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Genetic Algorithm with Variable Neighborhood Search for the Optimal Allocation of Goods in Shop Shelves

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Abstract

Shelves on which products are being displayed are one of the most important resources in retail environment. The decision of shelf space allocation and management is therefore a critical issue in retail operations management. In this paper a hybrid algorithm that combines a genetic algorithm with a variable neighborhood search is proposed to address the shop shelf allocation problem. Results obtained from an extensive experimental phase show the suitability of the proposed algorithm in addressing the problem at hand.

Keywords: Allocation, Shelf Space, Heuristics.

1. Introduction

The shelf space allocation problem is a real-world problem faced by many retail companies. The problem arises when there is a large number of products to display, but with limited shelf space available at disposal. As reported in [7], increasing sales by attracting the consumer's attention and encouraging consumers to have additional purchase opportunities can be implemented by proper management of shelf space allocation and products display. However, as reported in [4], retail shelf-space management is one of the most difficult aspects of retailing due to several reasons. A significant reason is that while retail shelf-space is fixed, the numbers of new potential products, customer wants, and competitors are constantly growing and evolving. At the same time, customers are consolidating shopping trips toward multi-purpose shopping [8]. Thus, the success of any retailer depends on its ability to match its changing environment by continually deciding between how much of which products to shelve, where and when. Many retailers have now adopted software programs for creating allocation plans. However, as pointed out in [13], because of the NP-hard complexity of the shelf space allocation problem, many intuitive approaches have been applied in commercial systems for allocating shelf space within the retailing industry. The concern for simplicity and practicability of these commercial approaches, however, results in space allocation decisions that reach far from the optimal performance levels [13]. Hence, considering the complexity of the problem, heuristic techniques seem to be the best road available to produce solutions to the problem in a reasonable computational time.

In this paper we propose an hybrid algorithm for the shelf space allocation problem. The proposed algorithm combines a genetic algorithm with a variable neighborhood search. The use of a genetic algorithm, combined with a variable neighborhood search, results in an effective exploration/exploitation ratio for the considered problem, thus improving the quality of the final solutions.

The paper is organized as follows: Section 2 defines the problem addressed in this paper and presents its mathematical formulation. Section 3 provides a detailed description of the proposed method. Section 4 presents the experimental settings and the results, and finally section 5 draws some final conclusions and suggests some hints for possible future work.

2. Problem Definition

Before presenting the mathematical model considered in this paper, we introduce some definitions related to shelf space allocation. The first term is a stock-keeping unit (SKU) which is used to uniquely identify a specific product or goods. SKU is the smallest management unit in a retail store. Facing is a very important variable for shelf space allocation. The number of the facings of a SKU is defined as the quantity of an item that can be directly seen on the shelves or fixtures by the customers. The items placed behind other items cannot be seen directly and hence are not deemed as a facing.

2.1. Mathematical Model

In this section we present the mathematical model considered to represent the shelf space allocation problem. We denote with n the number of item (SKU) and with m the number of shelves. Then, considered a product i, with $i \in \{1, \ldots, n\}$ we denote with l_i the length of each facing of product i. We indicate with T_k the length of the k^{th} shelf, with $k \in \{1, \ldots, m\}$. The profit per facing of product i displayed on shelf k is p_{ik}, while x_{ik} represents the allocated amount of facings of product i on shelf k. With this notation we can describe a first basic shelf space allocation problem as follows:

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