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Adaptive genetic algorithm for lot-sizing problem with self-adjustment operation rate

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Abstract

This paper presents a new adaptive genetic algorithm (GA) to escape local optimum solutions of the traditional lot-sizing rules. In this GA, the timing of replenishment is encoded as a string of binary digits (a chromosome). Each gene in that chromosome stands for a period. Standard GA operators are used to generate new populations. These populations are evaluated by a fitness function using the replenishment scheme of solution based on the total cost. Through this evaluation, the rates of GA operators for the next generation are automatically adjusted based on the rate of survivor offsprings, which are generated by corresponding operators. The oriented search procedure using these self-adjustment rates of operator schemes can give faster and better solutions. Some experimental results confirm the theoretical judgment.

Keywords: Genetic algorithm; Lot-sizing; Self-adjustment operation rate

1. Introduction

The industrial lot-sizing problem determines the best replenishment strategy that size of replenishment and timing of the production quantities satisfy the minimum total cost based on a given demand pattern. Although the well-known dynamic programming of Wagner–Whitin (W–W) (Wagner and Whitin, 1958) gives the optimal solution, it still suffers from its computational complexity. Several lot-sizing rules are developed to improve the computational efficiency. However, these methods can only guaranty a local optimum solution.

Moreover, another difficulty of the production lot-sizing problem is its insight conflict criteria: replenishment and carrying cost. The total cost includes both total replenishment and setup cost. However, if the timing and size of production quantities (lot-size) decrease, carrying cost decreases but replenishment cost increases.

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Otherwise, if the timing and size of production quantities increase, carrying cost increases but replenishment cost decreases. The requirement is how to find the best scheme for replenishment production quantities to trade-off between these costs in order to minimize total cost.

Genetic algorithm (GA) is a search procedure that mimics the natural evolution processes. Because its ability gives the near optimal solution and escape from local points, it is widely used in many applications. Therefore, GA would be a promising tool to solve the two above requirements of the lot-sizing problem efficiently.

In this paper, we proposed an adaptive GA to cope with these requirements. The proposed GA uses a flexible coding scheme of replenishment timing. Then the size of production quantities is also determined flexibly. Hence, each generation of solution is evaluated using the total cost function in order to redirect the search orientation to reach the best solution faster. With this flexible coding scheme, the conflicting criteria are handled. And, the nature of random search of GA gives the near optimal solution instead of local optimum. The next section of this paper will review the related work. In Section 3, we describe the problem under consideration. The proposed algorithm is presented in Section 4. Section 5 gives some experimental results when the proposed adaptive GA is compared with the famous lot-sizing rules of SM. Finally, the conclusion section summarizes achievements and addresses some future research directions.

2. Related work

The lot-sizing problem has been widely studied under different aspects of demand rates (constant or time varying), demand characteristics (deterministic or stochastic), products (single or multiple), quantity discount or not, etc. General description of this problem is discussed extensively in Silver et al. (1998). Wagner and Whitin (1958) developed an optimal solution for dynamic multistage production systems under some special assumptions, but it still suffers from computation complexity, and thus several heuristic approaches has been proposed in various aspects of the lot-sizing problem (Silver and Meal, 1973; Wee, 1995; Hariga, 1995; Hariga and Ben-Daya, 1996; Sikora, 1996; Chyr et al., 1999; Ho and Ho, 1999; Kang et al., 1999; Ben-Daya and Rahim, 1999; Voros, 1999, etc.). For the basic deterministic lot-sizing problem of W–W, several well-known heuristic rules have been developed to cope with the requirement of simple computation but still captures the potential saving in terms of total replenishment and carrying costs such as Silver–Meal (SM) heuristic, Periodic Order Quantity, Lot-for-Lot (L4L), Least Unit Cost, Part-Period Balancing (PPB) (see Silver et al., 1998). For other cases of the lot-sizing problem, some interesting results are obtained under additional assumptions. For instance, Wee (1995) develops an exact solution to the problem of finding a replenishment policy for an item that faces declining demand and that deteriorates overtime. Hariga (1995) considers the case of increasing demand. Hariga and Ben-Daya (1996) also solves for the case of inflationary condition. Voros (1999); Ben-Daya and Rahim (1999) focused on lot-sizing models with consideration of process quality effects and setup time reduction. Chyr et al. (1999) presented a model of dynamic lot-sizing problem for the case of quantity discount. In the rolling-horizon environment such as in MRP systems, the handling systems nervousness issue has been evaluated by Ho and Ho (1999) to measure the effectiveness of using lot-sizing rules. The integration between lot-sizing and sequencing decisions are also addressed in Sikora (1996) and Kang et al. (1999).

As Baker (1989) summarized, among the well-known heuristic rules, the SM rule gives the best performance. However, this method can only guarantee a local optimal solution. As mentioned, the GA approach may be an appropriate tool to overcome this draw back. The experimental results will prove that the proposed GA can give better or as good as SM results in the long run.

3. Problem description

3.1. Problem statement

The lot-sizing problem has several variations, which depend on the assumptions of each case. In