A Comparative Study of Methods for Solving the Large Flexible Assembly Job Shop Scheduling Problems

Laurie Boveroux
University of Liège, Department of Electrical Engineering and Computer Science
e-mail: laurie.boveroux@uliege.be

Damien Ernst
University of Liège, Department of Electrical Engineering and Computer Science
e-mail: dernst@uliege.be

Quentin Louveaux
University of Liège, Department of Electrical Engineering and Computer Science
e-mail: q.louveaux@uliege.be

Keywords: Assembly Flexible Job Shop

1 The Flexible Assembly Job Shop Scheduling Problem (FAJSP)

Scheduling is a decision-making process and plays an important role in diverse industries, including manufacturing, transportation and healthcare. It refers to the process of efficiently allocating a set of jobs to machines in order to minimise one or more objectives. In the context of Job Shop Scheduling Problems (JSPs), each job j consists of a set of operations $\{O_{j,1}, O_{j,2}, \ldots, O_{j,n}\}$ that must be performed in a given linear order on specific machines.

The Flexible JSP introduces flexibility by allowing operations to be processed on multiple machines. There exist alternative machines capable of performing the same operation. The assembly aspect introduces another dimension by defining the precedence between operations by a directed acyclic graph rather than a linear order. The goal of scheduling problems is to determine the optimal assignment of operations to machines and the sequencing of these operations while minimising an objective. The objective to be minimized in this paper is the sum of job completion times, reflecting the desire of industries to maximize billings. Working with instances of FAJSP has the goal of closely replicating real industrial scenarios.

2 Methods

This paper presents a comparative study that evaluates the effectiveness of seven methodologies in addressing the challenges posed by FAJSPs, particularly in the context of large-scale instances. The methods include:

1. Dispatching Rules (DPRs) [1],
2. Load Balancing Heuristics [1],
3. Genetic Algorithm (GA) [2],
4. Constraint Programming (CP),
5. Mixed Integer Linear Programming (MILP) [3],
6. Large Neighborhood Search (LNS),
7. Deep Reinforcement Learning (DRL) [4].

This comparative analysis aims to provide insights into the strengths and weaknesses of each method, specifically their performance on large-scale instances of the FAJSP created with the generator given in [3]. The results should facilitate decision-making by practitioners and researchers dealing with complex large-scale FAJSPs.

References

[1] Reijnen, R., van Straaten, K., Bukhsh, Z., & Zhang, Y. (2023). Job Shop Scheduling Benchmark: Environments and Instances for Learning and Non-learning Methods. arXiv preprint arXiv:2308.12794.

[2] Zhang, G., Gao, L., & Shi, Y. (2011). An effective genetic algorithm for the flexible job-shop scheduling problem. Expert Systems with Applications, 38(4), 3563-3573.

[3] Birgin, E. G., Feofiloff, P., Fernandes, C. G., De Melo, E. L., Oshiro, M. T., Ronconi, D. P. (2014). A MILP model for an extended version of the flexible job shop problem. Optimization Letters, 8, 1417-1431.

[4] Song, W., Chen, X., Li, Q., & Cao, Z. (2022). Flexible job-shop scheduling via graph neural network and deep reinforcement learning. IEEE Transactions on Industrial Informatics, 19(2), 1600-1610.