

# Research on Fuzzy Adaptive Search Method for Parallel Genetic Algorithms

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## 1. Intruduction

It is a problem to GA that the search ability of the ordinary GA is not always optimal specially in the early and final of the search stage, because genetic parameters (crossover rate, mutation rate and so on) are fixed. To order overcome this problem, our laboratory have already proposed Fuzzy Adaptive Search method for Genetic Algorithm (FASGA) as the modified method [1]. This method is able to realize the efficient search by describing of fuzzy rules to tune genetic parameters according to the search stage. On the other hand, some GAs in parallel methods were already proposed as the effective method for finding high quality solution [2]. The disadvantage of PGA is that it is not always effective by using parallel processing because there are many parameters as compared with ordinary GA and the migration of individuals are not necessarily performed only in case of necessity. Therefore, in this research, we proposed Fuzzy Adaptive Search method for Parallel Genetic Algorithm (FASPGA) combined FASGA with PGA[3]. It is the method with the ability search high-quality solutions in fast which is tuned the crossover, mutation and migration rate by fuzzy reasoning. In the end, we simulated with Rastrigin function by computer for confirming the performance of FASPGA proposed in this paper.

## 2 FASPGA

### 2.1 Parameters

As above, we know that the whole genetic parameters of FASPGA include in crossover rate  $r_{c_i}$ , mutation rate  $r_{m_i}$  and migration degree  $r_{e_i}$  are decided by fuzzy rule. The membership function in *IF* part in FASPGA we proposed is same to FASGA. It is composed of the average fitness value  $f_{a_i}$  and the difference between the maximum and average fitness value ( $f_{m_i}-f_{a_i}$ ). But, FASPGA add a new parameter called migration degree in *THEN* part. The fuzzy rule, membership function in *IF* part and singleton in *THEN* part are shown in Figure 1.

### 2.2 Migration

In ordinary PGA, it is not always effective by using parallel processing because the migration interval is

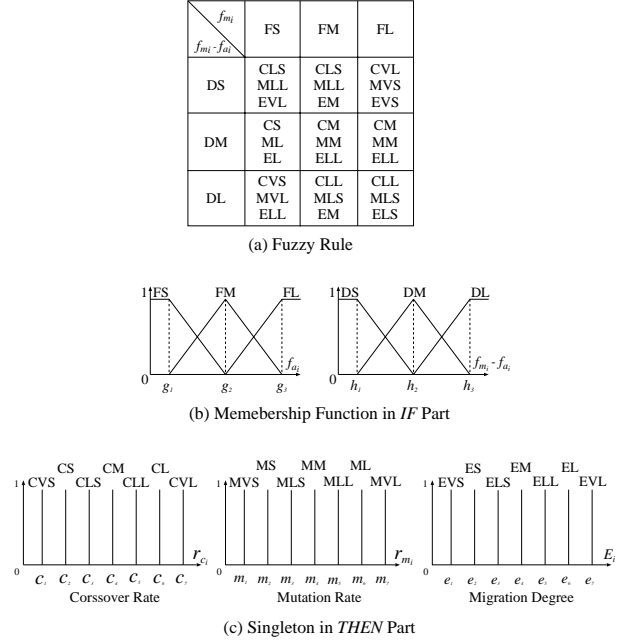


Figure 1. Fuzzy rule of FASPGA

constant. So the case is caused, when migration is necessity but not to migrate, however, on the other hand the migration is executed when migration is not nessity. So the necessity of migration is not considered in PGA. In this proposed method, migration process is asynchronously performed according to the precondition of migration.

- **Precondition of Migration** This migration precondition is decided by the migration degree  $E_i$  ( $i$ : Island Number,  $i = 1, 2, \dots, n$ ) in each island obtained by Fuzzy Rule. The migration process is executed only when the migration degree in each island exceeds an constant value  $\lambda$  as shown in the following equation (1). In this migration process, some individuals in sub-population with the advanced evolutionary condition is easy to be spreaded in whole population. On the contrary, some individuals in sub-population with the delayed evolutionary condition is difficult to be spreaded in whole population.

$$IF E_i - \lambda > 0 \text{ then migration} \quad (1)$$

- **Emigration Partner** The emigration partner means a sub-population (receiver island  $j$ )

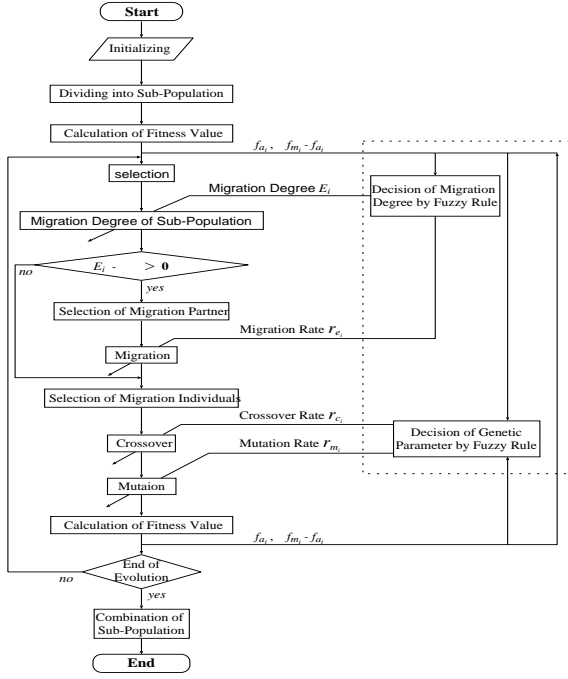


Figure 2. Algorithm flowchart of FASPGA.

which receive the migrators from other sub-population (sender island  $i$ ). This emigration partner should be a sub-population with the delayed evolutionary condition. In other words according to statistics, a sub-population which is the most distant in the average and the deviation is selected as emigration partner. It is realized by using the following equation (2). By this selection, we are able to expect that the variety of all populations increase higher.

$$d = (f_{a_i} - a_j)^2 + (f_{m_i} - f_{a_i}) - (f_{m_j} - f_{a_j})^2 \quad (2)$$

- **Migration Rate** Migration rate means the ratio of migrated per all individuals in a sub-population. In this method, the migration rate  $r_{e_i}$  is decided in proportion to the migration degree  $E_i$  in each sub-population as shown in the following equation.  $k$  in this equation is a constant value.

$$r_{e_i} = k \cdot E_i \quad (3)$$

- **Selection of Migration Individuals** We used the roulette wheel selection as the selection method to select migration individuals. Probability of the roulette wheel selection for selecting individuals with high fitness value is used high in the sender island and low in the receiver island as shown in the following equations. In these equation,  $p$  means the number of individuals of each-population.

*Probability of Individual Selection in Sender Island:*

$$\frac{f_i}{\sum_{i=0}^p f_i} \quad (4)$$

*Probability of Individual Selection in Receiver Island:*

$$\frac{f_{m_j} - f_j}{\sum_{j=1}^p (f_{m_j} - f_j)} \quad (5)$$

### 3. Simulation

The computer simulation was performed in this research to confirm the efficiency of FASPGA proposed in this paper by using the Rastrigin function. Rastrigin function is the  $n$ -dimensional function with multiple peaks and the function which has Lattice-shaped semi-optimum solutions around an optimum solution and is no dependence between design parameters. The optimum solution in this function shows a point with zero value. In this simulation, we used 20 design parameters and gray coding. The equation of Rastrigin function is shown in equation (6).

$$F_{Rastrigin}(x) = 10n + \sum_{i=1}^n x_i^2 - 10 \cos(2\pi x_i) \quad (6)$$

$$(-5.12 \leq x_i < 5.12)$$

$$\min(F_{Rastrigin}(x)) = F(0, 0, \dots, 0) = 0$$

In this simulation, we performed the optimization simulation using Rastrigin function by three methods, GA, PGA and FASPGA in the same precondition. Then compare their performance based on maximum fitness values. The result of simulation is shown in my graduation thesis.

### 4. Conclusions

In this paper, we propose FASPGA which the parameter, the crossover, mutation and migration rate, are adaptively tuned by fuzzy rules according to the search stage. The aim of FASPGA combined PGA with FASPGA is that improve performance of existent genetic algorithms in search efficiency and solution quality. In order to confirm the performance of FASPGA, we simulated with Rastrigin function.

### References

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