

Accepted Manuscript

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Authors: Ehsan Ahmadi, Boris Goldengorin, Gürsel A. Süer, Hadi Mosadegh



PII: S1568-4946(18)30001-2
DOI: <https://doi.org/10.1016/j.asoc.2017.12.045>
Reference: ASOC 4642

To appear in: *Applied Soft Computing*

Received date: 4-6-2017
Revised date: 19-12-2017
Accepted date: 30-12-2017

Please cite this article as: Ehsan Ahmadi, Boris Goldengorin, Gürsel A. Süer, Hadi Mosadegh, A hybrid method of 2-TSP and novel learning-based GA for job sequencing and tool switching problem, Applied Soft Computing Journal <https://doi.org/10.1016/j.asoc.2017.12.045>

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A hybrid method of 2-TSP and novel learning-based GA for job sequencing and tool switching problem

Ehsan Ahmadi^a, Boris Goldengorin^a, Gürsel A Süer^a, Hadi Mosadegh^b

^a Department of Industrial and Systems Engineering, Russ College of Engineering and Technology, Ohio University, Athens, OH 45701, USA

^b Department of Industrial Engineering, Amirkabir University of Technology, Tehran, Iran

Highlights

- The job sequencing and tool switching problem (SSP) is approximated by the 2-TSP
- A dynamic Q-learning-based genetic algorithm (DQGA) is proposed
- The DQGA enables learning from the experience of selecting the order of operators
- The proposed method outperforms the state-of-the-art of models and algorithms
- The method can be used for scheduling problems with sequence-dependent setup time

Abstract

One of the well-known problems in single machine scheduling context is the Job Sequencing and Tool Switching Problem (SSP). The SSP is optimally sequencing a finite set of jobs and loading restricted subset of tools to a magazine with the aim of minimizing the total number of tool switches. It has been proved in the literature that the SSP can be reduced to the Job Sequencing Problem (JSeP). In the JSeP, the number of tool switches from the currently processed job to the next job depends on the sequencing of all predecessors. In this paper, the JSeP is modeled as a Traveling Salesman Problem of Second Order (2-TSP). We call the induced JSeP by 2-TSP as the Job Sequencing Problem of Second Order (2-JSeP) with a different objective function formulation from JSeP and prove that 2-JSeP is *NP*-hard. Then the Assignment Problem of Second Order (2-AP) and Karp-Steele patching heuristic are incorporated to solve 2-JSeP. The obtained solution, however, does not guarantee the optimal sequence and are used to seed a Dynamic Q-learning-based Genetic Algorithm (DQGA) to improve the solution quality. Q-learning, which is a kind of reinforcement learning method, is used to learn from the experience of selecting the order of mutation and crossover operators in each generation of the genetic algorithm. The computational results on 320 benchmark instances show that the proposed DQGA is comparable to the state-of-the-art methods in the literature. The DQGA even outperforms the existing methods for some instances, as could improve the reported “best-known solutions” in notably less time. Finally, through the statistical analysis, the performance of DQGA is compared with those of non-learning genetic algorithms.

Keywords: combinatorial optimization, jobs scheduling, tool switches, genetic algorithms, Q-learning, reinforcement learning

1. Introduction and background

The Flexible Manufacturing Systems (FMS) containing Computer Numerical Control (CNC) machines are able to process various kinds of jobs when the tools required for processing the jobs are available in the machine’s magazine. The magazine has C slots for tools and each tool occupies one slot.

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