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A recursive branch-and-bound algorithm for constrained homogenous T-shape cutting patterns

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ABSTRACT

The manufacturing industry often uses the two-phase process to divide stock plates into rectangular items. A guillotine machine cuts the plates into homogenous strips at the first phase, where each strip contains items of the same type. Either a guillotine machine or stamping press cuts the strips into items at the second phase. This paper presents a recursive branch-and-bound algorithm for generating constrained homogenous T-shape (HTS) cutting patterns at the first phase, where the frequency of an item type is constrained by its upper bound. A HTS pattern includes two segments. Each segment contains homogenous strips of the same direction. The strip directions of the two segments are perpendicular to each other. Two versions of the algorithm are presented. The first uses the unconstrained solutions to estimate the upper bounds, and the second uses the constrained solutions. The computational results indicate that the algorithm is much faster than existing algorithms.

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1. Introduction

This paper discusses the constrained two-dimensional cutting problem (CTDC): m types of rectangular items are produced from stock plate $L \times W$ (length $\times$ width) using guillotine cuts, such that the total value of the produced items is maximized, where the ith type has size $l_i \times w_i$, value c_i and upper bound d_i, $1 \le i \le m$. Each item in the plate can take two directions, with either its length or width being parallel to the length of the plate. Assume that pattern P includes z_i pieces of type i. The formulation of the CTDC is:

$$\max\left(\sum_{i=1}^{m} c_i z_i\right); \quad P \text{ is a guillotine pattern; } z_i \text{ integers, } 0 \le z_i \le d_i,\ i = 1, \ldots, m$$

where $\sum_{i=1}^{m} c_i z_i$ is the pattern value. The related unconstrained two-dimensional cutting problem (UTDC) comes if the constraint of the upper bound is relaxed.

An exact algorithm for homogenous T-shape (HTS) patterns is presented in this paper, where it is assumed that both the plate and item sizes are integers. The computational results indicate that the algorithm is much faster than existing exact algorithms for generating HTS patterns.

The contents below are organized as follows: Section 2 introduces the HTS patterns and reviews the literature briefly. Section 3 describes the algorithm. Section 4 presents the computational results. Section 5 gives the conclusions.

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