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Review of Crossover Techniques for Genetic Algorithms

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Abstract-- Evolutionary algorithms are the ones that follow the Darwin concept of "Survival of the fittest" mainly used for optimization problems for more than four decades. Evolutionary algorithms are heuristic search algorithms which do not always guarantee to provide the exact optimal solutions, but they will definitely find better optimal solutions within less amount of time. Some of them are Genetic algorithms, Genetic algorithm is related to biological background. Performance of genetic algorithms mainly depends on type of genetic operators – Selection, Crossover, Mutation and Replacement used in it. Crossover operators are used to bring diversity in the population. This paper studies different crossover operators.

Keywords-- *Optimization, Genetic Algorithm, Operators, Crossover, Mutation, Selection*

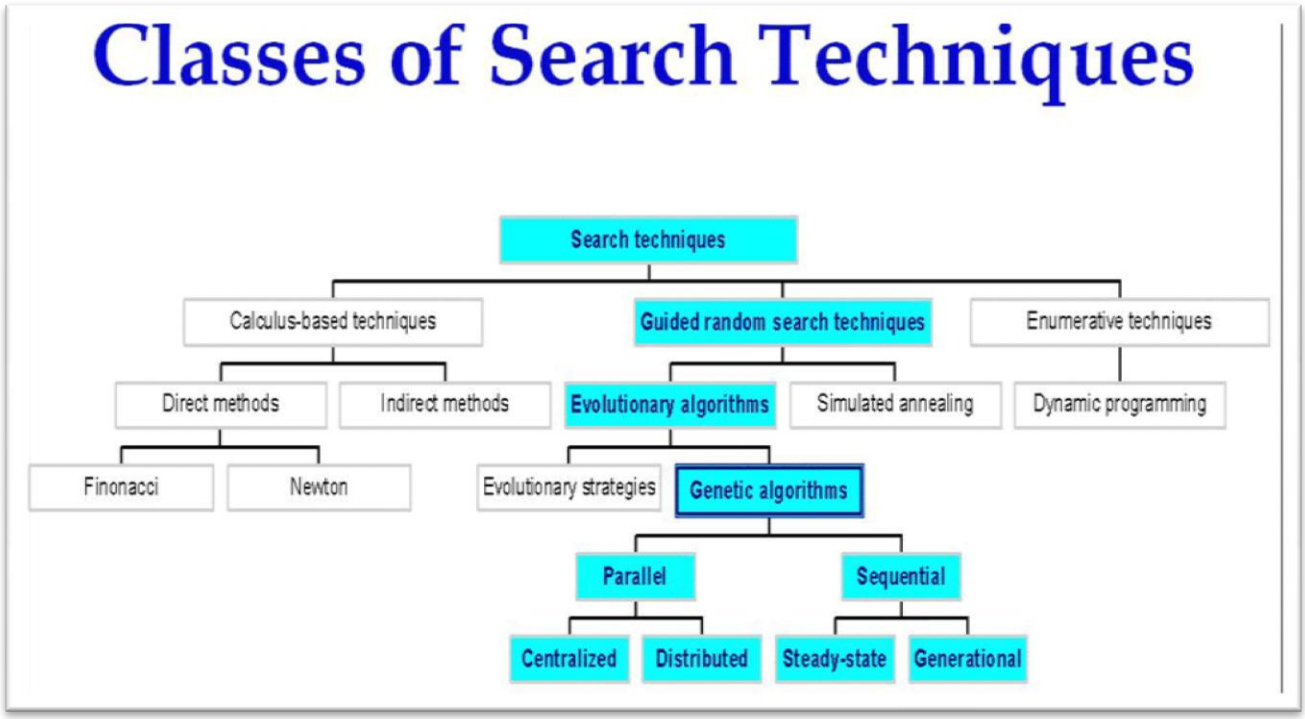
I. INTRODUCTION TO GENETIC ALGORITHMS

The genetic algorithm is a generalized, computer executable version of fishers formulation. It consists of two points.

1. Process of iterations of chromosomes .
2. Enlagement of the set of genetic algorithm operators.

The genetic algorithm is an optimization and search technique based on principle of genetic and evolutionary algorithm. genetic algorithm are intialised with a population of guesses these are usually random and will be spread throughtout the seach space.A typical algorithm the uses 3 oprators selection, crossover and mutation.the initial guesses are held in binary codes called string.we can say that genetic algorithm is a method of optimization with is introduced by the john Holland in 1970.genetic algorithms works very well in mixed combinatorial problems.

For solving a problem we must represents the solution of the problem as a cromosoms. then genetic algorithm create a population for further calculation or we can say for produce a netter next generation with the help of operators that is selection, crossover and mutation. it uses many criteria of selection so that it picks the best individual for matting. the population is the candidate solution that are consider for further process new population are born into the old population while other is dies. A single solution are depend on an individual. the next generation is processed by the fitness function fitness function finds that how good the solution of next generation.



II. STEPS OF THE GENETIC ALGORITHM

Step 1: Randomly generate an initial population

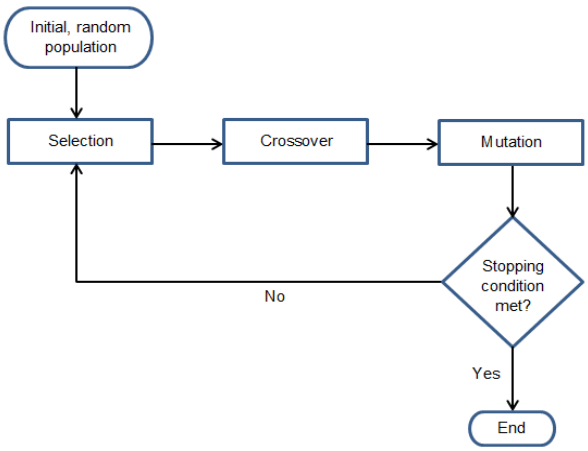
Step 2: Compute and save the fitness for each individual in the current population.

Step 3: Define selection probabilities for each individual.

Step 4: Generate probabilistically selecting individuals from population to produce offspring via genetic operator.

Step 5: Repeat step 2 until satisfying solution is obtained.

III. FLOW CHART OF G.A.



IV. GENETIC ALGORITHM OPERATORS

Genetic algorithms are good at taking larger, potentially huge, search spaces and navigating them looking for optimal combinations of things and solutions which we might not find in a life time. Three most important aspects of using GA are :

1. **Encoding: -**the chromosome should in some way contain information about solution which it represent.

   a. Binary Encoding

   Most common method of encoding is in binary form. Chromosomes are strings of 1s and 0s and each position in the chromosome represents a particular characteristic of the problem.
   Chromosome A – 10110010110011100101
   Chromosome B - 11111110000000011111

   b. Permutation Encoding

   Permutation encoding can be used in ordering problems. Each chromosome is represented in numbers.
   Chromosome A – 1 5 3 2 6 4 7 9 8
   Chromosome B – 8 5 6 7 2 3 1 4 9

   c. Value Encoding

   Used in problems where complicated values, such as real numbers, are used and where binary encoding would not suffice.
   Chromosome A - 1.235 5.323 0.454 2.321 2.454
   Chromosome B- (left), (back), (left), (right), (forward)

2. **Fitness Function:-** A fitness function quantifies the optimality of a solution (chromosome) so that that particular solution may be ranked against all the other solutions. A fitness value is assigned to each solution depending on how close it actually is to solving the problem. Certain genetic operators require that fitness function be non-negative, although certain operators do not have this requirement.
   Consider the following transformations-
   F(X) = f(X) for maximization problem
   F(X) = 1/f(X) for minimization problem, if f(X) = 0
   F(X) = 1/ (1+f(x)), if f(x) = 0
   A number of such transformations are possible.

3. ***Reproduction/Selection:-***Reproduction is usually the first operator applied on population. Chromosomes are selected from the population to be parents to cross over and produce offspring's.

4. **Recombination:-**It is the process for getting new offspring for the mating pool. A simple genetic algorithm uses three basic operators which are

   a. Reproduction
   b. Cross over
   c. Mutation

a. ***Cross over***

It is the process in which two chromosomes (strings) combine their genetic material (bits) to produce a new offspring which possesses both their characteristics. Two strings are picked from the mating pool at random to cross over.The method chosen depends on the Encoding Method. The most widely used cross over methods are –

1. **Single Point Crossover**- Here a cross-site is selected randomly along the length of the mated strings and bits next to the cross-sites are exchanged.
2. **Two-point Cross over**- Two random points are chosen on the individual chromosomes (strings) and the genetic material is exchanged at these points.
3. **Uniform Cross over**- Each gene (bit) is selected randomly from one of the corresponding genes of the parent chromosomes.

b. Mutation

After cross over, the strings are subjected to mutation. It is the process by which a string is deliberately changed so as to maintain diversity in the population set. Mutation of a bit involves flipping it, changing 0 to 1 and vice-versa with a small mutation probability P_m. Mutation Probability determines how often the parts of a chromosome will be mutated. Types:-

1. Flipping
2. Interchanging
3. Reversing

Mutation for real no's can be done as

Before (1.38 -69.4 326.44 0.1)

After (1.38 -67.5 326.44 0.1)

Hence, mutation causes movement in the search space (local or global) and restores lost information to the population.

V. CROSSOVER OPERATORS TYPES

A. Single Point Crossover

Single point crossover is the most commonly used crossover [3]. A crossover site is selected randomly along the length of the mated strings and bits next to the cross-sites are exchanged. If appropriate site is chosen, better children can be obtained by combining good parents else it severely hampers string quality. In one point crossover the head and tail of one chromosome separates and if both head and tail contains the good genetic material then none of the offspring will obtained the both good features directly.

B. N-Point Crossover

The N-point crossover was first implemented by De Jong in 1975 [4]. It consists of more than one cross over sites but principle used is same as that of single point crossover [3]. In 2-point crossover value of crossover sites is 2. Adding of the more crossover sites causes more disruptions of building blocks that sometimes reduce the performance of genetic algorithm. But it allows the head and tail portion of a chromosome to be passed together in the offspring.

C. Uniform Crossover

Uniform crossover do not fragments the chromosomes for recombination. Each gene in offspring is created by copying it from the parent chosen according to the corresponding bit in the binary crossover mask of same length as the length of the parent chromosomes [3]. If the bit in crossover mask is 1, then the corresponding gene is copied from the first parent and if the bit in crossover mask is 1, then the corresponding gene is copied from the second parent. A new crossover mask is generated randomly for each pair of parent chromosomes. The number of crossover point is not fixed initially. So, the offspring contains a mixture of genes from both the parents.

D. Three Parent Crossover

In three parent crossover, three parents are chosen randomly. Each gene of the first parent is compared with the corresponding gene of the second parent. If both genes are same, the gene is taken for offspring otherwise the corresponding gene from the third parent is taken for the offspring [3]. It is mainly used in case of binary encoded chromosomes.

E. Arithmetic Crossover

Arithmetic crossover is used in case of real-value encoding. Arithmetic crossover operator linearly combines the two parent chromosomes [3]. Two chromosomes are selected randomly for crossover and produce two offsprings which are linear combination of their parents according to the following computation: offspring1 = a.P1gen + (1-a). P2gen offspring2 = a.P2gen + (1-a). P2gen Where Pgen represent the corresponding gene either from parent1 or parent2, and „a‟ is the weight which governs dominant individual in reproduction and it is between 0 and 1.

F. Partially mapped Crossover

Partially Matched or Mapped Crossover (PMX) is the most commonly used crossover operator in permutation encoded chromosomes. It was proposed by Goldberg and Lingle [5] for Travelling Salesman Problem. In Partially Matched Crossover, two chromosomes are aligned and two crossover sites are chosen randomly. The portion of chromosomes between the two crossover points gives a matching selection that undergoes the crossover process through position-by-position exchange operations [2, 3]. PMX tends to respect the absolute positions.

G. Order Crossover (OX)

It was proposed by Davis and also used for chromosomes with permutation encoding [6]. The order crossover begins in a manner similar to PMX by choosing two crossover points. But instead of using point-by-point exchanges as in case of PMX, order crossover applies sliding motion to fill the left out holes by transferring the mapped positions. It copies the fragment of permutation elements between the crossover points from the cut string directly to the offspring, placing them in the same absolute position [2, 3]. OX tends to respect the relative positions.

H. Cycle Crossover (CX)

Cycle crossover is used for chromosomes with permutation encoding. During recombination in cyclic crossover there is a constraint that each gene either comes from the one parent or the other [7]. The basic principle behind cycle crossover is that each allele comes from one parent together with its position. To make a cycle of alleles from parent1, start with the first allele of parent1. Then look at the allele at the same position in parent2 and go to the position with the same allele in Parent1.Add this allele to the cycle and repeat step the above until you arrive at the first allele of parent1. Put the alleles of the cycle in the first child on the positions they have in the first parent and the remaining alleles of first child come from the second parent along with their position. Generate next cycle from parent2.

CONCLUSION & FUTURE WORK

We can use the different crossovers operators of genetic algorithm in various applications. we can also use these operators to produce hybrid crossover which can be further utilize in various ways.

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