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A fuzzy railroad blocking model with genetic algorithm solution approach for Iranian railways

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ABSTRACT

In the railway, the fright car classification takes place in the terminals. This classification always imposes a remarkable delay to the movement of the cars from origin to destination. To reduce car handling, it is necessary to group various shipments together with respect to their destination in the railroad blocking plan. In this paper, for the first time, a railroad blocking model with fuzzy travel costs is proposed. In the model, the preferred fuzzy paths are determined by a fuzzy shortest path method. Then, the fuzzy model is transformed into a classic railroad blocking model. The real-life blocking problems are very large with many variables and constraints, and modeling and solving them using commercially available software is very time consuming. Therefore, a solution method based on genetic algorithm is developed. To evaluate the performance of the solution method, several simulated problems are tested and the solutions of genetic algorithm are compared with those of the CPLEX software. The results reveal the algorithm has promising accuracy and computing speed for solving the railroad blocking problem. As a case study, the proposed model for creating the Iranian railway blocking plan is utilized. Iran railways can significantly diminish the some costs and save the time in delivering the loads.

1. Introduction

A hierarchy model at strategic, tactical, and operational levels is presented by Assad [1]. The main differences of these levels are planning horizon, required investment, and modeling methods. The railroad blocking problem (RBP) is placed in the tactical level. The operating plan has a key role in railroad operations by specifying the shipments, crews, and locomotive movement along the rail network. The RBP is an important part of the operating plan. To facilitate well-organized movement of shipments, railroad companies have a department for service design that is in charge of operating plans construction (Fig. 1) [2].

Train scheduling is composed of train route designing, operation days, timing, and routing of blocks on trains. Minimizing the total cost is the goal of train scheduling. The total cost consists of the cost of car, crew, and locomotive hiring. Three railroad asset flows such as crews, locomotives and railcars are determined in operating plan [2].

In order to reach destination, freight may transfer on several classification yards. Usually the load is consist of different shipments, is regrouped in the yards. However, it is possible to group different shipments together in form of a block to prevent reclassification at intermediate yards. A block contains shipments which are regrouped only in the destination.

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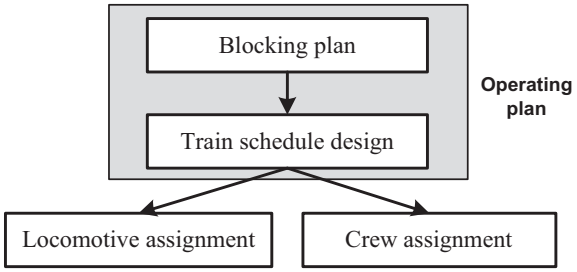

Fig. 1. Operating plan: blocking plan and train schedule [2].

The RBP finds blocks to be formed and the sequences of them that transfer each shipment. The objective of RBP is to minimize the total travel distance of the shipments. More explanation about the RBP can find in Yaghini et al. [3].

The RBP is defined in a physical rail network. Based on the physical network, the blocking network (virtual network) is defined. A commodity can take a block (virtual arcs) to have non-stop service between two terminals. Virtual arcs on the blocking network may not have a direct physical rail link connection [4].

The RBP in the real-life is a very large-scale problem and often contains a lot of variables. Therefore modeling and solving them using commercial software is nearly impossible. Railroads usually design the blocking plans based on manual decision-making processes. Usually, the outputs of these processes are not cost effective and optimized. Consequently, it is necessary to use an optimization-based approach to determine blocking plans.

Here, in the railway network, the distance between origin and destination terminals represent transportation time and cost. The time and cost is influenced by various uncertain parameters. The exact costs such as the time which the cars stay in the terminals or cost of fuel and additional units of locomotive, which increases with train size often not exactly determined for planners. These parameters can be affected by different factors and using deterministic values is not practical. As a result, modeling and solving this problem with flexible fuzzy framework is desirable and can take into account the real-life conditions.

In this paper, a fuzzy model is proposed for the railroad blocking problem. A genetic-algorithm based solution method with several genetic search operators is used to solve the proposed model. In order to evaluate the algorithm, several test problems are created and solved by the proposed algorithm and the results are compared to CPLEX software. The outcomes show that the effectiveness and efficiency of the solution approach. Finally, the proposed model is applied to solve the RBP in Iran Railways.

This paper is organized as follows. Section 2 presents a literature review. In Section 3, the fuzzy mathematical formulation for the classic RBP and the proposed RBP with fuzzy travel costs are stated. In Section 4, the steps of the proposed genetic algorithm are explained. In Section 5, experimental results over the simulated problems are given. In Section 6, a case study in Iran railway is presented. Finally, in Section 7, conclusions are provided.

2. Literature review

The RBP is a network budget design problem (NBDP). The goal of NBDP is to minimize the flow and fixed costs. The NBDP consists of wide range of problems. For example, the fixed-charge network design problem is one type of the NBDP. The fixed-charge network design problem is different from the NBDP in that the fixed costs. This problem is known as NP-hard combinatorial optimization problem [5–10].

A concise review of the literature related to the blocking problem is given here. Previous surveys by Assad [A.A. Assad, Models for rail transportation, Transp. Res. Part A: Policy Practice 14 (1980) 205–220.], Cordeau et al. [11] and Crainic [12] review optimization models for rail transportation.

Bodin et al. [13] presented a nonlinear Mixed Integer Programming (MIP) formulation of the RBP problem. The model specifies the best blocking for all the classification yards. Assad [14] suggested a solution method based on a line network. The cars at the first yard should be separated as they proceed along the line to allow each successive yard to extract the traffic destined for it. Van Dyke [15,16] applied a heuristic solution method and solving several series of problems on a network.

Newton [4] and Newton et al. [17] modeled the RBP as a network-design and formulated it as an MIP. They proposed the column generation and branch-and-price approach for this problem. Barnhart et al. [18] proposed the Lagrangian relaxation technique, however, the disadvantage of the solution method is the high running time for large size problems. Ahuja et al. [2] applied a technique known as Very Large Scale Neighborhood (VLSN) for the RBP.

Yue et al. [19] proposed a formulation for the RBP. To solve the model, they utilized an improved version of the ant colony optimization. They do not consider the terminal capacity in handling classification process and maximum available block constraints, and discuss the problem with direct train routing and frequencies.

Yaghini et al. [3] presented a metaheuristic algorithm based on ant colony optimization for solving the RBP. To evaluate the quality of solutions and the algorithm efficiency, the results on several test problems are compared with those of CPLEX software. The solution method is applied to generate railroad blocking plan in Iran Railways.