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GENETIC ALGORITHM & OPERATORS

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ABSTRACT

The advent of electronic computer is a revolution in the field of science and technology. The applications of the electronic machine are not only limited to calculation rather it also motivated the scientist to implement biology and psychology with electronics. The natural systems are used as a guiding metaphor to invent such machines with artificial intelligence. The natural genetic system of species set a platform for the implementation of genetic algorithms to generate useful solutions to optimization and search problem.

Genetic algorithm provides a step by step process for moving from one population of chromosomes to a new population using the natural selection with the phenomenon of "survival of the fittest". The fitness of the genes changes with the population change. Different operators such as crossover, mutation and inversion play a vital role in the formation of new generation offspring.

In this paper different techniques for genetic algorithm operators are discussed and a new crossover operator called 'n bit right shift crossover' and a new mutation technique called 'complement mutation' is proposed.

KEYWORDS: Genetic algorithm, Crossover operator, n bit right shift crossover, mutation, complements mutation

INTRODUCTION

Genetic algorithms [2, 6] can be defined as the adaptive heuristic search algorithms developed by the evolutionary ideas of natural selection and genetics. They produce natural processes which are based on the principles of Lamarck and Darwin. As stated in Darwin's theory of natural selection the main evolutionary tool for the genetic development of the species is natural selection. According to Darwin as the time passes by all biological organism evolve to survive as per the principle of natural selection like "survival to the fittest" to reach the at most point of accomplishment . Darwin discovered that selection and reproduction are the two elements of species evolution. The selection contributes to the reproduction of a strongest and more robust individual, while reproduction is the part where evolution occurs.

Genetic algorithms [1, 2] are convincing methods that can be optimistically and easily used in every problem. Their performance depends on factors such as encoding scheme and the choice of genetic operators such as the selection crossover and mutation operators. The chief reason for Genetic algorithms is the exclusive co operation between selection, crossover and mutation operator. The process used in Genetic Algorithm to sustain genetic diversity is genetic operator.

The execution of genetic algorithm [7] depends on the genetic operators and the type of crossover operators respectively. In the evolution process by a genetic algorithm the crossover operators create offspring different from the parents, only if the selected chromosomes are non-identical. The best relationship between the crossover and the search problem provides a best result for effective crossover in genetic algorithm.

GENETIC ALGORITHMS

Genetic algorithms (GA) [2, 6] are search algorithms based on the mechanics of natural selection and natural genetics. A genetic algorithm (GA) is one such versatile optimization method. Figure 1 shows the optimization process of a GA.

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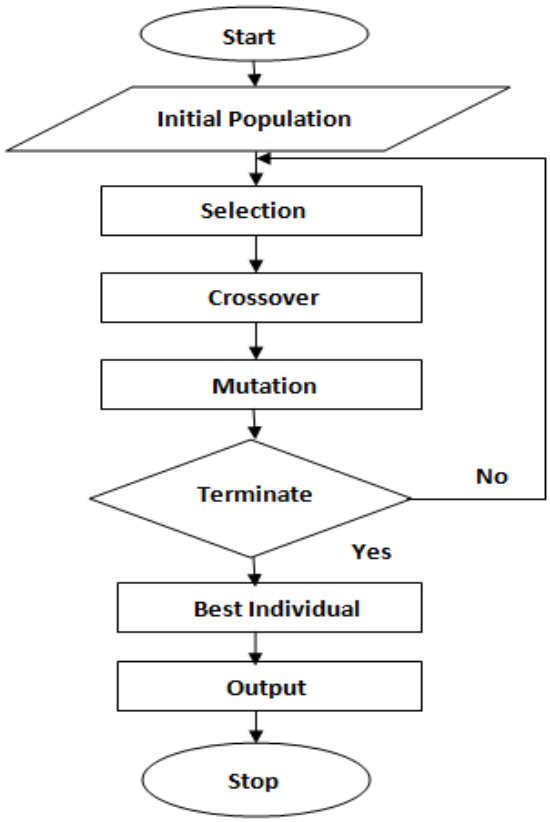

Figure 1 Flowchart for genetic algorithm[2,6]

In a general genetic algorithm an initial population is selected randomly from a collection of solution. Then a value for fitness is assigned to each solution which depends on how the value is close enough to solve the problem. The chromosomes having a high fitness value reproduce offspring. If the newly generated offspring contains the solution that generates an output which is close enough or equal to the desired answer then the result is obtained otherwise the previous steps are repeated until the problem is solved.

The algorithm contains the following steps
Begin /*A general genetic algorithm*/
Generate initial population randomly
Set a fitness value to each individual
WHILE NOT finished DO LOOP
Begin
Select individual from old generation
Apply recombination or mutation to generate offspring;
Compute fitness of the new individuals;
Destroy old individual to generate space for the new chromosomes and insert offspring to this space
IF best population is gathered
THEN finishes = TRUE;
END
END

GENETIC OPERATORS

1 Crossover Operators:

The search of the solution space is done by creating new chromosomes from old ones. The most important search process is crossover [1, 2]. The crossover operator is a genetic operator that combines (mates) two chromosomes (parents) to produce a new chromosome (offspring). The idea behind crossover is that the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents.

The various crossover techniques are discussed in the following section.

a) Single Point Crossover:

This is the traditional crossover [6] technique for genetic algorithm. In this technique both mating chromosomes are split at a randomly selected crossover point and the section after the split exchanged. A new offspring is created by appending the first part of the first parent with the second part of the second parent.

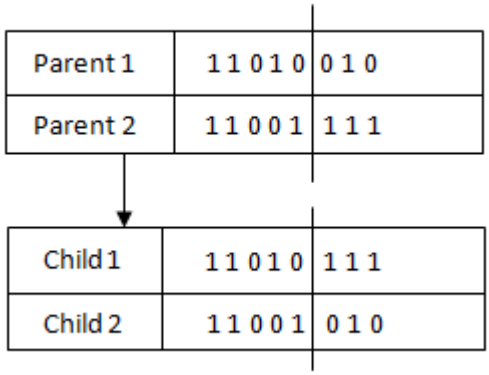

Figure 2 Single Point Crossover [6]

b) Two Point Crossover:

More than one cut point [6] can be involved to create a new offspring in mating pool. But the performance can be reduced by adding more cut points. However, an advantage of having more crossover points is that the problem space may be searched more intensely. In two point crossover, two crossover points are chosen in two mated parents and the content between these points are exchanged to generate the next generation children.

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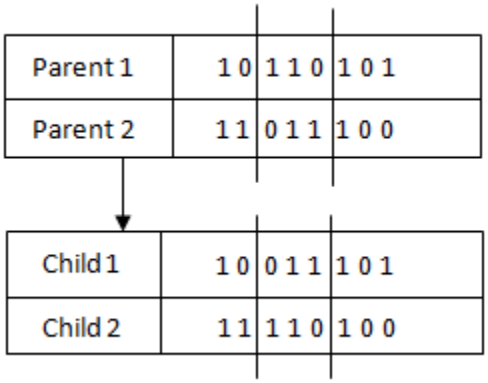

Figure 3 Two Point Crossover [6]

c) Uniform Crossover:

In uniform Crossover [3] a random generated binary crossover mask having the same length as the parent chromosome is taken. The offspring is created by copying the gene from one or the other parent chromosome according to the mask. If there is 1 in the crossover mask, the gene is copied from the first chromosome and if there is 0 in the crossover mask the gene is copied from the second parent chromosome.

Parent 1	1 0 1 1 0 1 0 1
Parent 2	1 1 0 1 1 1 0 0
Mask	1 1 0 1 0 1 1 0
Child 1	1 0 0 1 1 1 0 0
Child 2	1 1 1 1 0 1 0 1

Figure 4 Uniform Crossover [3]

d) Three Parents Crossover:

In this technique three parent [6] chromosomes are chosen randomly. The child chromosome is the combination of the parents. The gene from the parent chromosome is taken in such a way that each bit from first parent is matched with the bit of the second parent. If the bits are same, it is taken for the child otherwise the bit from the third parent is chosen for the offspring.

Parent 1	1 0 1 1 0 1 0 1
Parent 2	1 1 0 1 1 1 0 0
Parent 3	1 1 0 1 0 1 1 0
Child	1 1 0 1 0 1 0 0

Figure 5 Three Parent Crossover [6]

Purposed System:

e) N bit Right Shift Crossover:

A new crossover technique is proposed in this paper which is based on the concept of right shift. In this technique two parent chromosomes are taken randomly. The last n bits from both the parents are right shifted where n is a random no. The shifted bits of the second parent are appended to the left of the first parent to generate a new offspring and the shifted bits from the first parent are appended to the left of the second parent to generate another child.

Parent 1	1 1 0 1 0 0 1 1
Parent 2	1 0 1 1 0 1 0 0

After 3 bit right shift

Parent 1	_ _ _ 1 1 0 1 0	0 1 1
Parent 2	_ _ _ 1 0 1 1 0	1 0 0

Shifted Bits

After appending the shifted bits to the left of the parent chromosomes the child chromosomes are generated.

Child 1	1 0 0 1 1 0 1 0
Child 2	0 1 1 1 0 1 1 0

Figure 6 n bit Right Shift Crossover

2 Mutation Operator:

In mutation each gene of a solution is altered with a probability p which is called mutation probability [5, 6]. The crossover operation results into offspring from which two children are taken later for mutation operation in the end step for production of new generation.

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The operator mentioned earlier changes the bit values at some selected locations in a chromosome. The genetic variety in a population is the factor used in mutation operator to increase the ability of the genetic algorithm to find the best solution. This is required so that the overall solution space is utilized in the search to give optimal solutions. As loss of genetic material is prevented in mutation so it can end as an insurance policy.

Mutation prevents the trapping of an algorithm in local minima. Mutation provides various forms for various representations. In binary representation, simple mutation can be done by inverting the value of each gene with a small probability. 1/L is the probability usually taken, where L is the length of the chromosome.

The different techniques for the mutation are given below.

a) Flipping:

In this technique [6] a parent chromosome is taken and a mutation chromosome is generated randomly. To create a child chromosome the parent chromosome's bit are changed according to the mutation chromosome. For a 1 in the mutation chromosome the corresponding bit from the parent chromosome is flipped from 1 to 0 or vice versa.

Parent	1 1 0 1 0 1 0 1
Mutation Ch romosome	1 0 0 0 1 0 0 1
Child	0 1 0 1 1 1 0 0

Figure 7 Mutation Flipping [6]

b) Interchanging:

In this technique [6] two random positions in the parent chromosome are chosen randomly and the bits on the particular position are interchanged.

Parent	1 **1** 0 1 0 **1** 0 1
Child	1 **0** 0 1 0 **0** 0 1

Figure 8 Interchanging [6]

c) Reversing:

In this method [6] a random position in the parent chromosome is chosen and the bits after that position are reversed to produce a child chromosome.

Parent	1 1 0 1 0 | 0 0 1
Child	1 1 0 1 0 | 1 0 0

Figure 9 Reversing [6]

Proposed System:

d) Complements mutation:

A new mutation technique is proposed in this paper based on the 2's complement concept of basic electronics. As to get the 2's complement of an integer, the no is converted to binary then the digits are inverted and one is added to the result. Using the same concept a child can be muted from the parent chromosome.

In this technique the binary form of the parent is inverted by changing the bits from 1 to 0 and 0 to 1. And 1 is added to the result to generate the child offspring.

Parent	0 1 0 1 0 0 1 1
Inverted	1 0 1 0 1 1 0 0
	+ 1
Child	1 0 1 0 1 1 0 1

Figure 10 Complements Mutation

FUTURE SCOPE

In this paper new techniques for both crossover and mutation operator are proposed. The future scope is to implement these proposed systems practically and to test the operators by a number of test functions with various level of difficulty. The proposed systems will be tested with the probability parameter to check how often the crossover is performed in the case of n bit right shift crossover and how often the chromosomes are muted in the case of complements mutation.

CONCLUSION

In this paper the existing operators for the crossover and mutation are discussed and some new techniques are also proposed. The performance of different adaptive genetic algorithm operators varies on different functions.

As the genetic operator is a process used in genetic algorithm to maintain the genetic diversity. The main motive to write this paper is to provide a variety of

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crossover and mutation operators so that best technique is used for the evaluation process of a chromosome.

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