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Comparative Study of Different Selection Techniques in Genetic Algorithm

Saneh Lata Yadav[1]
Asha Sohal[2]

Abstract - Genetic Algorithm is search and optimization technique which has number of steps like initialization, selection, crossover, mutation and replacement. Genetic algorithms are optimization search algorithms that maximize or minimizes given functions. Since GA is heuristic procedures, they are not guaranteed to find the optimum, but experience has shown that they are able to find very good solutions for a wide range of problems. In this paper focus is given on selection phase of GA and comparison between different selection techniques of GA. In selection operator individual are selected according to their fitness and chooses those chromosomes in the population that will be allowed to reproduce, and on average the fitter chromosomes produce more offspring than the less fit ones. Researcher has done lot of work in selection phase of GA. In this paper a number of selection techniques have been described like roulette wheel selection, rank selection, tournament selection, steady state selection, Boltzmann selection and Elitism selection.

Keywords:

Genetic Algorithms
Selection Techniques
Roulette Wheel Selection
Tournament Selection

Author's correspondence:

Saneh Lata Yadav
Assistant Professor
Department of Computer Science & Engineering
K. R. Mangalam University, Gurgaon

Asha Sohal
Associate Professor
Department of Computer Science & Engineering
K. R. Mangalam University, Gurgaon

I. INTRODUCTION

The term "genetic algorithm"' (GA) is applied to any search or optimization algorithm that is based on Darwinian principles of natural selection. Genetic Algorithm is a population-based search and optimization method which mimics the process of natural evolution. Genetic Algorithms (GAs) were invented by John Holland in the 1960s and were developed by Holland (1975) and his students and colleagues at the University of Michigan in the 1960s and the 1970s. Holland's GA is a method for moving from one population of "chromosomes" to a new population by using a kind of "natural selection" together with the genetics inspired operators like crossover, mutation, and inversion. A chromosome contains a group of numbers that completely specifies a candidate solution during the optimization process (Rakesh Kumar G. G., 2013)[1]. GA is a method for moving from one population of "chromosomes" (e.g., strings of ones and zeros, or "bits") to a new population by using a kind of "natural selection. The selection operator chooses those chromosomes in the population that will be allowed to reproduce, and on average the fitter chromosomes produce more offspring than the less fit ones. Crossover exchanges subparts of two chromosomes, roughly mimicking biological recombination between two single–chromosome ("haploid") organisms; mutation randomly changes the allele values of some locations in the chromosome; and inversion reverses the order of a contiguous section of the chromosome, thus rearranging the order in which genes are

arrayed. The selection phase determines which individuals are chosen for mating (reproduction) and how many offspring each selected individual produces. The main principle of selection strategy is "the better is an individual; the higher is its chance of being parent." The process that determines which solutions are to be preserved and allowed to reproduce and which ones deserve to die out [2]. The primary objective of the selection operator is to emphasize the good solutions and eliminate the bad solutions in a population while keeping the population size constant as shown in figure 1.

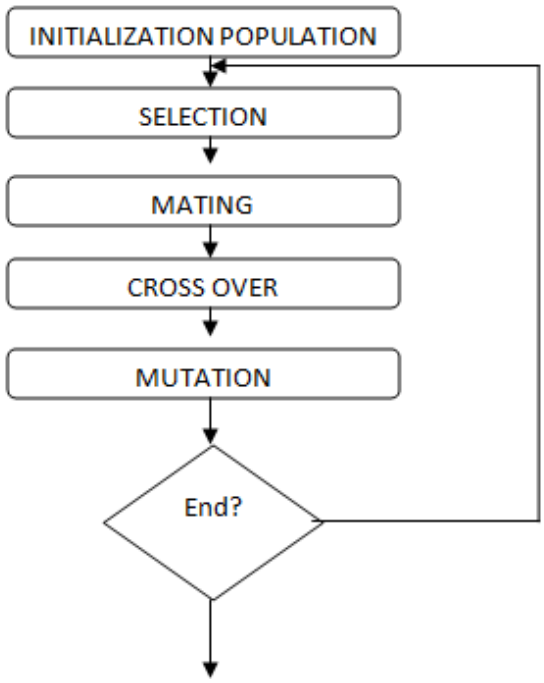

Figure 1: Basic Structure of Genetic Algorithm

II. LITERATURE REVIEW

There are different selection techniques in GA which are Roulette wheel selection, Rank selection, Tournament selection, Steady state selection, Boltzmann selection and Elitism selection.

Some steps in selection Operator

- Identify the good solutions in a population.
- Make multiple copies of the good solutions.
- Eliminate bad solutions from the population so that multiple copies of good solutions can be placed in the Population.

Roulette Wheel Selection: - Roulette selection is one of the traditional GA selection techniques. Roulette wheel is the simplest selection technique. In this technique, all the chromosomes in the population are placed on the roulette wheel according to their fitness value. Each individual is assigned a segment of roulette wheel whose size is proportional to the value of the fitness of the individual (Noraini Mohd Razali, 2011) [3]. The bigger the fitness value is, the larger the segment is. Then, the virtual roulette wheel is spinned. The individual corresponding to the segment on which roulette wheel stops are then selected. The process is repeated until the desired number of individuals is selected. Individuals with higher fitness have more probability of selection. It can possibly miss the best individuals of a population at certain times. There is no guarantee that good individuals will find their way (Rakesh Kumar J. , 2012)[4] into next generation. In proportional roulette wheel, individuals are selected with a probability that is directly proportional to their fitness values i.e. an individual's selection corresponds to a portion of a roulette wheel. The probabilities of selecting a parent can be seen as

spinning a roulette wheel with the size of the segment for each parent being proportional to its fitness as shown in Table 1.

Population	Fitness
1	25.0
2	5.0
3	40.0
4	10.0
5	20.0

Table 1: Ratio between population and fitness

Since the third individual has higher fitness value than any other, it is expected that the roulette-wheel selection will choose the third individual more than any other individual.

Rank Selection: - The Roulette wheel will have a problem when the fitness values differ very much. If the best chromosome fitness is 90%, its circumference occupies 90% of Roulette wheel, and then other chromosomes have too few chances to be selected. Rank Selection ranks the population and every chromosome receives fitness from the ranking. The worst has fitness 1 and the best has fitness N. It results in slow convergence but prevents too quick convergence. It also keeps up selection pressure when the fitness variance is low.

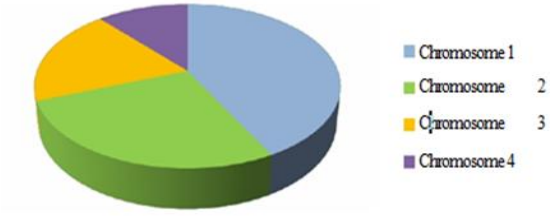

Figure 2: Ranking between different chromosomes

It preserves diversity and hence leads to a successful search. In Linear Rank selection, individuals are assigned subjective fitness based on the rank within the population as in figure 2. The individuals in the population are sorted from best to worst according to their fitness values. Each individual in the population is assigned a numerical rank based on fitness, and selection is based on this ranking rather than differences in fitness.

Tournament Selection: - GAs uses a selection mechanism to select individuals from the population to insert into a mating pool. Individuals from the mating pool are used to generate new offspring, with the resulting offspring forming the basis of the next generation. A selection mechanism in GA is simply a process that favors the selection of better individuals in the population for the mating pool. The selection pressure is the degree to which the better individuals are favored: the higher the select ion pressure, the more the better individuals are favored (S.N. Sivanandam)[5]. This selection pressure drives the GA to improve the population fitness over succeeding generations. The convergence rate of a GA is largely determined by the selection pressure, with higher selection pressures resulting in higher convergence rates. However, if the selection pressure is too low, the convergence rate will be slow, and the GA will unnecessarily take longer to find the optimal solution. If the selection pressure is too high, there is an increased chance of the GA prematurely converging to an incorrect (suboptimal) solution. Tournament selection provides selection pressure by holding a tournament among s competitors, with s being the tournament size. The winner of the tournament is the individual with the highest fitness of the s tournament competitors. The winner is then inserted into the mating pool. The mating pool, being comprised of tournament winners, has a higher average fitness than the average population fitness. This fitness

difference provides the selection pressure, which drives the GA to improve the fitness of each succeeding generation. Increased selection pressure can be provided by simply increasing the tournament size *s*, as the winner from a larger tournament will, on average, have a higher fitness than the winner of a smaller tournament (Brad L. Mille r) [6].

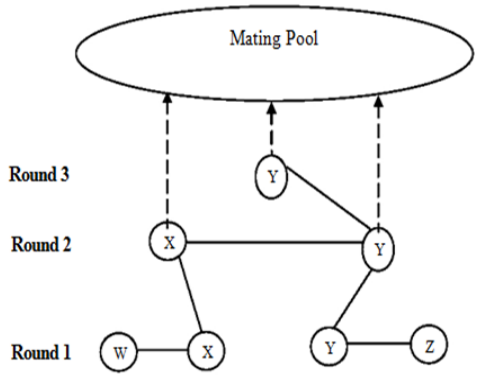

Figure 3: Tournament selection using mating pool

The final victor of the competition will always be the fittest chromosome in the population as shown in figure 3. The more successful the chromosome is in competition, the more often that chromosome is expected to appear in the mating pool.

Steady State Selection: - In this method, a few good chromosomes are used for creating new offspring in every iteration. Then some bad chromosomes are removed and the new offspring is placed in their places. The rest of population migrates to the next generation without going through selection process (Bhattachariya) [7]. Main idea of this selection is that big part of chromosomes should survive to next generation. In every generation is selected a few (good - with high fitness) chromosomes for creating a new offspring. Then some (bad - with low fitness) chromosomes are removed and the new offspring is placed in their place. The rest of population survives to new generation.

Boltzmann Selection: - In Boltzmann selection a continuously varying temperature controls the rate of selection according to a preset schedule. The temperature starts out high, which means the selection pressure is low. The temperature is gradually lowered, which gradually increases the selection pressure, thereby allowing the GA to narrow in more closely to the best part of the search space while maintaining the appropriate degree of diversity.

Elitism Selection: - The idea here is to arrange the chromosomes in the decreasing order according to their fitness values. Then apply the selection with each two chromosomes in the arranged set. In this way, Genetic Algorithm will be applied between strong chromosomes or between weak chromosomes. This means there is no chance to apply Genetic Algorithm between weak and strong chromosomes (Firas Alabsi, 2012) [8].Elitism is a kind of selection in which the best individual passed to the next generation as such without any modification. Elitism prevents the best individual to undergo the reproduction process so as to pass them without any modification into next generation.

III. RESULTS & DISCUSSION

Citation	Publication Year	Author and year	Factor Considered for study	Selection Technique	Observations
(Goldberg , 1991)[9]	1991	Goldberg, David E., and Kalyanmoy Deb	Expected fitness ratio and time to converge	Compared proportional, ranking, tournament and steady state selection.	Ranking and tournament selection is better than proportional selection in terms of Maintaining steady pressure toward Convergence. Binary tournament selection is recommended over linear ranking Selection because of its more efficient time complexity.
(Zhong, 2005)[10]	1999	Julstrom, Bryant A	Probability of ith chromosome	Studied the computing Time efficiency of 2 types of Rank based selection (linear and exponential),and compared them with Tournament selection method.	Tournament selection is better than rank based selection, since repeated tournament selection is faster than sorting the population and then assigning rank based Probabilities to them.
(Julstrom, 1999)[11]	2005	Zhong, J., Hu, X., Gu, M., & Zhang	Using 7 general test functions	Compared Proportionate roulette wheel Selection method and Tournament selection method. (tournament size=6)	Tournament selection is more efficient than Proportionate roulette wheel selection in terms of Convergence rate.
(Mashoho r, 2005)[12]	2005	Mashohor, Syamsiah, Jonathan R. Evans, and Tughrul Arslan	Maximum fitness Rate of accuracy Computation time	Compared Deterministic, Tournament and Roulette wheel selection methods.	The ability to reach the maximum fitness with lowest no. of generations is highest in deterministic. This is followed by roulette wheel and then tournament selection.

IV. CONCLUSION

In this paper we have described six types of selection strategy in the GA procedure to find the optimum solution for the chromosomes and compare the performance in terms of solution quality and number of generations to come out with the best solution. In Roulette wheel, all the chromosomes in the population are placed on the roulette wheel according to their fitness value. The virtual roulette wheel is spinned. The process is repeated until the desired number of individuals is selected. Individuals with higher fitness have more probability of selection. Rank selection ranks the population and every chromosome receives fitness from the ranking. It results in slow convergence but prevents too quick convergence. In tournament selection winner of the tournament is the individual with the highest fitness of the s tournament competitors. The winner is then inserted into the mating pool. In steady state selection some good chromosomes are selected and bad chromosomes are removed. Boltzmann selection controls the rate of selection by varying temperature. The result shows that the genetic algorithm with elitism provides more optimal solution and has better convergence speed than the simple genetic algorithm. All of these selection mechanisms have the same purpose of creating more copies of the individuals with higher fitness than those with lower fitness. However the selection mechanisms differ in the manner in which they allocate copies to the fittest individuals. A selection method has the higher selection measure than the other if it makes more copies of the best individuals thereby eliminating low fit individuals rapidly. A strong selection mechanism reaches equilibrium faster than a weaker method.

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