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Multi Agent model based on Chemical Reaction Optimization with Greedy algorithm for Flexible Job shop Scheduling Problem

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Abstract

Scheduling in production systems consists in assigning operations on a set of available resources in order to achieve defined objectives.The Flexible Job shop Scheduling Problem (FJSP) is one of the scheduling problems and also an extension of classical Job shop Scheduling Problem (JSP) such that each operation can be processed on different machine and its processing time depends on the used machine. The FJSP is classified, as most of scheduling problems, NP-Hard in complexity theory and can be decomposed into two sub-problems: a routing sub-problem, which consists of assigning each operation to a machine out of a set of alternative machines, and a scheduling sub-problem, which consists of sequencing the assigned operations on all selected machines in order to attain a feasible schedule with optimized objectives. In this paper, we propose a decentralized model named Multi Agent model based on Chemical Reaction Optimization with Greedy algorithm (MACROG−FJSP) to solve the FJSP in order to minimize the maximum completion time (Makespan). Experiments are performed on well known benchmark instances proposed in the literature which are Fattahi, Kacem, Brandimarte and Hurink instances to evaluate the performance of our model.

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Keywords: Multi-Agent system, Optimization, Manufacturing, Scheduling, Flexible Job shop Scheduling Problem, Chemical Reaction Optimization metaheuristic, Greedy algorithm.

1. Introduction

Scheduling in production systems consists in assigning operations on a set of available resources in order to achieve defined objectives. The Job shop Scheduling Problem (JSP) is considered as one of the most difficult scheduling problems. This problem consists on assigning a set of operations on a set of machines such as each operation must be processed on one machine. The Flexible Job shop Scheduling Problem (FJSP) is an extension of the classical Job shop Scheduling Problem (JSP) where each operation can be processed on different machines and its processing time depends on the used machine, thus FJSP is harder than JSP. FJSP is classified, as most of scheduling problems, NP-

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Hard in complexity theory[1]. We have done a study on the existing literature which has studied the FJSP and we cite them in the following.

The flexible job shop scheduling problem has been studied for the first time in [2], by authors they have developed a polynomial algorithm to solve FJSP. The metaheuristics are the most used methods to solve the FJSP. Several researches are made based on tabu search [3], which resolved the resource allocation problem using the rules of priority. The durations are varied resources functions, the assignment problem is solved then we get the classical job shop scheduling problem which is solved by a tabu search method. The neighborhood function used allows to permute two critical operations. Then a reallocation of these critical operations are performed at predefined time intervals. Tabu search was also used in [4,5,6] to solve the FJSP. A genetic algorithm was used to solve the FJSP in [7,8]. A hybrid Genetic Algorithm (GA) and a Variable Neighborhood Descent (VND) for FJSP was introduced in [9] where the GA used two vectors to represent a solution and the disjunctive graph to calculate it. Then, a VND was applied to improve the GA final individuals. A genetic algorithm approach was presented also in [10] to solve the FJSP and its objective is to minimize the makespan, an assignment algorithm of [7]was used to generate initial population. For the selection phase, individual presenting the highest fitness is selected. For the crossover phase, a two-point crossover is applied on two chromosomes. For the mutation phase, a random operation is selected and then recent machine for selected operation is interchanged with the machine that has shortest processing time among the alternative machine set. The proposed approach is tested on benchmark instances of [11]. The obtained results were compared with the results obtained by other approaches show that this approach surpasses other known algorithms for the same problem. A mathematical model and heuristic approaches (integrated and hierarchical) was proposed in [11] for FJSP to solve real size problems. For the integrated approach, they used an algorithm that uses tabu search called ITS (Integrated approach with Tabu Search heuristic) and another algorithm that uses simulated annealing named ISA (Integrated approach with Simulated Annealing heuristic) for the allocation and sequencing problems consecutively. An approach named AIA was proposed in [12] for the FJSP and based on natural immune system. A novel hybrid harmony search (HHS) algorithm based on the integrated approach was presented in [13]for solving the flexible job shop scheduling problem with the criterion to minimize makespan. A hybrid artificial bee colony algorithm was presented in [14] for solving the FJSP with the criterion to minimize the makespan. In the proposed algorithm, first, several dispatching rules and the harmony search algorithm are used in creating the initial solutions. Thereafter, one of the two search techniques is randomly selected with a probability that is proportional to their fitness values. The selected search technique is applied to the initial solution to explore its neighborhood. If a premature convergence to a local optimum happens, the simulated annealing algorithm will be employed to escape from the local optimum. Otherwise, the filter and fan algorithm are utilized. Finally, the crossover operation is presented to enhance the exploitation capability. Distributed methods are also used; So we find the approach of [15] to solve the FJSP and it is based on a tabu search method. A multi-agent approach has been introduced in [16] based on the combination of genetic algorithm and tabu search. Firstly, a Scheduler Agent applies a Neighborhood-based Genetic Algorithm (NGA) for a global exploration of the search space. Secondly, a Cluster agent set used a local search technique to guide the research in promising regions. In [17], a multi-agent model based on the Chemical Reaction Optimization metaheuristic (CRO) was proposed for solving the flexible job shop scheduling problem with the criteria to minimize the maximum completion time (makespan). This model presented two classes of agents: Interface Agent in charge of creating the initial solutions and n Scheduler Agents responsible of global optimization process where n is the number of jobs of the problem. Experiments are performed on benchmark instances of [7] and [11] to evaluate the performance of this model. A new metaheuristic hybridization approach that is a hybrid of genetic algorithm and tabu search based on clustered holonic multi-agent model was presented in [18,19] for the flexible job shop scheduling problem with tansportation times and many robots (FJSPT-MR). To measure its performance, numerical tests are made using three well known data sets in the literature of the FJSPT-MR, and where new upper bounds are found showing the effectiveness of the presented approach. In [20], a chemical reaction optimization metaheuristic hybridized with tabu search in multi-agent system was proposed to solve the FJSP in order to minimize the maximum completion time (makespan). This model presented two classes of agents: Interface Agent in charge of creating the initial solutions and n Scheduler Agents responsible of global optimization process based on hybridization of Chemical Reaction Optimization metaheuristic and Tabu Search. Experiments are performed on benchmark instances of [7,3,4] to evaluate the performance of this model. So, distributed methods used for the combinatorial problems and especially for the flexible job shop scheduling problem show their effectiveness. More, CRO is proposed by [21] to optimize combinatorial problems. Due to its ability to escape from the local optima, it has been