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## A modified genetic algorithm for the flow shop sequencing problem to minimize mean flow time

LIXIN TANG<sup>1</sup> and JIYIN LIU<sup>2</sup>

<sup>1</sup>Department of System Engineering, Northeastern University, Shenyang, China

<sup>2</sup>Department of Industrial Engineering and Engineering Management,

The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

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A modified genetic algorithm (MGA) is developed for solving the flow shop sequencing problem with the objective of minimizing mean flow time. To improve the general genetic algorithm (GA) procedure, two additional operations are introduced into the algorithm. One replaces the worst solutions in each generation with the best solutions found in previous generations. The other improves the most promising solution, through local search, whenever the best solution has not been updated for a certain number of generations. Computational experiments on randomly generated problems are carried out to compare the MGA with the general GA and special-purpose heuristics. The results show that the MGA is superior to general GA in solution quality with similar computation times. The MGA solutions are also better than those given by special-purpose heuristics though MGA takes longer computation time.

**Keywords:** Flow shop scheduling, mean flow time, modified genetic algorithm

### 1. Introduction

Genetic algorithms (GAs) were developed in the 1960s (Holland, 1975), as an adaptive searching technique for optimization, based on the mechanism of natural selection and evolution. Since then they have been applied to a wide variety of optimization problems. A survey on applications of GAs can be found in Goldberg (1989).

Much early work is focused on exploring new application areas of GA, suggesting genetic representations of the problems and crossing compatibility of crossover functions with the genetic representations. Many efforts have also been made on improving the performance of the method to better suit the problems, for example, on gene pool selection, genetic operator selection, parameter setting, etc. Although GA is widely applicable and its performance has been well demonstrated, it still remains a difficult task in practical applications to seek a good balance between solution quality and computation time. Further improvements are needed to make it

more cost (time) effective. This paper attempts to improve the GA procedure by modifying its evolution process and to apply the modified GA to the flow shop sequencing problem to minimize the mean flow time.

Many multi-stage production systems can be modeled as flow shops. Therefore, flow shop sequencing problems have been extensively studied. Most of the studies try to minimize the makespan. In today's highly competitive global market, quick response to customer orders becomes increasing important. This requires us to use more relevant criteria in making scheduling decisions. An appropriate criterion is to minimize the mean flow time (or total flow time). The flow shop sequencing problem with mean flow time criterion can be stated as follows.  $n$  jobs are to be processed on a series of  $m$  machines. All the jobs are available at time 0. Each machine can process at most one job at a time, and each job can be processed on at most one machine at any time. No pre-emption is allowed. The processing time  $t(i, j)$  is given for any job  $i$  on any machine  $j$ . Given a permutation (processing sequence) of the jobs  $\{J_1, J_2, \dots, J_n\}$ , the

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