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# Selection Schemes Study used in Genetic Algorithm for Multimodal Problem in Sharing Mechanism

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**Abstract** In aritifical intelligence algorithm, Sharing mechanism is widely used in genetic algorithm to solve multimodal problems, The number of niches and the optimal which were found using share mechanism are highly related with the selection method. In this paper, Three common used selection method which are Tournament selection Roulette wheel, and ranking selection was analysed. The paper analyses consider the three common algorithms and their performance for mulimodal problems.

**Keywords** Genetic Algorithm · Niche · ranking selection · tournament selection · Multimodal

## 1 Introduction

Genetic algorithms (GAs) are first introduced in 1975 by Holland[1], because of its powerful search ability, which was widely been used to solve many search, optimiation, and classification problem. Compared with other artificial integllience search algorithm, for example, particle swarm optimization, ant colony optimization, and simulated annealing algorithm[2], GAs are not easily trapped in local optima, and obtain the global optimal. Traditional GAs has been to successfully find the optimal value in the domain for unimodal problems, however, sometimes, not only the optimal point but also the secondary important point is needed. Because of its search rule, traditional GAs are failed to maintain the information for a multimodal problem.

For the multimodal problems, the niche sharing mechanism is used to in GA to find optimal value both in local and global.

### 1.1 Genetic Algorithm Procedure

According to Darwin natural evolution theory, the one who fits the environment most well are more possilbe to survive and reproduction. GA simulates the process of natural evolution which includes selection,crossover and mutation. Because of the powerful search ability of GA,it has been widely used in many fields for multimodal problems. The procedure diagram of GA as shown in figure 1

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### 1.2 Parent Selection

Selection is the most important step of GA algorithm which decides the diversity of the population. In the step, if the selection pressure increase, the converge speed of the population increase, however, the diversity of the dopulation decrease. To improve the search ability and reduce the search cost, many selection methods [3] has been invented,the selection schemes can be divided into four classes which are proportionate reproduction, ranking selection, tournament selection and Genitor(or "steady state") selection.In this paper, to maintain a stable subpopulation for multimodel problems,the stochastic remainer algorithm is used for experiment, stochastic remainder algorithm is one of proportional selection method according to corresponding fitness.

### 1.3 Tournament Selection

Tournament Selection is first comed up by. In a k-way tournament selection, each member in the tournament are random choosen from parents, and the K string form the group. Select the best string from the tournament according to their fitness. The benefifiecnt of this scheme, it increases the diversity of population.

### 1.4 Roulette Selection

According to the fitness of each string, assign corresponding probability to the individual. Then according to the probability of each string, schochastic choose individual, and pass them to the next generation.

### 1.5 Ranking Selection

Ranking Selection is the method of choosing the parents of next generation from high to low according to their fitness. The string with best fitness are choosen as parents, repeat the process until you get the desired amount of population.the benificiency of this scheme is it keep the individual

### 1.6 Parents Crossover

According to the selected parents, crossover is used to generate the offspring, combining genes from parents to reproduce new members. There are so many research [4, 5] about the crossover operation in GAs to maximize the divistiy of the population. In this paper, one-point crossover strategy is implemented.

### 1.7 Offspring Mutation

Mutation simulates the situation genes on the chromosomes which received from parents randomly changed. The process are used to provide new evolution direction and information for the population, the parameters has during this process has been well researched by Schaffer[6].

### 1.8 Niched Mechanism

Niched mechanism simulates another natural process of subpopulation in the evolutionary process, and introduce the concept niches which means sharing resource. Because GA select the best individual according to their fitness, so the GA converges quickly to find the global optimal value. Howerver, In order to deal with the multimodal problem, It is significant to maintain the diversity of the population. Niched mechanism simulates the There are several methods to achieve this target,which are Crowding, Deterministic Crowding and Sharing methods. share Function[7]. In this paper, the parameters of share function is studied.

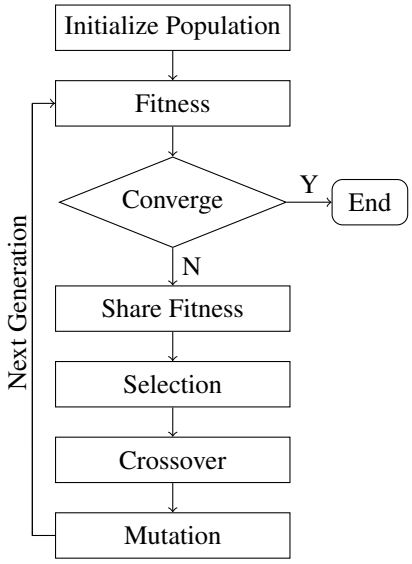


Fig. 1: GA Procedure with Share Function

### 1.9 Sharing

Sharing mechanism is first introduced by Holland [8] to reduce the fitness of similar individual in the population and increase the diversity of the population. For Sharing mechanism, the most important thing is how to identify the number of niches, Miller comed up dynamic niche sharing method, and lin developed the method to identify the number of niches in the population.[9] The problem within sharing mechanism is how to identiy the range of parameters in the formula. Given the number of peaks in population,Deb and Goldberg comed up method to set up the appropriate value for

## 2 Research Method

With the increase of the of size of the population, the GAs are more eazily too find all the possible possible modal values. so the computation cost will also increase. In this paper, we focus on with the limited population, to evaluate the performance of GA, The following three criteria is comed up:

### 2.1 Criteria

The first evaluation criterion is apparent reliability denoted as $R$, which is calulate by the following formula

$$R = \frac{n}{\mathrm{N}} \tag{1}$$

$n$ stands for the number of GA finds at least one optimal point, $N$ stands for the number of the runtime of GA.
The second criterion is population richness, denoted as $P_r$, which is calculated by the following formula:

$$P_r = N/P$$

Population richness is used to denote how many optimal points these GA maintains.
The last criterion is the number of niche, denoted by $N_n$, the number of niche can be used to represents the ability of the GA to maintain subpopluation.

### 2.2 Share Function

Share function is used to increase the diversity of the subpopluation, the function is shown as Fig.2

$$sh(d_{i,j}) = \begin{cases} 1 - \left(\frac{d_{i,j}}{\sigma_{sh}}\right)^{\alpha_{sh}} & \text{if } d_{i,j} < \sigma_{sh} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where $d_{i,j}$ denotes distance between two strings, $\alpha_{sh}$ is a contant number, $\sigma_{sh}$ is also a constant number.

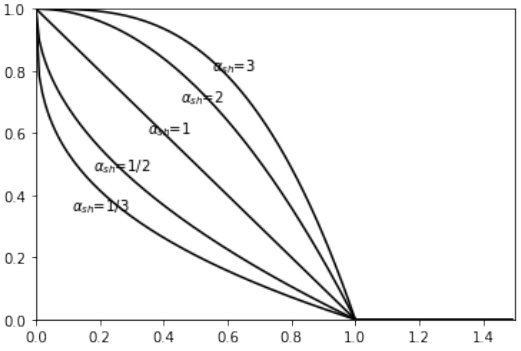


Fig. 2: Share Function

### 2.3 GA Parameters

In order to evaluate the impact of the parameters, the mutation process is ignored. The parameters of GA is shown in the table 1

Table 1: GA-parameters

| parameter | value |
|---|---|
| runtimes | 100 |
| generation | 50 |
| encoding length | 16 |
| encoding method | binary encoding |
| selection strategy | roulette wheel |
| crossover strategy | one-point |
| mutation strategy | None |

The ith individual in the population converted from binary to decimal by the following formula:

$$x_i = \frac{\sum_{j=1}^{16} 2^{j-1} g_i^j}{2^{15}} \tag{3}$$

## 3 Experiment and Results

### 3.1 Case 1: Equal stationary value

In the first experiment, the target function is as shown in the Eq.4 and the graph is as shown in Fig.3

$$f_1(x) = \sin^6(5.1\pi x + .5) \tag{4}$$

As we can see in the in the Fig.3, There are five niches in the domain, and all peaks are equal to 1.

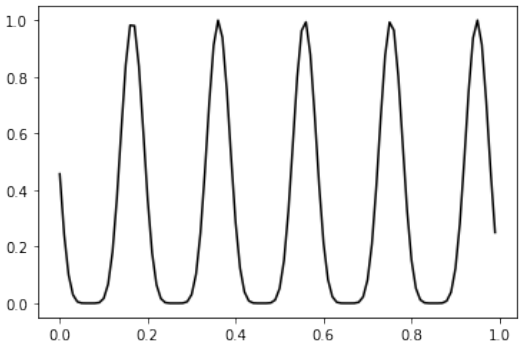


Fig. 3: Target Function

Tournament selection, roulette selection and ranking selection is taken in the GA. The experiment results is shown in the table Tab.2 Tab.3 Tab.4

Table 2: Tournament Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.5 | 0.38 | 2.46 |
| 50 | 0.78 | 0.87 | 3.17 |
| 70 | 0.90 | 1.72 | 4.16 |
| 90 | 0.99 | 2.18 | 4.61 |

Table 3: Roulette Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.81 | 1.36 | 4.16 |
| 50 | 0.95 | 2.11 | 4.55 |
| 70 | 1.00 | 2.85 | 4.64 |
| 90 | 1.00 | 3.48 | 4.87 |

Table 4: Ranking Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.82 | 1.41 | 4.31 |
| 50 | 0.98 | 2.27 | 4.52 |
| 70 | 0.99 | 2.67 | 4.75 |
| 90 | 0.99 | 2.79 | 4.84 |

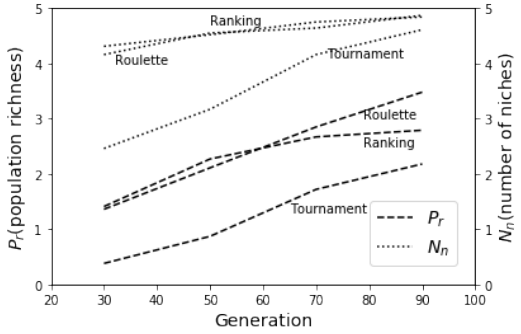


Fig. 4: Result 1

According to the three table, with the increases of the population size, the population richness $P_r$, The number of best output $O_n$ and the number of niches $N_n$ decrease,and when $r = 1$ and $q = 0$,apparent reliability R obtain the maximaize value,GA obtains the best result. as shown in Fig. 5

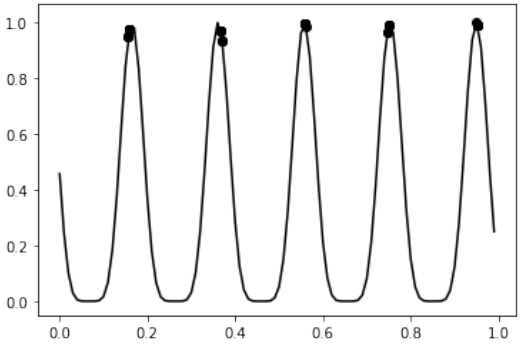

Fig. 5: Result 1

### 3.2 Case 2: Non-equal Stationary Value

In the last experiment, all the function value of the stationary points are equal. So in this experient the performance of selected scheme is studied for multimodal problems. The target function is as shown in Eq.5

$$f_2(x) = f_1(x) \cdot e^{\left[-4\ln 2 \frac{(x-0.086)^2}{0.8^2}\right]} \quad (5)$$

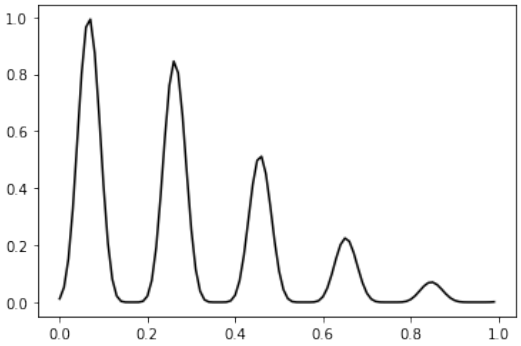

Fig. 6: Target

Table 5: Tournament Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.69 | 0.52 | 1.74 |
| 50 | 0.91 | 1.05 | 2.44 |
| 70 | 0.99 | 1.44 | 2.69 |
| 90 | 0.98 | 2.45 | 2.84 |

Table 6: Roulette Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.75 | 0.56 | 2.47 |
| 50 | 0.94 | 2.11 | 3.07 |
| 70 | 1.00 | 2.16 | 3.65 |
| 90 | 0.98 | 3.34 | 3.85 |

Table 7: Ranking Selection

| Population Size | $R$ | $P_r$ | $N_n$ |
|---|---|---|---|
| 30 | 0.91 | 1.44 | 2.95 |
| 50 | 0.99 | 2.12 | 3.08 |
| 70 | 1.00 | 3.24 | 3.34 |
| 90 | 1.00 | 4.32 | 3.36 |

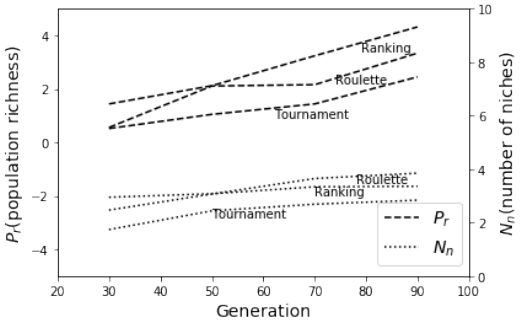


Fig. 7: Result 1

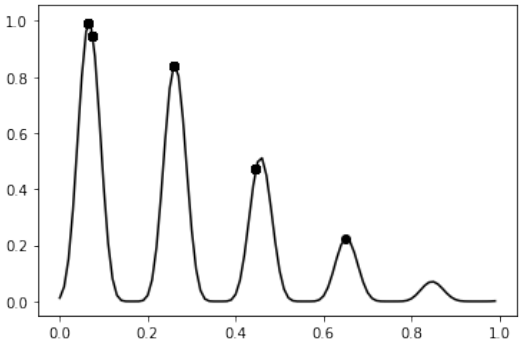

Fig. 8: Result 2

## 4 Conclusion

In this paper, the influence of three common selection schemes on sharing function for two different situations were researched. The experiment result is measured by three indexes,apparent reliability

population richness, the number of niche number.According to the experiment, Compared with Ranking selection and Roulette Selection, the performance of tournament selection are the worst. .

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