jobs J_i $(i = 1, 2, \cdots, I)$ is processed by using K machines M_k $(k = 1, 2, \cdots, K)$. A machine can process at most one job at a time. A job J_i should be completed by the due date D_i^*. Moreover, J_i consists of K operations O_{ij} $(j = 1, 2, \cdots, K)$. An operation O_{ij} is executed on $\mathrm{M}_{R(i,j)}$ $(R(i, j) \in \{1, 2, \cdots, K\})$, which is given in advance, and its processing time is given as PT_{ij}. No preemption of operation is allowed. There exists a precedence constraint between operations belonging to a job, and the operations must be executed in the order of j. This constraint is often called the technological constraint. The total number of operations is denoted as Q $(Q = IK)$.

The problem P^* is to determine the completion time c_{ij}^* of O_{ij} in such a way that the total tardiness F_1^* should be minimized. The objective function F_1^* is formulated as

$$F_1^* = \sum_{i=1}^{I} \max(c_{iK}^* - D_i^*,\ 0). \tag{1}$$

By applying a GA to P^*, the population at the final generation and the best solution (schedule) S^* can be obtained.