Using Genetic Algorithms to schedule multicriteria Flow-shop

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Abstract.

Flow-Shop problems have received a great attention, but most of the works deal with problems in their single-criterion form. I this work, we are interested in a multicriteria version of the problem, using Genetic Algorithms (GAs) to solve it. Genetic algorithms have turned out to be of great efficiency to deal with combinatorial optimization problems. The extension of this method to the multicriteria case has been elaborated in different manners (e.g. for multicriteria flow-shop problems, see Ishibuchi and Murata [2]). In this work we study the problem of minimizing the makespan and the total tardiness in permutation m-stages flow-shops. This problem is denoted : F/permu, d_i/ (Cmax, T).

The difficulte of f the multicriteria case lies, in particular, in the absence of a total order relation that links the solutions of the problem. Considering the GAs, this insufficiency appears in the difficulty of deffining a selection operator. Another drawback is related to the genetic drift which often induces the premature loss of the diversity, and hence imposes to develop technics to maintain the diversity.

A multicriteria genetic algorithm has been implemented for the Flow-Shop problem. We present the encoding of solutions used, as well as the objective function and the operators (mutation and crossover). Then several selection and diversity strategies are studied.

Six different selection strategies are proposed :

- Weighted sum objective selection, that combines the two objectives in a single one.
- Parallel selection, that selects half of the population accoding to the makespan and the other one according to the tardiness.
- NSGA selection (Non-Dominated Sorted Genetic Algorithm), that classifies individuals according to solutions that dominate them, and uses these classes to calculate the ranks.
- NDS selection (Non-Dominated Sorting), that ranks individuals according to the number of solutions that dominate them.
- WAR selection (Weighted Average Ranking), that ranks individuals according to their rank for each objective.

- Elitist selection, that uses an archive of Pareto-optimal solutions, in order to keep track of interesing solutions.

An experiment has been drawn in order to compare the different selection strategies. Results of comparaisons are exposed. it appears that non Pareto strategies (Weighted sum, Parallel selection) are non adapted to the multicriteria case. The three stratigies NSGA, NDS and WAR have similar performances. The gain of using an elitism strategy is experimentally proven. Therefore, an experiment has been drawn to know the impact of the choice of the elitist pressure parameter.

We also present and compare several methods to maintain the diversity:

- Gonotypic sharing, that calculates the distance between individuals according to the difference between chromosome (decision space).
- Phenotypic sharing, that calculates the distance between individuals according to the difference between their objective functions (objective space).
- Combined sharing, that combines both approches.

The experiment has shown that the contribution of the genotypic diversification is slightly appreciable compared to the results obtained by phenotypic diversification. However, the genotypic diversification is distingished by an effecive set of solutions not found by the genotypic diversification. Hence, the combined diversification presents a better solution quality than the two previous methods.

Finally, we propose in this work an hybridization of the multicriteria genetic algorithm with a local search method. We were interested in the use of local search as a mean of acceleration and refinement of the Genetic Search. In this case, the idea is to run the GA first, in order to approach the Pareto solutions. The hybridization principe is very simple, once the GA is over (the limit generation number is reached), the local search is run with the previously obtained Pareto set as an entry. The performance tests of the hybrid GA with the local search shows that hybridization is of no interest for little size problems, notably Heller 20*10 [1]. However, the hybridization is able to improve solutions as soon as the size of the problem increases.

In this work, we constructed our approach by progressive introduction of concepts such as selection, diversity strategies and hybridization. At each stage we have shown the contribution of the introduced mechanisms, and experiments allowed us formulate conclusions about the implementation of these mechanisms. The work presented here deals with a bi-criteria problem, however, the method proposed is able to be extended very easly to multi-criteria problems.

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[2] H. Ishibuchi, T. Murata "**A multi-objective Genetic Local Search Algorithm and Its Application to Flowshop Scheduling**", *IEEE Transactions on System, man and cybernetics, Vol 28, N°3. 392-403, 1998.*