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ISSN : 2348 - 5612 | Volume : 04 , Issue : 05 | July - September 2017

Study of Basic Principles Of Genetic Algorithms

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ISSN : 2348-5612 © URR

ABSTRACT: Genetic Algorithms were developed scientist John Holland based on the theory of natural selection which takes population of 'solutions' and use these solutions to multiply and take the best characteristics of their predecessors. Fitness value of thus produced progeny is calculated and further breeding is done for millions of generations and the best offspring can be selected as the solution to the problem i.e. timetable optimization, CPU scheduling etc. This paper reviews the genetic algorithm its benefits, applications and various steps need to be applied to use genetic algorithm or problem solving.

Keywords: *Genetic Algorithms, Fitness, Crossover, Optimizations*

I. INTRODUCTION

GA developed by John Holland's in 1960 and further studied by De Jong's, Goldberg, Davis, Koza, Mitchell, an many more, have been proposed as a general model of adaptive processes. John Holland's book "Adaptation in natural and artificial systems" as well as De Jong's book ,"Adaptation of the behaviour of a class of genetic adaptive systems," are seen as the foundation of Genetic Algorithms. Genetic algorithms are stochastic algorithms which are based on natural phenomenon. A genetic algorithm is an optimization tool used to solve optimization problems. Optimization problems attempt to find the best solution for a given problem that has several parameters with associated constraints. Genetic Algorithms are based on the evolutionary ideas of natural selection and genetics. Genetic algorithms are a part of evolutionary computing, inspired by Darwin's theory of evolution -"Survival of the fittest". Genetic Algorithms is an optimization technique which takes large, potentially huge population and finds optimal solution. Genetic algorithms are based on the concept of biological evolution [5].The interaction between genetic algorithms and the real problems are due to the need for optimization. It usually has a space of very large dimensions, in which each point represents a potential solution to the problem. In this world of solutions, only a few, if not only one, fully satisfy the list of constraints that give shape to the problem. The main theme of GA is robustness i.e. the balance between the efficiency and efficacy which is necessary for survival in different environments.

GA are among several types of optimization methods that use a stochastic approach to randomly search for good solutions to a specified problem, including Simulated Annealing, Hill Climbing and numerous variations. It gives better results than various traditional methods. GA belongs to the class of probabilistic algorithms. GA is more robust than various existing search methods. Genetic Algorithms are adaptive methods which may be used to solve search and optimization problems [3]. They are based on the genetic processes of biological evolution. GA is a powerful technique in optimization problem problems. GA is a search algorithm based on a simple idea from biology "Survival of the Fittest". They have been used for many different applications including scheduling, predicting the stock market and creating the art etc. Genetic Algorithms start with an initial random population, and subsequently allocate more trials to regions of the search space and found to have high fitness. GA can be combined with hill-climbing techniques to speed up the search process, but are able to 'jump' from local maxima because the elements that promote a good solution are being mixed up in subsequent iterations.

Goldberg (1989) presents four fundamental characteristic that differ GA from other traditional optimization and search procedures [2]. These characteristics are:

1) GA works with encoding of the parameter set, not the parameters themselves: GA require natural parameter set to be coded as finite length of strings. Coding can be done in several ways.
2) GA searches from a population of points, not from a single point: In many optimization methods, we move from single point to next in space using some transition rule to find the next point. This point to point method may locate false peaks in multimodal search spaces. But GA works from a rich database of points simultaneously, climbing many peaks in parallel. Thus probability of finding false peak reduces.

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Figure 8: Uniform crossover example

Mutation: After crossover mutation takes place. Mutation plays a secondary role in the operation of GA. Mutation is needed as it prevents loss of diversity at a given bit position. Mutation is a random searching through the string space. Mutation has a very little effect. Mutation occurs according to the mutation probability; usually set to low value i.e. 0.01. If mutation probability is kept high then chances for losing the main characteristics of chromosomes become high. Mutation changes one or two gene values from the chromosome by many ways [8]. Some are listed below.

1. Bit Inversion: In this mutation operator simply inverts the value of the chosen gene i.e. from 0 to 1 or 1 to 0. Figure 9 shows bit inversion.

Offspring	11011 00100 110110
Mutated Offspring	11010 00100 100110

Figure 9: Bit Inversion Mutation operator example

2. Order Changing: In this mutation operator, two allele positions are selected from chromosomes and the values of these two positions are interchanged to get the new mutated offspring. In the figure given below, values of 2nd and 5th positions are interchanged. Figure 10 shows order changing.

Offspring	154672893
Mutated Offspring	124675893

Figure 10: Order Changing Mutation operator example

After having genetic action on the selected chromosomes, the fitness for each member will be recalculated after all the genes have been mutated. The population members are then ordered according to their fitness. The best members of the old population may be added to the new population in some algorithms, unless the best members of the old population are not as good as the worst members of the new population.

IV. BENEFITS OF GA

Some benefits of using GA are listed below:

i) Concept is easy to understand and Modular–separate from application (representation); building blocks can be used in hybrid applications.
ii) Supports multi-objective optimization
iii) Good for “noisy” environment
iv) Always results in an answer, which becomes better and better with time
v) Can easily run in parallel
vi) The fitness function can be changed from iteration to iteration, which allows incorporating new data in the model if it becomes available [10].

V. APPLICATIONS OF GA

Genetic Algorithm can be used to solve both unconstrained and constrained problems. Thus it can be used to solve various optimization problems. By applying the Genetic Algorithm to linear and nonlinear programming problems it is possible to solve typical problems. Another area where Genetic Algorithms can be applied are combinatorial optimization problems. Genetic algorithms can be used in various areas [9]. Some more potential applications include:

1) Optimization– numerical and combinatorial optimization problems, e.g. travelling salesman, routing, graph colouring and partitioning and job scheduling problems.
2) Robotics– trajectory planning
3) Machine learning– designing neural networks, classification and prediction, e.g. prediction of weather or protein structure
4) Signal processing– filter design
5) Design– semiconductor layout, aircraft design, communication networks
6) Automatic programming– evolve computer programs for specific tasks, design cellular automata and sorting networks
7) Economics– development of bidding strategies, emergence of economics markets
8) Ecology– model symbiosis, resource flow
9) Biology and medicines- Construct antibodies, model somatic mutations

VI. CONCLUSION

GA has effective ability to solve complex optimization problems. Genetic Algorithm can be applied to many other applications in Engineering and other fields. Genetic algorithms can be used as a good optimization tool. Here we reviewed application of GA to various areas of Robotics, Machine learning, semiconductor layout, aircraft design, communication networks, Automatic programming etc.

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