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Review of Selection Methods in Genetic Algorithms

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Abstract-
Genetic Algorithm solves a problem using an evolutionary approach by generating mutations to the current solution method, selecting the better methods from this new generation, and then using these improved methods to repeat the process. Selection is the process of finding out the best individuals for mating process so that the offsprings are produced are fit than the previous population. This paper reviews the commonly used selection methods.

Keywords – Boltzmann selection, Genetic Algorithm, Rank selection, Roulette wheel, Tournament selection.

Introduction
Algorithm is defined as the steps followed to solve a given problem. Genetic Algorithm is a problem solving method that uses genetics as the model of problem solving. Genetic Algorithm finds its application in various optimization problems such as Travelling Salesman Problem (Chudasama, Shah, & Panchal, 2011). For population evolution, Genetic Algorithms follows the following steps (Jadaan, Rajamani, & Rao, 2008):

- SELECTION: This is the first step which aims at selecting individuals for individuals for reproduction. In order to choose the best and the fittest individuals, selection is done on the basis of fitness of each individual participating in selection.
- REPRODUCTION: The selected individuals produce offsprings. In this algorithm, recombination and mutation operators are used.
- EVALUATION: In order to assess the quality of offsprings produced, their fitness is evaluated at this step.
- REPLACEMENT: In the last step, individuals from the old population are replaced by new ones.

Figure 1 show the flow chart of Genetic Algorithm (Sharma & Mehta, 2013).

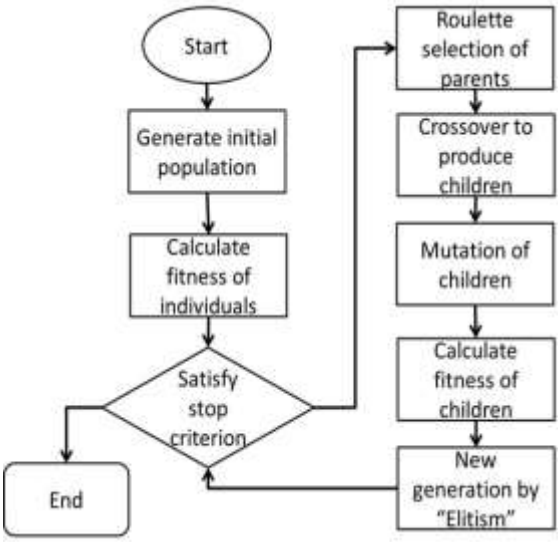

Figure 1: Flowchart of Genetic Algorithm

The Genetic Algorithm stops when population converges towards the optimal solution.

Selection Methods
Selection is the process of choosing two parents from the population for crossing. The purpose of selection is to emphasize fitter individuals in the population so that the offsprings hence produced have higher fitness. According to Darwin's theory of evolution the best individuals survive to participate in reproduction (Shukla, Pandey, & Mehrotra, 2015). Selection, however, must be balanced with variation from crossover and mutation. Very strong selection will lead to highly fit individuals taking over the population, thus reducing the diversity needed for change and progress. On the other hand very weak selection may result in too slow evolution.

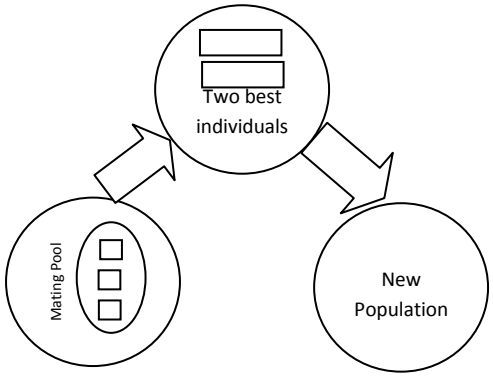

Figure 2: Selection

The most commonly used selection methods include Roulette Wheel Selection, Rank Selection, Tournament Selection, Boltzmann Selection.

- Roulette Wheel Selection: Selection in this method is proportionate to the fitness of individual. Higher the fitness of individual, higher the chances of getting selected. The principle of roulette selection follows a linear search through a roulette wheel with the slots in the wheel weighted in proportion to the individual's fitness values. The probability of an individual being selected as a parent for crossover is given by (Jebari & Madiafi, 2013),

$$p(i) = \frac{f(i)}{\sum_{j=1}^{n} f(j)}$$

Roulette Wheel Selection is the easiest and simplest method to implement and consumes the least amount of time. However it suffers from problem of premature convergence which results in finding a solution which is locally optimum.

- Rank Selection: Roulette wheel Selection suffers from problem of premature convergence. In rank selection, after sorting the individuals on the basis of their fitness, rank is assigned to them. The best individual gets rank N and the worst individual gets rank 1. The selection probability of an individual is given by (Jebari & Madiafi, 2013),

$$p(i) = \frac{rank(i)}{n \times (n-1)}$$

Rank Selection maintains a consistent selection pressure and the selection strategy is robust. However it leads to slower convergence as fitness of individuals participating in reproduction is almost similar (Anand, Afreen, & Yazdani, 2015).

- Tournament Selection: In tournament selection, n individuals are selected from a large population. Then those n individual compete against each other. The one with the highest fitness wins and participates in crossover. Number of individuals competing against each other is termed as tournament size. Since tournament selection gives an equal chance to all the individuals to compete, hence, diversity is preserved. But this also leads to degradation in convergence speed (Razali & Geraghty, 2011). The probability of an individual being selected for reproduction is given by (Jebari & Madiafi, 2013),

$$p(i) = \begin{cases} \frac{C(k-1,n-1)}{C(k,n)} if\ i \in [1, n-k-1] \\ 0\ if\ i\ \in [n-k, n] \end{cases}$$

In tournament selection, it is possible to adjust the selection pressure by changing the tournament size. This technique is used in parallel architectures.

- Boltzmann Selection: In Boltzmann selection, the rate of selection is controlled by a continuously varying temperature. Initially the temperature is high and selection pressure is inversely proportional to temperature. So selection pressure is low initially. The temperature is decreased gradually which increases the selection pressure. This results in narrowing of search space along with maintaining the diversity in population. The selection of an individual is done with Boltzmann probability which is given by,

$$P = \exp[-\frac{fmax - f(Xi)}{T}]$$

Where $T = T_o(1-\alpha)^k$ and $k=(1+100*g/G)$; g is the current generation number; G is the maximum value of g.

In Boltzmann selection, the probability of selecting best string for mating is very high. Execution time of this technique is also very less. However by using this technique, certain information may be lost during mutation stage. But this can be prevented through elitism.

Elitism

In order to improve GA's performance, best individuals must always participate in reproduction. But such individuals may be lost if they are destroyed by crossover or mutation operator. Hence the first best chromosome or the few best chromosomes are copied to the new population (Sharma, Wadhwa, & Komal, 2014).

Exploitation Vs Exploration

The limiting factor of a GA search run is in most cases the numbers of fitness evaluation. Fitness evaluations consume a lot of time in real world application and might even involve testing by an expert. Thus, the goal of every GA should be to get the best results with regard to a limited number of fitness evaluations. The key for an efficient search is the

balance between exploration and exploitation. In the beginning of the search premature convergence should be avoided before having covered as much of the search space as possible. In this phase exploration must be enforced while at the end of the search process it is favourably to make the most out of the already found best solutions. So exploitation is the better choice. In other words, the degree of exploitation should be monotonically decreasing and the degree of exploration should be monotonically increasing during the search run, respectively.

Conclusion

In order for evolution to take place, reproduction stage must have the best individuals. Hence it becomes necessary to select such individuals which are fit and the best. Various selection techniques can be used for this purpose. Presented paper has reviewed some of the commonly used selection methods each having its own merits and demerits. Depending upon the type of application, appropriate selection method can be used.

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