Integrating preference models into multiobjective optimization for scheduling problems

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1 Introduction

When faced with a multi-objective optimisation problem, it is necessary to consider the decision-maker's (DM) preferences in order to propose the best compromise solution. Three strategies can be followed when integrating preferences within the optimization process [5] : a priori, a posteriori and interactive. The first strategy may be difficult to apply when dealing with heterogeneous criteria, as non-compensatory models are generally difficult to exploit in an optimization context, while the preference elicitation may also be based on fictitious solutions. The second strategy, on the other hand, has to focus computational resources on areas of the search space that may not be of interest to the DM. The third strategy tries to deal with the shortcomings of the first two where both the preference elicitation and the optimization are done one after the other in multiple step sequences.

We focus in this work on integrating the preferences of DM's within the optimization process for a multi-objective flexible jobshop problem. We assume that the DM is able to provide reference performance levels corresponding to multiple levels of aspiration but the heterogeneity of the criteria scales does not allow for compensatory models to be used. We therefore use the SRMP (Simple Ranking using Multiple Profiles) [4] model within an evolutionary population-based optimization approach and compare the a priori and a posteriori strategies. The initial tests performed on literature instances show promising results.

2 Problem description

In this work, we consider the Flexible Job Shop problem which consists of ordering a number of jobs involving operations. Each operation can be processed by any machine from a subset of machines. The FJSP is a highly NP-Hard problem even when each task has at most three operations, and there are two machines [1]. We consider three objectives : the makespan (f_1), the total machine processing time (f_2), the balanced machine utilization (f_3). The first objective is ensured by the minimization of the finishing time of the last job C_{max} and is mainly used in shipment planning. The second objective is given by the sum of the processing time of each operation in the machines where they will be executed while the third objective is ensured by the minimization of the variance between the working time of each machine with respect to the average processing time of all machines. They are introduced to improve machine utilization and reduce the load on some machines at the expense of others.

3 The proposed approach

A solution to our problem consists in a first level corresponding to machine assignments of all operations of each job, and a second level where operation sequencing needs to be performed in order to provide a detailed schedule containing the start and complete dates of all operations.

The main steps of the proposed algorithm are :

1. Initial population : generate N machine assignments according to the machine compatibility of each operation.
2. Evaluation : objectives f_2 and f_3 are computed directly from the machine assignments, while f_1 is computed using a new auxiliary model inspired by [3].
3. Mutation : a single operation assignment is changed to another compatible machine.
4. Selection : solutions are selected using a roulette based on :
   (a) a criterion that orders areas of the solution space using the SRMP mode of the DM.
   (b) a criterion that uses a non-dominating sorting of the solutions.
5. Stopping condition : a set number of iterations is not reached, a fixed amount of time passes or any other convergence condition.

4 Preliminary results

In order to test the proposed approach, we used well-known public instances available in [2]. The preliminary results show that the algorithm proposed in this work focuses its search on the areas of the search space that correspond to solutions achieving better levels of aspiration of the decision-maker than the classical NSGA algorithm. The algorithm arrives in these areas faster and when both approaches find solutions from the same area, the proposed approach is able to find solutions that dominate those given by the NSGA algorithm.

5 Conclusions and perspectives

The initial results are promising and show that integrating a preference model inside an optimization approach allows to find better solutions faster. Further experiments are required in order to validate this assertion, however we consider extending this work to neighbourhood search approaches where the use of the preference model would influence the operators used in a more direct manner. We additionally envision exploring online learning approaches during the first steps of the optimization together with topics linked to the evolving preferences of the decision-maker as more and more solutions are iteratively presented to them.

Références

[1] Yunus Demir and S Kürşat İşleyen. Evaluation of mathematical models for flexible job-shop scheduling problems. *Applied Mathematical Modelling*, 37(3) :977–988, 2013.

[2] Imed Kacem, Slim Hammadi, and Pierre Borne. Approach by localization and multiobjective evolutionary optimization for flexible job-shop scheduling problems. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 32(1) :1–13, 2002.

[3] Cemal Özgüven, Lale Özbakır, and Yasemin Yavuz. Mathematical models for job-shop scheduling problems with routing and process plan flexibility. *Applied Mathematical Modelling*, 34(6) :1539–1548, 2010.

[4] Antoine Rolland. Reference-based preferences aggregation procedures in multi-criteria decision making. *European Journal of Operational Research*, 225(3) :479–486, 2013.

[5] Bernard Roy. *Méthodologie multicritère d'aide à la décision.* Economica, 1985.