HYBRID EVOLUTIONARY ALGORITHMS TO SOLVE SCHEDULING PROBLEMS

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ABSTRACT

The choice of a search algorithm can play a vital role in the success of a scheduling application. Evolutionary algorithms (EAs) can be used to solve this kind of combinatorial optimization problems. Compared to conventional heuristics (CH) and local search techniques (LS), EAs are not well suited for fine-tuning those structures, which are very close to optimal solutions. Therefore, in complex problems, it is essential to build hybrid evolutionary algorithms (HEA) by incorporating CH and/or LS to provide fine-tuning.

EAs are good at global search but slow to converge, while local search is good for fine-tuning but often falls into local optima. The hybrid approach complements the properties of evolutionary algorithm and other techniques.

This research guide attempts to develop EAs hybridized with local search and conventional heuristics. They are incorporated at different stages of the evolutionary process. Either when the initial population is created, or in intermediate stages, or in the final population, or within the evolutionary process itself.

1. INTRODUCTION

Over the past decades, extensive research has been done on the scheduling problems: there is no easy algorithm, which can provide an optimal solution. Integer programming and branch and bound techniques can be used to find the optimal solution [3]. However, they are not very effective on large problems. Hence, many *heuristics* have been developed to provide a good and quick solution.

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Local search techniques try to continuously improve solutions initially obtained by constructive heuristics. Given a solution *s*, the *neighbourhood* of *s* is a set of solutions that can be derived by applying predefined slight modifications to *s*. The moving operators provide moves from one solution to another in the neighbourhood. The process continues until a termination criterion is fulfilled.
Many researchers have shown that EAs perform well for global searching because they are capable of quickly finding and exploiting promising regions of the search space, but they take a relatively long time to converge to a local optimum. The EA finds a good solution but requires many more generations to reach the optimal solution (or the best known solution). Local improvement procedures quickly find the local optimum of a small region of the search space, but are typically poor global searchers. These procedures do not guarantee optimality.
With the hybrid approach, evolutionary algorithms are used to perform global exploration among the population while other heuristic methods are used to perform local exploitation around chromosomes. Because of the complementary properties of evolutionary algorithms and local improvement procedures, the hybrid approach often outperforms either method operating alone.

2. HIBRYD EVOLUTIONARY ALGORITHMS

When designing a hybrid evolutionary algorithm, a fundamental principle is to hybridize where possible. This can be done in a variety of ways, including the following [2]:

- Incorporate heuristics into initialization to generate a well-adapted initial population. In this way, a hybrid evolutionary algorithm with elitism guarantees to do no worse than the conventional heuristic does.
- Incorporate a local search heuristic as an add-on to the basic loop of the genetic algorithm, working together with genetic operators, to perform quick and localized optimization in order to improve offspring before returning it to be evaluated.
- Improve the final population with local search heuristic.

3. SCHEDULING PROBLEMS

The above mentioneed hybrid approaches have been used in the following scheduling problems:

- ✓ Flow shop scheduling (FSSP): consists of *n*-job and *m*-machine. A job is processed on one machine at a time without pre-emption, and a machine processes no more than one job at a time. Each job consists of *m* operations, and each operation requires a different machine. *n* jobs have to be processed in the same sequence on *m* machines. The processing time of job *i* on machine *j* is given by t_{ij} (i=1,.....,n; j=1,.....,m). The objective is to find the sequence of jobs minimizing the maximum flow time, which is called *makespan* [2].
- ✓ Job shop scheduling (JSSP): consists of *m* different machines and *n* jobs. Only one job may execute on a machine at a time. All schedules and jobs are non-preemptive. Jobs can have distinct priorities and all of them are available at production initiating time. Each job visits all machines, only once, following a predetermined sequence of machines, called a route. Consequently a job can be seen as composed by various steps, called operations. The objective is to find a schedule of minimum makespan [2].
- ✓ Travelling salesman problem (TSP): attempts to find a minimum distance (or cost) for a hamiltonian circuit in a graph.

3. CONCLUSIONS AND FUTURE WORK

All the hybrid approaches improved results obtained by EAs with diverse extra effort. Besides different improvements to those evolutionary algorithms were incorporated through modified NEH [8] and CDS [1] heuristic algorithms, Simulated Annealing [6,5, 9, 10] and Tabu Search [4, 7, 11]. These hybridizations obtained whole populations closer to the optimum than the evolutionary algorithm alone. Further, the individuals in the final population represent different sequences. However, hybridized options needed a bigger number of evaluations of the objective function.
Further work is driven to the analysis of effects of the incorporation of new solutions into the population. These solutions can be obtained by the above mentioned techniques.

4. References

[1] Campbell, H., Dudek, R., Smith, M., A Heuristic Algorithm for the *n*-job *m*-machine Sequencing Problem, Management Science, vol. 16B, pp. 630-637,1970.

[2] Gen M., Cheng R., Genetic Algorithms & Engineering Design, Wiley Interscience, 1997.

[3] Ignall, E., Schrage, L., Application of the Branch and Bound Techniques to Some Flow Shop Scheduling Problems, Operations Research, vol. 13, pp. 400-412, 1965.

[4] Michalewicz,Z., Fogel, D.B., How to Solve It: Modern Heuristics, Germany: Springer-Verlag Heidelberg, 2000.

[5] G. Minetti, R. Gallard, H. Alfonso, "Hybrid Multi-Inver-Over Evolutionary Algorithms for the Euclidean Travelling Salesman Problem", in proc. 4th International ICSC SOCO, Paisley, UK, 2001, pp. 134.

[6] Minetti G., Gallard R., Alfonso H., Influence of Temperatures Settings for Simulated Annealing in a Hybrid Evolutionary Algorithm, in Proc. 5th World Multiconference on SCI 2001 and 7th International Conference ISAS, ISBN 980-07-7543-9, Orlando – USA July 2001, pp. 397-400.

[7] Minetti G., Gallard R., Alfonso H., Bermudez C., Hybridizing Multi-Inver-Over Evolutionary Algorithms with Tabu Search for the Symmetric TSP, VII Congreso Argentino de Ciencias de la Computación – CACIC'2001, ISBN 987-96-288-6-1, Calafate – Argentina, October 2001, pp. 1141 a 1150.

[8] Nawaz M., Enscore E., Ham I., A Heurisitic Algorithm for the *m*-machine *n*-job Flow Shop Sequencing Problem, Omega, vol. 11, pp. 11-95, 1983.

[9] Salto, C., Alfonso, H.A., and Gallard, R.H., Evolutionary Algorithms and Local Search to Solve Scheduling Problems, in proc. 4th International ICSC SOCO, Paisley, UK, 2001, pp. 131.

[10] Salto, C., Alfonso, H.A., and Gallard, R.H., A Hybrid EA Approach Used to Solve the Job Shop Problem, Proc. 5th World Multiconference on SCI 2001 and 7th International Conference ISAS, Orlando, USA, 2001, pp. 424-428.

[11] Fernandez, N., C. Salto, Alfonso, H. and Gallard, R.H., Incorporating Tabu Search for Local Search into Evolutionary Algorithms to Solve the Job Shop Scheduling Problem, in proc. VII Congreso Argentino de Ciencias de la Computación – CACIC'2001, Calafate, pp.. 1151 a 1162.