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A hybrid method for the parallel flow-shop scheduling problem

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CONTENTS

ABSTRACT

- In this study, we have dealt with a scheduling problem that has not been studied enough, the parallel flow-shop scheduling problem. Its difficulty lies in the fact that it consists of two sub-problems: the assignment of jobs to workshops and the scheduling of these jobs once assigned.
- Due to the complexity of the research problem, we propose a hybridization of two well-known optimization algorithms, a bio-inspired meta-heuristic (Particle Swarm Optimization, PSO) and a local search algorithm (Tabu Search, TS); with the aim of minimizing the maximum execution time of all jobs within constraints.
- The purpose of this hybridization is to combine the strengths of the two methods in order to obtain more efficient results than those achieved by classic methods. The concept of the proposed method is to start by generating a set of near-optimal solutions by the PSO meta-heuristic. Then the TS algorithm refines and improves these solutions in order to attain the optimal solution.

INTRODUCTION

- The scheduling problem is a classical optimization problem that consists in assigning tasks to resources in an optimal way according to their availability, dependencies, and deadlines.
- Solving this problem brings many benefits such as increased productivity, reduced costs, and better customer satisfaction,
- The scheduling challenges cover many areas such as production, transport, health, and project management. In particular, effective scheduling in project management is essential to completing jobs on time and on budget,
- In this study, we aim to minimize the total time required to execute a set of jobs in a Parallel Flow Shop (PFS)Approximate methods have proven to be effective in solving this problem.
- The objective of this study is to provide a better understanding of the PFS problem and to propose a hybridization of two approximate optimization methods to deal with this problem.
- To test the performance of the proposed method (PSO-TS), we apply it to 06 different scales, and the results obtained are compared with those found previously by a PSO method [1].

PARALLEL FLOW SHOP SCHEDELING PROBLEM

A parallel flow shop is a type of manufacturing shop in which several identical line flow shops are arranged in parallel. each line of this workshop consists of a sequence of machines. The job is first assigned to a line, once a job is assigned, it must be scheduled on the machines of the assigned line.

- Each job can only be assigned to a single line, and each line can process only one job at a time.
- Each machine can process only one job at a time and once a job is being processed on a machine, it must finish processing before the next job can begin processing on the same machine.
- The order in which jobs are processed on each machine must match the order in which they were assigned to the production line.

METHODOLOGY

The steps of the proposed method are details as follows:

1. Initialization: random generation of the initial population of particles by the PSO method.
2. Fitness evaluation: evaluate the fitness of each particle. An update at each iteration of the velocity and the position of the particles is carried out according to the fitness found.
3. The algorithm process is terminated once the maximum number of iterations is reached.
4. Tabu search: the taboo search starting solution is the best overall fitness found by the particle swarm.
5. Tabu search carried out on the best particles selected previously, then the searches for the neighbors of these particles. The neighbors are then evaluated and the best one is selected.
6. The tabu list is updated after each iteration.
7. Termination: The process is terminated once the maximum number of iterations is reached.

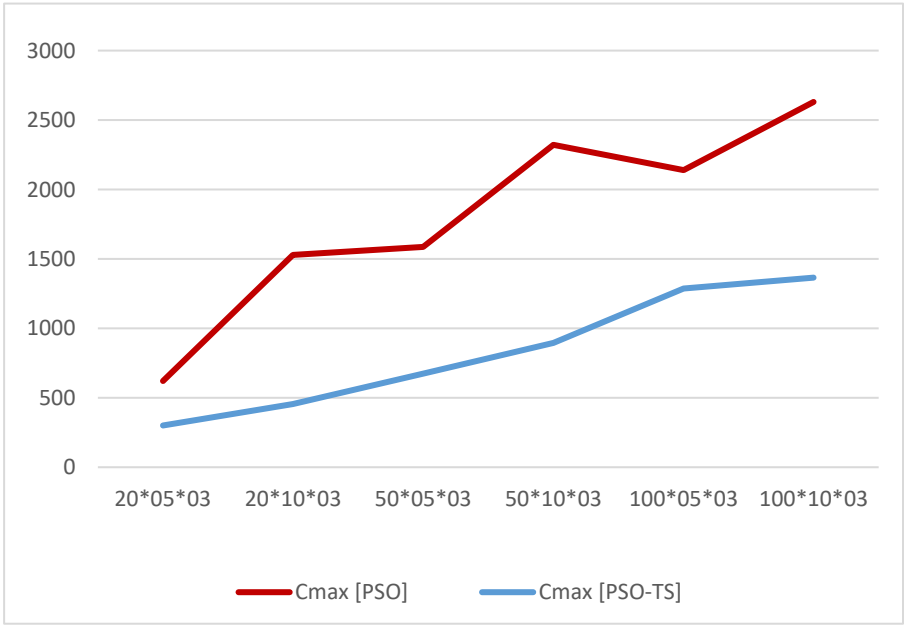
RESULTS AND DISCUSSION

- The proposed algorithm is tested to minimize the Makespan function in a flow shop workshop composed of 03 parallel lines identical, with 06 different instances of jobs and machines ((20*50), (20*10), (50*05), (50*10), (100*05), (100*10)).
- The algorithm is programmed by (MATLAB R2018b) by a computer of the following performance: Intel(R) Core (TM) i5-7200U CPU ,2.50GHz, 2.71 GHz, 4,00 Go memory.

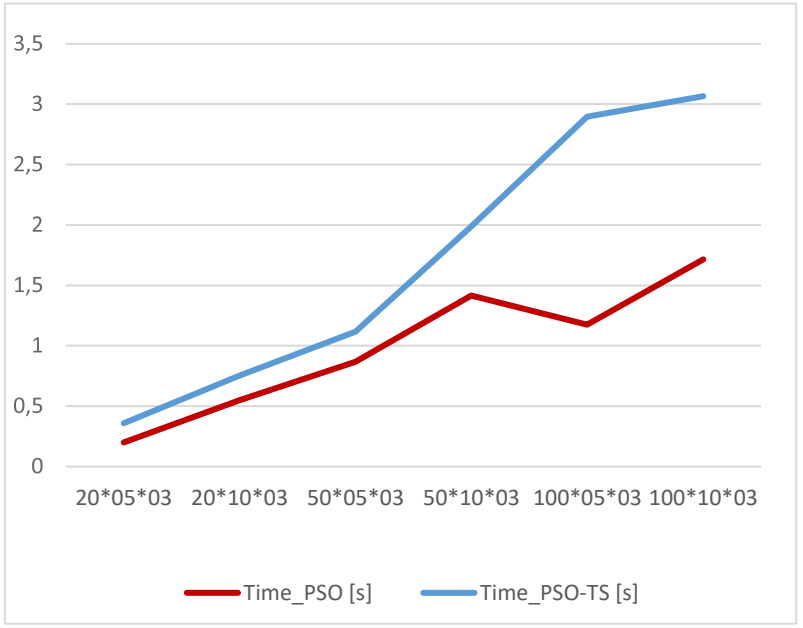
Table 1. The results of the experiment for the six (06) instances.

	PSO		PSO-TS	
Instances	**Optimal values**	**Times [s]**	**Optimal values**	**Times [s]**
20*05*03	623	0,2003	302	0,359
20*10*03	1531	0,5493	456	0,753
50*05*03	1587	0,8672	674	1,116
50*10*03	2323	1,4155	897	1,988
100*05*03	2141	1,1744	1289	2,895
100*10*03	2632	1,7135	1366	3,066

RESULTS AND DISCUSSION



- **Figure 1.** Optimal values of PSO and PSO-TS for six different abscise.



- **Figure 2.** Computation time values of PSO and PSO-TS.

CONCLUSION

This study used a hybrid method (PSO-TS) for a parallel flow-shop scheduling problem in order to minimize the makespan function. To evaluate the performance of the proposed method, we conducted a computational experiment and compared the results obtained with those obtained by the PSO method alone. In terms of makespan values, hybridization (PSO-TS) is better than PSO alone. Still, in terms of computational time, PSO alone is better than (PSO-TS), which encourages us to improve our method so that the computational time will be as optimal as the makespan values.

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IOCMA 2023

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