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Variants of Genetic Algorithm and Its Application to Mechanical Engineering: A Review

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Abstract: **In this paper, we present the use of Genetic Algorithm (GA) and it's variants for the various field of the Mechanical engineering & other engineering discipline. Genetic algorithm is method for optimization based on the mechanics on the natural selection and the natural genetics. It means, it works on the principle of natural selection and natural genetics to comprise search and optimization process. The genetic algorithm based heuristic is easily parallelizable, one of its important attribute to be investigated in the near future. GA has many variants like – "Real coded GA, Binary coded GA, Least mean square GA, Saw-tooth GA, Differential Evolution GA". This review paper discusses a few of the forms of GA and applies the Function optimization and System Identification and the application and limitations.**

Keywords: **Genetic algorithm, Optimization, Variant of GA.**

1. INTRODUCTION

Genetic algorithm have a wide range of a global optimization process. [1] The genetic algorithm is built on by John Holland and his collaborators in 1960-70. Genetic algorithm is a research and optimization approach depend on the principle of the natural genetics and selection. [2] Genetic algorithm are used to solve multi-optionality problems of the optimization in the mechanical engineering, where optionality function and constraints are defined as terms of decision variables using the different models. GA is motivated by the Charles Darwin theory of the evolution – "survival of the fittest" [1]. GA is a deterministic method which is guarantee for the optimization determination. Genetic algorithms are mostly used to find high-quality solutions to optimization and search problems by relying on bio-inspired operators such as selection, mutation, and crossover.

Many real life problems from the fields of engineering applied science, and management science are generated as a non-linear optimization problem. These problem are very difficult to solve using traditional optimization methods because of their non-continuous, non-linearity, non-smooth and non-differentiable [3].These problems are solved by the Constructive algorithm heuristic, greedy algorithm, genetic algorithm, Dspur algorithm etc. Constructive algorithm and Dspur algorithm is part & expansion of greedy algorithm, where greedy algorithm have a main disadvantage is that it is not give always optimal solution in all local and global problem. Hence, genetic algorithm is used for solution and it have parts of selection, crossover and mutation. Since then many variants of genetic algorithm are developed and uses to an optimization problem [4].

2. GENETIC ALGORITHM

Genetic algorithm is popular heuristic for solving the optimization problem. It fits in the evolutionary algorithm [5]. GA are search algorithms that based on the natural selection and natural genetics. GA does not guarantee for give optimal solution will found, but it gives a good result [6]. GA have the terms like selection or the generation techniques, crossover and mutation or simulation operator. This operations creates a loop as shown in the figure.

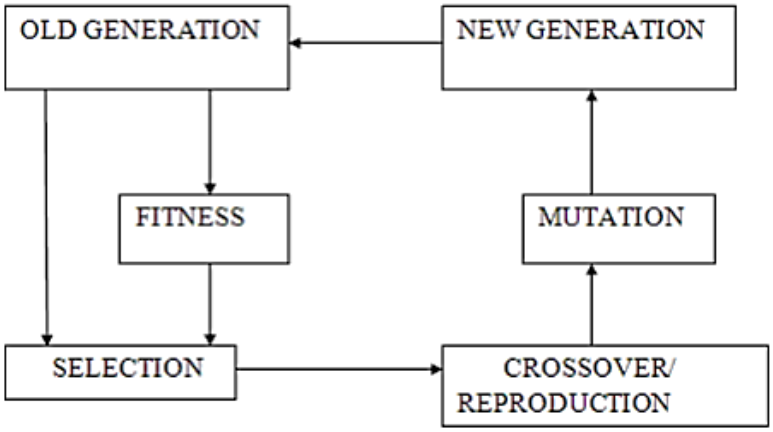

Fig. 1: Genetic loop

As per figure genetic algorithms is start with the set of solutions called as generation or chromosome. Then the solution are go ahead as a selection best solution of them and after mutation it gives optimal solution. Here selection, crossover, mutation are known as the genetic operators.

Selection: Mechanism for selecting the good solution as per their fitness. Fitness is the optimality of the function.

Crossover: crossover is merging the two individual's information [11]. The effectiveness of the crossover is depended on the phenotype and genotype.

Mutation: Mutation is changes the chromosomes or other deformations genes [11]. Mutation is used to maintain genetic diversity from one generation population to the next.

After completing these all operators as per loop chromosome comes close to the optimal solution and further the loop is started. After many iterations optimal solution is given out by this genetic algorithm. This number of iteration is depend on the fitness of the chromosome which selected and the robustness of the solution. Here fitness of the selected chromosome and the robustness is inversely & directly proposal to the number of iteration respectively. The vocabulary genetic algorithm to engineering as below [2].

Genetic algorithm	Explanation
Chromosome(individual)	Solution
Genes	Part of solution
Phenotype	Decoded solution
Genotype	Encoded solution

Advantage of genetic algorithm over usual optimization heuristic are as the ability to deal with the complex functions and parallelism. Genetic algorithm is solve the problems which objective function is stationary or non-stationary, linear or non-linear, continuous or non-continuous and also for non-differentiable [4]. Because chromosome in population act like independent variable, so population may go in many direction simultaneously. This characteristic include parallelize feature in the algorithm for optimization.

However, Genetic algorithm have some disadvantages. The formulation of the fitness function, use of population size, rate of mutation and crossover and the selection criteria of the population taken out carefully. Any inappropriate choice will make it difficult for the algorithm or it will be become a meaningless [4].

Application of genetic algorithm are as use in solving the problem of distributing a plant or facility [2]. Flow shop sequencing problem or assembly line problem are optimized by genetic algorithm and also use for the designing the suspension system of automobile [2].genetic algorithm uses for determination of the cutting parameters in machining operations is proposed [7]. Flywheel design and development has control in many application where minimizing mass is critical, so genetic approach is used [9].the stability of cutting tool is depend on the cutting force, so for reducing the cutting force genetic heuristic is used [8].

3. VARIANTS OF GENETIC ALGORITHM

3.1 Real coded genetic algorithm:

In this algorithm, the chromosome must be remain same length for the optimization solution of the problem. It is the expansion of the binary coded genetic algorithm, so it have many advantages on the counterpart of the binary coded genetic algorithm when it have a large quantity to search[2,6]. Here, algorithm works with the large quantity domains so it sacrifices precision as the binary genetic algorithm. As well as the same size of chromosome is not possible in all problems like – circular cutting, distribution of resources. Further, RCGA increase the capacity of local tunning, so the knowldge of the domain problem is increase. Hence performance of genetic algorithm is increase.

3.2 Binary coded genetic algorithm:

The binary coded genetic algorithm is repeatively alternation a set (individual or population) of a matematical form, each with a related fittest value. Into the new generation as per darwinian theorem, fittest value and robustness of old generation are may be seen. This algorithm need to solve with very carefully, because it have repeatively steep of mathematical model and this heuristic is difficult to solve long and different algorithm - like in problem have some differentiable chromosome and some non-linear then problem is difficult.

3.3 Differential algorithm:

Differential algorithm is replace the crossover and mutation technique of genetic algorithm by alternative differential operators. It has ability to solve non-differentiable and nonlinear and multimodal cost functions. Differential algorithm ease of use, i.e. few control variables to steer the minimization. These variables should also be robust and easy to choose [10]. But there is Parameter tuning of necessary. Same parameters may not guarantee the global optimum solution [10].

3.4 Least mean square algorithm:

Least mean square (LMS) algorithm, also known as the delta rule or the Widrow-HofSrule (Widrow and Hoff, 1960). LMS are used convenient filters to find the co-efficient that interact to producing the least mean squares of the error signal (difference between the actual value and desired value) [2]. The LMS algorithm has set up itself as an important functional block of convenient signal [6]. It provides some highly desirable features like Simplicity of functions and ability to operate satisfactorily in an unknown environment so robustness is increase.

3.5 Saw-tooth genetic algorithm:

In the method, take a variable population size with periodic initialization is used that follows a saw-tooth scheme with a specific amplitude and period of variation. In each period, the population size decreases linearly and at the beginning of the next period randomly generated individuals are appended to the population [6].

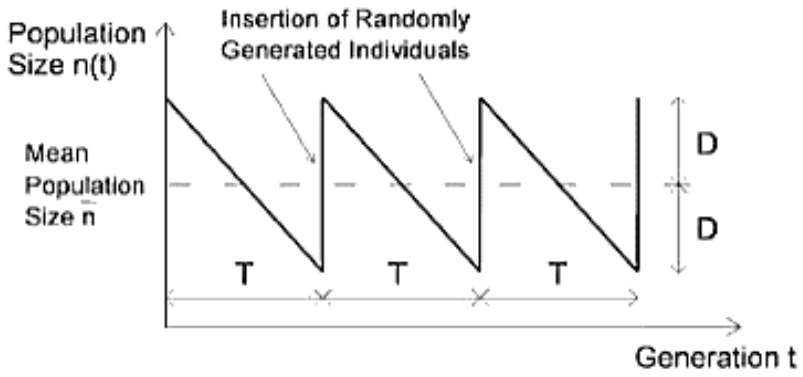

Fig. 2 : Variable population of the saw-tooth GA

4. LITERATURE REVIEW

Ms.Trupti Bhoskar, Mr. Omkar K Kulkarni[1] reviewed the genetic algorithm and the variants of the genetic algorithm and application of the genetic algorithm in mechanical engineering.

Mohammad Zahid Rayaz Khan , Dr. A K Bajpai [2] reviewed the variant of the genetic algorithms with its operators, also reviewed the need, benefits and application of the genetic algorithm in mechanical engineering

B.A. Sawyerr , A.O. Adewumi , M.M. Ali [3] investigated the brief in real coded genetic algorithm using 30 test problems . also includes the random local search in genetic algorithm improves the genetic algorithm improves the quality of genetic algorithm.

Xin-She [4] reviewed the genetic algorithm, role of genetic algorithm and variants of genetic algorithm.

Mhand Hifi, Rym M'Hallah [5], investigate about the algorithms are used about the circular cutting problem by constraints and genetic algorithms heuristic. They conclude that the best heuristic for circular cutting with respect to time. The use of parallel approaches will increase the size of the problem that can be solved.

Rakesh Kumar Patnaik [6] reviewed about the genetic algorithms and variant of genetics algorithms LMS gives the better result than the binary algorithm. Each variable investigated by differential method and real coded genetic algorithm.

Doriana M. , Roberto Teti [7] investigate the GA based optimization of turning parameters and find out the capability of performed multi-object optimization, minimum machining time while considering technological and material constrains.

MOuleeswaran senthil Kumar, Yogesh Kumar [9] investigate the optimization is carried out to find out the minimum mass and respective values of the radius and angular velocity.

Mahamad Nabab Alam [10] researched about the genetic algorithm coding system MATLAB codes discussed here can be extended to solve any type of optimization problem of any size.

Sharapov R.R [11] reviewed about to basic ideas of the genetic algorithm and also about the variants of the genetic algorithm. After analysis about the variation of the genetic algorithm with evolutionary and real coded genetic algorithm. They also reviewed about the fuzzy genetic algorithms with neutral network and natural genetics.

5. CONCLUSION

Genetic algorithm are applicable to mechanical engineering as very large range of problem from optimization problem like shop scheduling to various applications in material science and manufacturing. This is very easy to implement in every real problems. It has own advantages and disadvantages as explained above. GA gives every solution as compare to other algorithms. Every variants of the GA is gives the better performance than GA because of some govern technique. But from in all variant (explained above) LMS algorithm is easy to solve problem because of its linear form calculation and ability of set up of functions.

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