EVOLUTIONARY ALGORITHMS WITH STUDS AND RANDOM IMMIGRANTS TO SOLVE E/T SCHEDULING PROBLEMS

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ABSTRACT

The study of earliness and tardiness penalties in scheduling is a relatively recent area of research. In the past, traditionally the emphasis was put on regular measures that are nondecreasing in job completion times such as makespan, mean lateness, percentage of tardy jobs or mean tardiness. Current trends in manufacturing is focussed in just-in-time production which emphasize policies discouraging earliness as well as tardiness.

Evolutionary algorithms have been successfully applied to solve scheduling problems. New trends to enhance evolutionary algorithms introduced *multiple-crossovers-on-multiple-parents* (MCMP) a multirecombinative approach allowing multiple crossovers on the selected pool of (more than two) parents. MCMP-SRI is a novel MCMP variant, which considers the inclusion of a stud-breeding individual in a pool of random immigrant parents. Members of this mating pool subsequently undergo multiple crossover operations.

This paper describes implementation details and the performance of MCMP-SRI for a set of single machine scheduling instances with a common due date.

1. EARLINESS AND TARDINESS SCHEDULING PROBLEM

The problem we are facing is also known as the restricted single-machine common due date problem [1, 3, 4, 12, 14] and can be stated as follows:

A set of n jobs with deterministic processing times p_i and a common due date d are given. The jobs have to be processed on one machine. For each of the jobs an individual earliness α_i and tardiness β_i penalty is given, which is incurred, if a job is finished before or after the common due date d, respectively. The goal is to find a schedule for the n jobs which jointly minimizes the sum of earliness and tardiness penalties. More precisely, as defined in [11]

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$$\min \sum_{i=1}^{n} \left(\alpha_i E_i + \beta_i T_i\right) \text{ where}$$

$$E_i = \max\{0, d - c_i\},\ T_i = \max\{0, c_i - d\} \text{ and } c_i \text{ is the completion of job } j_i$$

Even simple in the formulation, this model leads to an optimization problem that is NP-Hard [4].

2. MULTIRECOMBINATION OF STUDS AND INMIGRANTS

Balance between exploitation and exploration is a main factor influencing search in an evolutionary algorithm. Extreme exploitation can lead to premature convergence and intense exploration can make the search ineffective [13]. As a later multirecombinative variant [5, 6, 7, 8, 9, 10] and attempting to achieve this balance we devised MCMP-SRI. Here, the process for creating offspring is performed as follows. From the old population an individual, assumed as the stud, is selected by means of proportional selection. The number of n_2 parents in the mating pool is completed with randomly created individuals (random immigrants). The stud mates every other parent, the couples undergo crossover and 2* n_2 offspring are created. The best of these 2* n_2 offspring is stored in a temporary children pool. The crossover operation is repeated n_1 times, for different cut points each time, until the children pool is completed. Finally, the best offspring created from n_2 parents and n_1 crossover is inserted in the new population.

3. EXPERIMENTAL TESTS AND RESULTS

The evolutionary algorithms were tested for selected instances from the Beasley J. E. Common Due Date Scheduling, OR Library, (http://mscmga.ms.ic.ac.uk/jeb/orlib) benchmarks [2, 3]. We performed a series of 10 runs for each of the 10 instances of 10, 20 and 50 job problems. The maximum number of generations were fixed at 50, 100 and 150 for 10, 20 and 50 job problems, respectively. Population sizes were fixed at 100 individuals for 10 and 20 job problems and at 150 for the 50 job problem. Probabilities were set to 0.65 and 0.00 for crossover and mutation, respectively, in all experiments. The number of crossover n_1 and the number of parents n_2 were set to 6 and 8, respectively, for the 10 jobs problem and to 14 and 15, respectively, for the larger problems (20 and 50 jobs). New optimal solutions were found for the 10 jobs problem size and upper bounds for the 20 and 50 jobs problem sizes were improved in about 1.9 to 2.7%. Details will be shown in the presentation.

4. CONCLUSIONS

This work introduces MCMP-SRI, the latest variant of the multi-recombinative family applied to the common due date problem for single machine scheduling. The main objective of this new recombinative method is to find an equilibrium between exploration and exploitation in the search process. An individual of the old population is selected as the stud and subsequently mated with a set of new generated individuals (immigrants). The presence of the stud ensures to retain good features of previous solutions while the immigrants, as continuous source of genetic diversity, avoid premature convergence and make unnecessary to apply mutation. Preliminary results are promising and showed its potential by finding new optimal solution for smaller instances and improving the upper bound in the larger instances of the common due date scheduling problem.

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