

## Job-shop Scheduling Method Based on Modified Immune Algorithm

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**Abstract.** The mechanism of vaccination was analyzed in the immune system and the improved immune algorithm for the job-shop scheduling problem was presented. The proposed method can reserve the advantage of vaccination and it is independent of the initial antibodies. Especially, the adaptive process of vaccination with the automatic pattern recognition can not only quicken the convergence of the algorithm but also overcome some deficiencies in distilling manually the transcendent knowledge of the problem. Simulation results show that it is an effective approach.

### Introduction

As a resource allocation problem subject to allocation and sequencing constraints, Job-shop Scheduling Problem (JSP) [1] is a ubiquitous and general production problem in manufacturing and it is very complicated and challenging [2]. JSP has been researched for several decades and many approaches for solving the optimization problems are proposed. However, systemic approaches and theory have been not formed so far [3,4]. Because of the amount of calculation, most of algorithms are only appropriately applied to solve the smaller scale problems. Many studies show that it is very difficult to find the optimal solution of JSP. It is very practical to abandon finding the optimal solution and turn to find an approximate and useful solution in the reasonable amount of time.

Immune Algorithm (IA) [5-9] has some advantages different from the other optimization methods such as genetic algorithm [10]. It is capable of diversity in the generation of antibodies, self-adjusting mechanism and immune memory function [5,6], so it is a more feasible method for solving larger scale optimization problems. Based on the vaccination, IA can use the transcendent knowledge of the problem to quicken the convergence of the solutions. An approach of injecting bacterin in the immune system is proposed in literature [8]. There, bacterin is used as an estimation of genes of the optimal antibody based on the transcendent knowledge of the problem. According to bacterin, the amending process of the genes is called as vaccination. Because the transcendent knowledge of many actual problems is lacking and unreliable, it is difficult to distill bacterin in the course of the vaccination. Generally, it can result in the mistaken search and the low efficiency of solving. An improved immune algorithm is proposed to solve JSP. Based on self-learning and self-recognition, the effective bacterin is generated to suppress the objective produced by the antigen. Namely, the objective value can approach automatically to the optimal solution of scheduling.

### Representation of Immune Algorithm for JSP

Using the immune algorithm to solve the problem, the antigen is conventionally defined as the optimization problem and the antibody is considered to be the solution of the problem. The affinity between the antigen and the antibody is decided by the value of the objective function, while the similarity between antibodies is decided by the resemblance of solutions [5,6].

For JSP, the antigen is described as  $\{m/n/M/J/O/T/\min F_{\max}\}$ . Where  $m, n, M, J, O, T$  and  $\min F_{\max}$  are the total number of machines, the total number of jobs, a set of machines, a set of jobs, a set of operations, a matrix of processing time and the objective to minimize the max complete time, respectively.