Chapter XIV

Flexible Job-Shop Scheduling Problems: Formulation, Lower Bounds, Encoding and Controlled Evolutionary Approach

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ABSTRACT

The Job-shop Scheduling Problem (JSP) is one of the hardest problems; it is classified NP-complete (Carlier & Chretienne, 1988; Garey & Johnson, 1979). In the most part of cases, the combination of goals and resources can exponentially increase the problem complexity, because we have a very large search space and precedence constraints between tasks. Exact methods such as dynamic programming and branch and bound take considerable computing time (Carlier, 1989; Djerid & Portmann, 1996). Front to this difficulty, meta-heuristic techniques such as evolutionary algorithms can be used to find a good solution. The literature shows that they could be successfully used for combinatorial optimization such as wire routing, transportation problems, scheduling problems, etc. (Banzhaf, Nordin, Keller & Francone, 1998; Dasgupta & Michalewicz, 1997).
In this chapter we deal with the problem of flexible JSP which presents two difficulties: the first one is the assignment of each operation to a machine, and the second one is the scheduling of this set of operations in order to minimize a global criterion defined by a combination of many criteria (the makespan, the workload of the critical machine and the total workload of the machines). Practical and theoretical aspects of this problem are presented and carefully studied. Then we describe the state of the art concerning scheduling problems and evolutionary techniques. The evaluation function will be constructed by combination of the criteria and the corresponding lower bounds. The resolution method is based on many original direct chromosome representations. Also, based on practical examples, we present the efficiency of the suggested approach and some discussions about this research work.

INTRODUCTION

Several problems in various industrial environments are combinatorial. This is the case of numerous scheduling and planning problems. Generally, it is extremely difficult to solve this type of problem in its general form. Scheduling can be defined as a problem of finding the optimal sequence to execute a set of operations respecting the different problem's constraints. The problem set is extremely difficult to solve, it consists generally in a simultaneous optimization of a set of conflicting and concurrent goals. Therefore, the exact methods such as branch and bound, dynamic programming and constraint logic programming need a lot of time to find an optimal solution. So, we expect to find not necessary the optimal solution, but a good one to solve the problem. New search techniques such as genetic algorithms (Banzhaf, Nordin, Keller & Francone, 1998), simulated annealing (Kirkpatrick, Gelatt, & Vecchi, 1983), tabu search (Golver, Taillard & De werra, 1993) are able to reach our aim: find near optimal solutions for a wide range of combinatorial optimization problems.

In this work, we propose a new controlled evolutionary approach for solving a JSP and we describe the incorporation of the scheduling specific knowledge in the genetic operators and in the different chromosome representations.

This chapter is organized as follows: the first section presents the formulation of our flexible job-shop scheduling problem. In the second section, we present the lower bounds and we construct a global fitness function. Some definitions and a short description of genetic and evolutionary algorithms are presented in the third section. In the section four, the different codings and the implemented operators of the proposed methodology are described. Finally, the experimental results, discussions and conclusions are presented in the last section.
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