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A STUDY ON GENETIC OPERATORS IN EVOLUTIONARY COMPUTING- BIRD'S EYE VIEW

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ABSTRACT

Evolutionary Computing is one of the computing technique, that makes use of biological concepts to solve computational problems, particularly NP-Hard problems. Evolutionary computing finds its applications in Data Mining, primarily to improve the performance and correctness of the mining process. The heart of Evolutionary computing is genetic operators. The three important genetic operators are Selection operator, Mutation operator and Cross over operator. The aim of the research article is to provide an overview of genetic operators and the role of the genetic operators in solving computational problems. Of course, a single article cannot provide complete explanation to illustrate all the genetic operators, yet we hope that it will provide a fundamental guideline for future researches in Evolutionary computing.

Keywords- Evolutionary Computing, Genetic Algorithms, Genetic Operators, Data Mining.

I. INTRODUCTION

Evolutionary Computing deals with application of Biological concepts to solve computational problems. It is also called Bio-Inspired computing. Taking biological concepts, analyzing and adopting them to solve computational problems is the central goal of evolutionary computing. Soft computing is one of the computing technique, that makes use of evolutionary computing concepts to solve NP-Hard problems. Computational problems are classified into NP-Hard, NP-Complete. In case of NP-Hard, the solution for that problem remains in accurate or in otherwise we can say that many feasible solutions exist for the problem. But the problem of finding an optimal solution from the set of feasible solutions is too difficult. This phenomenon makes NP-Hard problems, an attractive research area for the scientific community.

Algorithmic techniques are traditional ways to solve any kind of problems and for finding solutions within a guaranteed amount of time. Traditional method includes Greedy, Backtracking, Branch and Bound. The computing time and the effectiveness of the solution to the given computational problem should be considered. As we know that the performance of an algorithm depends on computing time, space measure and complexity of the algorithm. Complexity can be analyzed in terms of $O(n)$,$O(n^2)$… The main reason behind the usage of evolutionary concepts to solve computational problems lies in the fact that search space, while using soft computing techniques for a problem will gets minimized, and the probability of getting an optimal solution will be maximized.

Several sub classes of evolutionary computing particularly to solve optimization problems exist. Widely used optimization technique includes ant-colony optimization, swarm optimization, fish-eye optimization, Genetic algorithms and so on. Genetic algorithm is one of the sub classes of evolutionary computing which focuses on Human genetic concepts to solve optimization problems. “Theory of Evolution” proposed by Darwin forms the basics of genetic algorithms. Genetic algorithm finds its application in the knowledge mining. The size of datasets gets increasing day by day, which in turn leads to big data analytics, and mining such data’s in a minimized time can be achieved through genetic algorithms.

II. GENETIC ALGORITHM-CONCEPTS

A. Population, Genotype and Phenotype

The most primary element in genetic algorithm is organism. An organism can be expressed in terms of both genotype and phenotype. Phenotype is based on external morphological feature of the organism. For example we

can say phenotype of an organism can be human, monkey, pigeon. The genotype represents the unique chromosomal or genetic pattern of the organism. The genotype of the organisms of same phenotype will always be same. Any deviation from that due to genetic operations, will leads to creation of new phenotype. Population is another important concept of genetic algorithm. Collection of organisms with similar genotypes forms population. Populations are often correlated with generations.

B. Encoding

With respect to computational perspective, the genotypes or chromosomal patterns of the individuals are represented in the form of Binary Encoding Techniques, i.e., series of 1's and 0's.

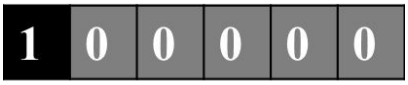


Figure 1. Sample Encoding Pattern

C. Genome, Chromosome and Allele

A particular feature in the chromosome is said to be genome. Each and every genome carries some values, that determines the phenotype of the individual. The value that each genome carries is said to be allele. Basically genomes are classified into two types, they are dominant allele and recessive allele. In case of dominant allele, the feature remains same even after any number of generations. But in case of recessive allele, the feature carried by the genome changes with respect to mating allele. In our computational technique, dominant allele is represented by '1' and recessive allele is represented by '0'. In Figure 1, '1' represents dominant allele and '0' represents recessive allele.

D. Fitness Function and Fitness Evaluation

Fitness function is a measure, used to calculate the capability of the individual. Depending on the computation problem, we can choose our fitness function. For example fitness function for finding frequent itemset mining problem is occurrence of items in the database. 'Survival of the fittest' is one of the important property related to genetic algorithms. According to this property, the fittest individuals of a particular generation are preserved in order to allow them for mating to create next generation population.

E. Termination Condition

It is one of the important concept related to evolutionary computing. Termination condition determines when the execution of genetic computing stops. Some popular termination conditions are fixed number of generations reached, expected number of individuals with high fitness values for the given problem domain is reached.

III. GENETIC OPERATORS

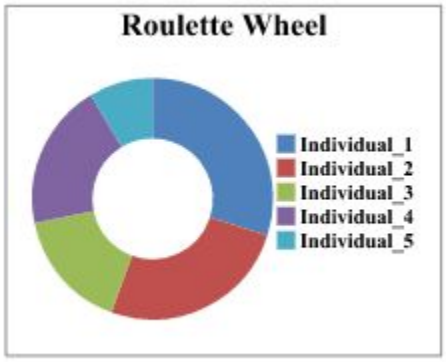
A. Selection

Selection is one of the popular genetic operator, which helps in selecting best chromosomes from a particular generation. Selection is purely based on fitness value of the individual and in some cases, probability is used. Several selection methods including Roulette wheel based selection, Rank based selection, Tournament selection, Truncation selection, Deterministic sampling and so on.

(i) Roulette Wheel Based Selection

In Roulette wheel based selection technique, the sum of fitness value of all the individuals of a particular generation is calculated. And the probability of picking a individual can be calculated by dividing the fitness of the individual by sum of fitness of all the individuals of the particular generation. Although the computing time of Roulette wheel

selection technique is high, it is widely used due to effective selection of individuals. The probability of selecting a particular individual can be calculated using the formula as given below



PHENOTYPE	FW	P(i)
Individual_1	140	0.29
Individual_2	120	0.25
Individual_3	76	0.14
Individual_4	92	0.19
Individual_5	40	0.08

Figure 2. Illustration of Roulette Wheel Based Selection Method

(ii) Rank Based Selection

In Rank based selection technique, all the individuals are assigned rank values based on the fitness value. Then the individuals are selected with selection probability, that is directly proportional to the fitness value or rank of the individual. Figure 3 explains the probability of selecting an individual through Rank Based Selection method.

PHENOTYPE	FW	Rank
Individual_1	140	1
Individual_2	120	2
Individual_3	76	4
Individual_4	92	3
Individual_5	40	5

Figure 3. Illustration of Rank Based Selection Method

(iii) Tournament Selection

In Tournament selection technique, a tournament size is chosen. Based on the tournament size, individuals of a particular generation are chosen randomly and are allowed for game i.e., picking best individuals of a particular match. This process is repeated until you get all best individuals.

B. Mutation

Mutation is one of the popular genetic operator, which helps in reducing the loss of fittest individuals. Biologically, we can define mutation as sudden heritable changes that occur in the genetic pattern or genes of the organism. Similarly, here we are changing the value of alleles of a particular individual in order to get an optimal solution. Mutation can be done using some probabilities. The probability 'P_m' can be defined between the range 0 and 1. i.e., $0< P_m<1$. Let us consider that the mutation probability of a particular individual is 0.1 and length of the chromosome is 10, then only one allele value of the individual changes from '0' to '1'.

Mutation Conditions:

$0 < Pm < 1$,

Example: if CL=10 , Pm=0.1

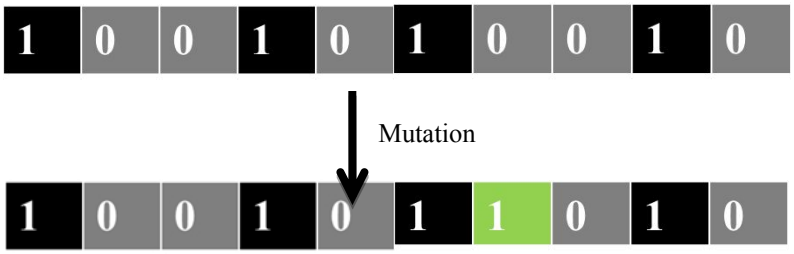


Figure 4. Illustration of Mutation

C. Cross Over

Cross over is one of the popular genetic operator that helps in creation of subsequent generations for the individuals. It is formally defined as the mating of two chromosomes to yield a new chromosome. The genetic pattern of the new chromosome is inherited from the parent chromosome. During cross over dominant allele retains as it is. But recessive allele gets modified when it mates with dominant allele. Several types of cross over techniques exist. Popular techniques are single-point cross over, multi-point cross over, random cross over, arithmetic cross over.

(i) Single Point Cross Over

In case of single-point cross over, the value of parent 1 at a particular point gets modified with those of parent-2.

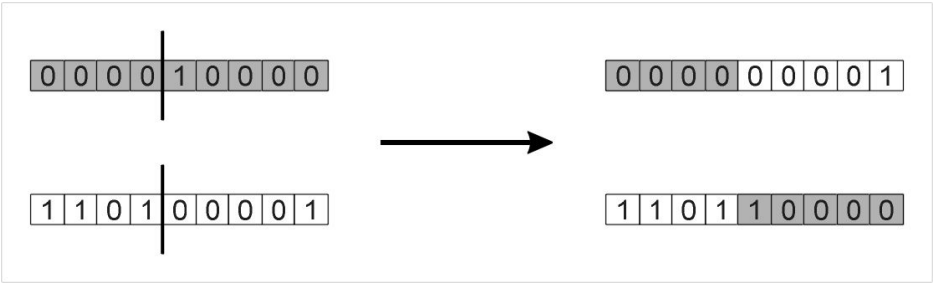


Figure 5. Single Point Cross Over

(ii) Multi Point Cross Over

In case of multi-point cross over, the value of parent 1 gets modified at many regions by parent-2.

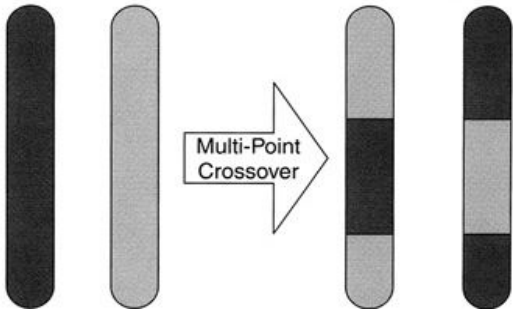


Figure 6. Multi Point Cross Over

(iii) Arithmetic Cross Over

In case of arithmetic cross over, child chromosome is formed by performing some arithmetic operations with parent 1 and parent 2.Some of the popular arithmetic operations are Arithmetic-OR, Arithmetic-AND, Arithmetic-XOR operation. Depending upon the problem, one can select the operator that is more suitable to solve the problem. Figure 7 illustrates Arithmetic-OR Cross Over.

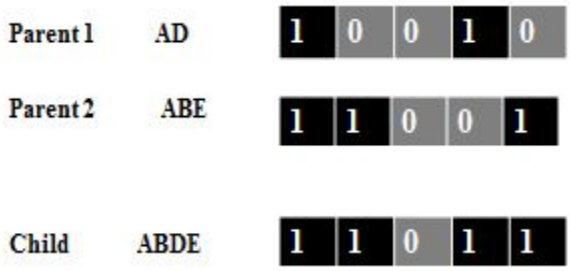


Figure 7. Arithmetic-OR Cross Over-Example

IV. CONCLUSION

Evolutionary computing deals with application of biological concepts in solving computational problems. Genetic algorithm is one of the subset of evolutionary computing and it finds its application in the areas of knowledge mining and in solving optimization problems. The heart of genetic algorithms is genetic operators. Selection, Cross over and Mutation are the popular genetic operators. Our research article focuses on providing a bird's eye view of genetic operators and hence it acts as guide for future researches in Evolutionary computing.

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