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A Multi-objective Variable Neighborhood Search algorithm for solving the Hybrid Flow Shop Problem

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Abstract

This paper addresses the Hybrid Flow Shop Problem (HFSP) through the Multi-objective Variable Neighborhood Search metaheuristic (MOVNS). In this problem, we have a set of jobs that must be performed on a set of stages. At each stage, we have a set of unrelated parallel machines. Some jobs may skip stages. In this paper we considere two evaluation criteria under simultaneous analysis: the minimization of the makespan and the minimization of the weighted sum of tardiness. Instances of the HFSP from literature are solved by four versions of the MOVNS algorithm. The results are evaluated using the Hypervolume, Epsilon, Spacing and Sphere counting metrics.

Keywords: Hybrid Flow Shop, MOVNS, Multi-objective optimization, VNS

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1 Introduction

This paper treats the Hybrid Flow Shop Problem (HFSP). This problem has some very common constraints and characteristics associated to real-world problems. According to [8], HFSP is NP-hard. As stated by [7], job scheduling is a decision problem, very common in industries and service sector. It addresses the resource allocation for performing jobs over a period of time and, in its optimization version, may involve the optimization of one or more objectives. The addressed problem in this paper considers two conflicting objectives: (i) the minimization of the makespan (ii) and the minimization the weight sum of the tardiness.

A brief bibliographical review is concerned in the sequel. A comparison of three algorithms based on Multi-objective Variable Neighborhood Search – MOVNS [4] is presented in [1]. These algorithms are applied to solve a single machine problem in order to minimize the weighted sum of the earliness and the tardiness and to minimize the total flow time. The authors of [2] solve a HFS problem by applying a multi-objective approach that combines the characteristics of the Non-dominated Sorting Genetic Algorithm II (NSGA-II) and VNS metaheuristics for minimizing the makespan and the average tardiness. Algorithms based on Iterated Pareto Greedy and Genetic Algorithms are used by [12] and [5], respectively, for solving a bi-objective hybrid flow shop problem to minimize the makespan and the total tardiness.

The HFSP considered in this paper has a set of jobs $N = \{1, 2, \ldots, n\}$, which must be performed on a set of stages $M = \{1, 2, \ldots, m\}$. For each stage i, we have a set of unrelated parallel machines. Some jobs may skip stages. The processing of job j in stage i is called an operation. A common situation in practice is considered, where some jobs can only be performed on certain specialized machines, which in turn can only perform a certain group of jobs. The problem is defined as follows: (i) F_j: set of stages visited by the job j, $1 < |F_j| < m$; (ii) p_{ilj}: processing time of job j on machine l and stage i; (iii) E_{ij}: set of eligible machines for the job j at stage i; (iv) d_j: due date for job j; (v) w_j: weight of the job j. The objectives are: (i) to minimize the makespan $(C_{\max})$ and (ii) to minimize the weight sum of the tardiness $(\sum w_j T_j)$.

The rest of this paper is outlined as following. Sections 2 and 3 present the proposed algorithm and the results of its application on an adapted set of instances of the literature. Finally, Section 4 concludes this work.