The Improved Initialization Method of Genetic Algorithm for Solving the Optimization Problem

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Abstract. TSP(Traveling Salesman Problem) used widely for solving the optimization is the problem to find out the shortest distance out of possible courses where one starts a certain city, visits every city among N cities and turns back to a staring city. At this time, the condition is to visit N cities exactly only once. TSP is defined easily, but as the number of visiting cities increases, the calculation rate increases geometrically. This is why TSP is classified into NP-Hard Problem. Genetic Algorithm is used representatively to solve the TSP. Various operators have been developed and studied until now for solving the TSP more effectively. This paper applied the new Population Initialization Method (using the Random Initialization method and Induced Initialization method simultaneously), solved TSP more effectively, and proved the improvement of capability by comparing this new method with existing methods.

Keywords: Genetic Algorithm, GA, Optimization, Initialization.

1 Introduction

To solve the optimization problem effectively, this paper used TSP as an experiment model. TSP is one of basic and important problems which is used widely in modern industrial fields such as physical distribution, the network of telephone, the design of integrated circuit, industrial robot-programming, optimization of network etc.

TSP is the optimization problem of sequence mixture finding the shortest course. The shortest course means the minimum course visiting every city only once among N cities in two dimension. This problem is defined easily, however, as the number of cities increases, the calculation rate increases geometrically. Therefore, this is classified into NP(Nondeterministic Polynomial)-Hard problem.

Owing to this problem, Genetic Algorithm(GA) proposed by John Holland is used representatively to obtain the optimal solution. [1],[2],[3]

The investigation space of TSP is $\{T_1, T_2, ..., T_n\}$, the set of all traveling, and the size of it is $N!$. The solution is the shortest traveling distance.

This paper drew the new Mixture Initialization method using both Random Initialization method and Induced Initialization method at the same time for Population Initialization which should be preceded to apply GA, applied this to Population Initialization and experimented to get the nearest value to the optimal solution.

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2 Operator Used in This Paper for Experiment

In Table 1, there are operators used to prove the capability of methods proposed in this paper.

Table 1. Operators used in experiment

Selection Operator	Roulette wheel Rank-based selection
Crossover Operator	PMX Edge Recombination One-Point Crossover Multi-Point Crossover
Mutation Operator	Inversion Swapping mutation

2.1 Selection Operator

The common rule is that the probability for superior solution to be chosen should be high although various Selection Operators have been presented so far. This paper used Roulette wheel selection and Rank-based selection operators.

Roulette wheel selection operator is the most representative Selection Operator. This operator estimates the quality of each solution and adjusts the fitness of the best solution to be k times than that of the worst solution. The fitness of solution i in the set of solutions is calculated like this:

$$fi = (Ct - Ci) + (Ct - Ce)/(k-1), k > 1 \tag{1}$$

Ct: Cost of the worst solution in group
Ce: Cost of the best solution in group
Ci: Cost of i

If the value of k is made high, the choice probability becomes high. Generally, the commonest value of k is 3~4. This is chosen by the standard of fitness value.

By adjusting k value, Roulette wheel selection can prevent good-quality solution and bad-quality solution from having excessive difference of fitness, but cannot adjust the distribution of solutions. Rank-based selection makes a rank in the order of qualities of solutions in solution group, and then allocates fitness first-functionally from the best solution. The formula (2) is showing the allocation function of fitness of Rank-based selection. The fitness of the i th chromosome among n chromosomes can be calculated like this: In this formula, choice probability can be adjusted through changing the difference of max and min values. The fitness of solutions is distributed regularly between max and min. [3],[4].

$$fi = \max + (i-1) \times (\min - \max)/(n-1) \tag{2}$$

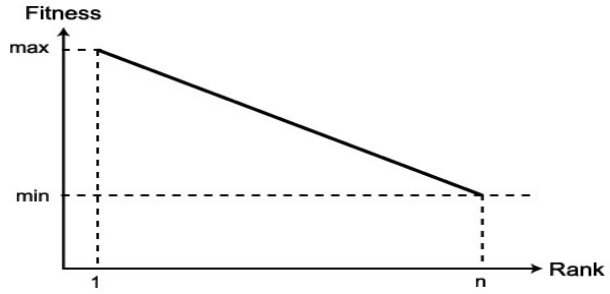

Fig. 1. The allocation function of fitness of Rank-based selection

2.2 Crossover Operator

Crossover Operator is the most various and representative operator in GA. PMX, One-Point Crossover, Multi-Point Crossover, and Edge Recombination(ER) was used in this paper. ER operator is one kind of heuristic Crossover Operator introduced by Grenfensetette and is introduced by Starkweather. [5],[6],[7]

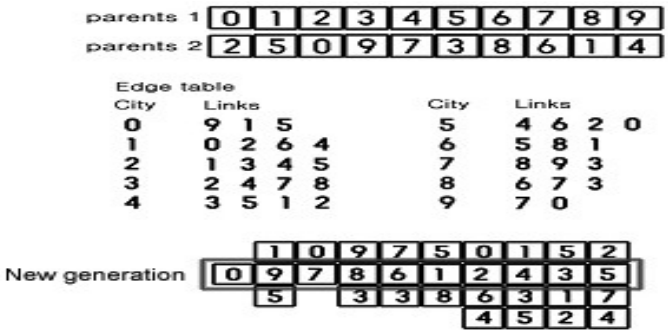

Fig. 2. Edge Recombination

Edge Recombination is a crossover operator which focuses on the adjacency relation. As illustrated in Fig 2, Edge Recombination uses an edge table to record parental edges, and then limits the generation of offspring to the edges contained in this table. In other words, the candidates of offspring edges come from parental edges principally.

With reference to the edge table, Edge Recombination builds a tour according to specific heuristics. In the original Edge Recombination(Edge-1)[8], the building process intends to select the city with the fewest links, namely, the most isolating city. Edge-1 initially generates the edge table by scanning both parents. Afterwards, Edge-1 begins the process of building the filial tour. [9]

(1) Select one of the first parental cities as the starting city.
(2) Select its next city from the remaining adjacent cities of the current city. We call these links candidates for the next city. According to the heuristic's "priority of isolating cites", the candidates with the smallest number of links is chosen.
(3) Repeat (2) until the complete tour is built.

2.3 Mutation Operator

Each population becomes stronger and more look-alike by Selection Operators and Crossover Operators. However, the more the generation goes down, the less the variety of genes is. Mutation Operators is used to compensate these faults. With Mutation Operators, new population can be made by preventing a specific bit from fixing from the early generation.

In this paper, Swapping Mutation and Inversion were used out of Mutation Operators. [1],[4]

3 Proposed Method

This paper proposes Mixture Initialization method to obtain a superior solution of TSP.

3.1 Mixture Initialization Method

There are two methods in Population Initialization. One is Random Initialization method where population is produced by extracting at random without any rules. And the other is Induced Initialization method where population is produced consistently by using background knowledge and information relating to given values.

The Population Initialization is more important than any other thing to get the nearest value to the optimal solution. Random Initialization method has been used mostly for Population Initialization of TSP.

This paper proposes Mixture Initialization using both Random Initialization method and Induced Initialization method at the same time. (Random Initialization method uses a random generator and Induced Initialization method is based on background knowledge or experience.)

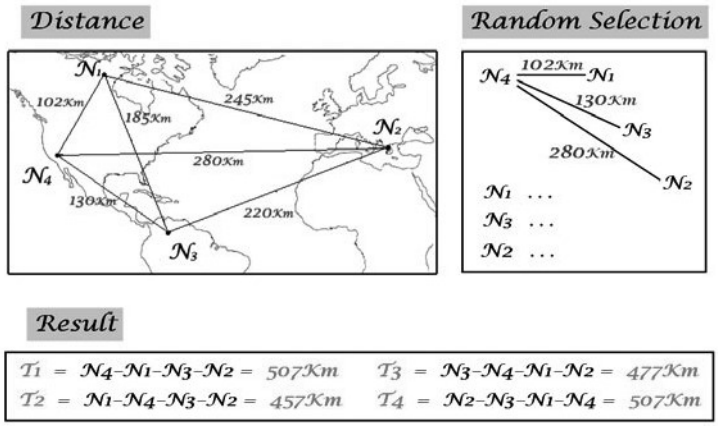

Fig. 3. Mixture Initialization Method

Like Fig 3, one chooses a starting city through random generator, and lists cities orderly from the city with the shortest distance to the city with the farthest distance,

referring already-known information about distance among cities. If N cities are listed like this order, $N \times N$ matrix is formed. This matrix is considered as the first population.

4 Consequence of Experiment

To measure the capability of Mixture Initialization method for TSP, this paper used 2 Selection Operators, 4 Crossover Operators, and 2 Mutation Operators and preserved 2 superior genes by using elitism in each generation. Used values of variables are shown in Table 2.

Table 2. Used values of variables

Variables	Values
Total cities	60
Population size	500
Total generations	600
Probability of Crossover(P_c)	0.7
Probability of Mutation (P_m)	0.2

This experiment was realized by using PowerBuilder6.5 based on Windows2000 in P-4 2.0GHz and data were saved and analyzed by Oracle 8i.

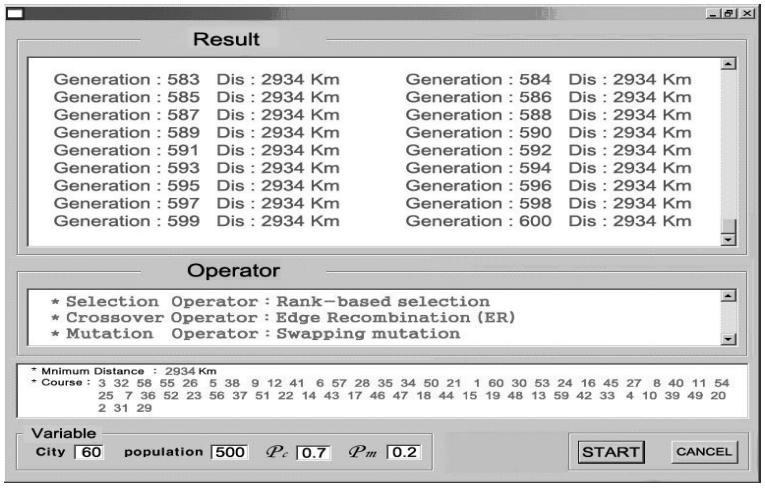

Fig. 4. Application used in experiment

Fig 4 is the TSP program for proving the capability of Mixture Initialization method proposed in this paper.