An Improved Genetic Algorithm for the Traveling Salesman Problem

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Abstract. The traveling salesman problem concerns the best way to visit a set of customers located in some metric space and to minimize the length of the tour over all customer subsets. The problem is a typical NP-hard combinatorial optimization problem, which is of major importance in real world applications. An effective hybrid genetic algorithm-ECOGA is proposed for the problem in this paper, which combines 2-exchange crossover heuristic operator and improved 2OPT of neighbor search algorithm absorbing K-Nearest Neighbor. What's more, the rule of 5 is applied to the proposed algorithm to guide the search direction. On a set of standard test problems with symmetric distances, the proposed ECOGA found the solutions that were optimal in every case and some of them are superior to the optimality found in TSPLIB. The ECOGA is completive with other genetic algorithm published to date in both solution quality and computation time.

Keywords: Traveling Salesman Problem, Hybrid Genetic Algorithm, 2opt, 2-exchange crossover heuristic, K-Nearest Neighbor, the rule of 5.

1 Introduction

The well-known traveling salesman problem (TSP) is one of the typical NP-hard combinatorial optimization problems. In its simplest form, TSP involves finding an optimal route for visiting N cities and returning to the point of origin, where the inter-city distances are known. Any improvement in finding TSP optimized solutions can be adapted to the entire class of NP- hard problems because TSP's nature presents all aspects of NP- hard combinatorial optimization [4]. Therefore, TSP is regarded as a representative problem of studying algorithms capability.

The Genetic Algorithm (GA) is a kind of optimizing algorithm that is modeled after the evolution of organisms. Some of GA's merits are that it can be easily developed because it does not require detailed knowledge about the problem. Moreover, it can search globally, and adapt to the changing conditions in the problem. In despite of these advantages, the premature convergence and the evolutionary stagnation are the main obstacles to the GA's development [9] [15]. This is because GA does not utilize explicitly the knowledge of how to search for the solutions. Therefore, hybrid methods that combine GA with other techniques such as local search have been attempted.

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The novel genetic algorithm with 2-exchange crossover heuristic operator and improved 2OPT (ECOGA) is addressed in this paper. In the interest of avoiding premature convergence and evolutionary stagnation, the strategy of killing chromosomes and the rule of 5 are applied to the algorithm, accelerating the speed of convergence. In order to evaluate and analyze the performance of ECOGA, the experiments are carried out from the aspect of computation time, stability of global convergence and accuracy. The experiments are carried out on standard test cases in TSPLIB.

2 ECOGA

ECOGA is an improvement and innovation based on the Genetic Algorithm. The improved 2OPT operator provides mutation, and the 2-exchange crossover heuristic operator provides the capability of jumping out from the local minima, where the solution often falls where only 2OPT is used. The framework of the ECOGA consists of the following steps as a whole.

Initialization: Generate the population of M individuals randomly.
Selection: Eliminate Pc% individuals. The population decreases by M*Pc/100.
Crossover by 2-exchange crossover heuristic: Choose M*Pc/100 pairs of individuals randomly and produce an offspring from each pair of individuals.
Mutation by improved 2OPT: Choose Pi% of individuals randomly and improve them by improved 2OPT method.

2.1 Crossover in Multiplication

When applying the improved 2OPT method to a solution, the solution often falls into a local optimum. Then it cannot be further improved by the improved 2OPT method. Consider two solutions that have fallen into different local minima. Potentially, each solution may have the best sub tour for a different part of the tour. Then a better solution can be made if those best sub tours are combined appropriately. In the 2-exchange crossover heuristic (ECH), the path representation is adopted for a genetic coding. For instance, the chromosome g=(D, H, B, A, C, F, G) means that the salesperson visits cities D, H, B, A, …, G in turn and return to city D.

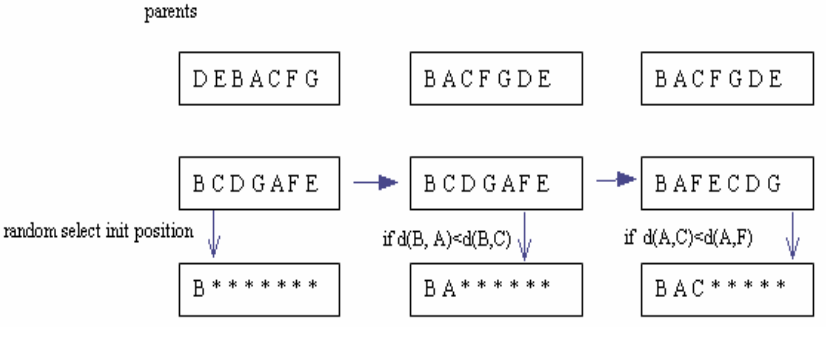

Fig. 1. The demonstration of 2-exchange crossover heuristic