Optimization of Rosenbrock function usingGenetic Algorithm

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Abstract—Nowadays, Optimization is the most interesting problems to be studied. It is a process of selecting the best alternative among a given set of options. In the past few decades, a lot of optimization algorithms came into existence to solve NP Hard problems. Genetic Algorithm is one of thepopulations based meta-heuristic to solve such problems. Different benchmark functions are available to test the performance ofoptimization algorithms. Rosenbrock function is a popular test problem for optimization based algorithms. This paper presents experimental results on optimization of Rosenbrock function used for performance evaluation of Genetic Algorithm.
Keywords: Genetic Algorithm, Optimization, Rosenbrock Function.

1. Introduction

Optimization is a very common process that forms an essential part of our day-to-day life. Optimization techniques are being extensively used in various fields of human activities.It is the fascinating problem which can be studied under Artificial Intelligence. Optimization problems are those that have an objective function which has to be either minimized or maximized subject to constraints depending on the problem [5]. To solve these hard optimization problems, different approaches are used. Genetic Algorithm is the most popular meta-heuristics used to solve optimization problems. Genetic Algorithm is a meta-heuristic algorithm that uses the concept of genetics and natural selection. It is one of the oldest and most successful optimization techniques. GA has wide range of applications to solve optimization problems such as Travelling Salesman Problem, Scheduling Problems, Image Processing,Vehicle Routing Problem, Machine Learning, etc.

The paper is organized in following sections: In section 2, Genetic Algorithm is discussed in detail with all the phases and steps. In section 3, literature review is given based on the views of different researchers. Section 4 presents fitness function. In section 5, Rosenbrock function is described.Experimental Results are specified in section 6. At last,Conclusion is given in section 7.

2. Genetic Algorithm

GA is the search technique based on some evolutionary ideas of natural selection and genetics [7]. GA is a metaheuristic search algorithm that belongs to evolutionary algorithm. It mimics the idea of 'survival of the fittest'. It was presented and introduced by John Holland in early 1970s [3]. Genetic Algorithm can be treated as a local search method that is used to generate extremely better solutions for combinatorial optimization problems. It is inspired from biological evolution of living beings and its terms have been obtained from the basic concepts of genetics. Genetic Algorithm is an approach to solve hard optimization problems which can be represented as a hereditary process in biology. It abstracts the problem space as a population of individuals, and tries to explore the fittest individual by producing generations iteratively [2]. It can be treated as an efficient method which can find a global optimal solution for different kinds of problems.

A. Phases of Genetic Algorithm are:

Initialization: Initial population of randomly initialized strings are generated. Each chromosome in GA includes many genes, which specify their traits. Fitness Function: It is a function that prescribes the optimality of a solution. It is also known as evaluation function. It takes the input and produces the solution as the output. It accesses the optimality of a solution by checking the closeness of given solution to the optimal solution of a problem. Additionally, it tests the solution based on the fitness score given to each individual.

Selection: Based on the fitness values given, the best individuals are selected as parents. It is inspired by the principle of "Survival of the fittest". Selected parents will mate and recombine to create offspring for the next generation. The basicobjective of this phase is to focus on the best solution and discards the worst solution where the population size should remain constant. "Select the best and discards the rest."

Crossover: It is the most significant phase of genetic algorithm. It is inspired by mating between individuals in biology. One or more crossover sites are chosen randomly, and then the genes of individuals are exchanged to create a new offspring. The whole process continues till a solution is not generated of appropriate size. In the next generation, chromosomes will be generated which are far better than the previous generation chromosomes.

Mutation: It is local modifications to the new generations randomly. It is typically the standard method of introducing new genetic material into the population. It can be performed by inserting new genes in offspring or flipping the existing ones. Mutation makes it possible to maintain the random aspect in the evolution of population to preserve the population diversity and to avoid premature convergence.

B. Steps of Genetic Algorithm:

Step 1: Start
Step 2: Generate initial random population
Step 3: Calculate fitness of each individuals
Step 4: Is termination condition satisfied? If yes goto end, ifno goto step 5
Step 5: Select the best individual based on fitness value
Step 6: Apply crossover operator on selected individual
Step 7: Apply mutation operator by flipping genes
Step 8: Generate a new population
Step 9: End

The Genetic algorithm is a highly adaptive heuristic search approaches which is based on population genetics [3]. This algorithm can generate global optimum solution if it is given a well-defined problem with enough time. Various combinatorial problems such as Path Planning, Travelling Salesman Problem, Vehicle Routing Problem, Image Processing, Network Routing Protocol, Gaming, etc. have been solved well using Genetic Algorithm concept.

3. Related Work

Maria Garcia et al [4] discussed the future of optimization technology to solve combinatorial optimization problems. There can also be a concept of multi objective formulations for complex optimization problems. Advantages and disadvantages of various metaheuristic approaches and hybridization ofmetaheuristics with other optimization methods are discussed by **Christian Blum et al. [1].** The introductory approach of Genetic Algorithm explains various different applications also explain the integration of OOA i.e. object oriented approaches with GA are described by **Manoj Kumar et al [3].** Genetic Algorithms are quite useful in various artificial intelligence approaches as

well as varieties ofbasic approaches like object oriented, robotics and other [3]. GA basic flow is discussed and the process included in GA is also described in detail. **Haldurai [2]** discussed that to obtain the optimal solution of a problem; Genetic Algorithm is combined with other optimization methods. **Seng Poh Lim et al [8]**compare the performance of different Benchmark functions using various techniques applied in Genetic Algorithm**. Kapil et al. [6]** uses the genetic algorithm concept to improve the performance of the Dejong function 2 under different selection schemes. Rosenbrock function is minimized by **Rajaa Salih et al. [9]** based on the fitness function using Genetic Algorithm concept.

4. Fitness Function

Fitness function is also called as Evaluation function. It accesses the optimality of a solution by checking the closeness of given solution to the optimal solution of a problem. It decides whether a solution is fit for a particular problem or not. In Genetic Algorithm, chromosomes are formed by combining the string of binary or real numbers known as genes. To come up with the best set of solutions, to solve a givenproblem, a score is provided to each solution called as fitness score. Fitness function is applied to produce the fitness score for testing the performance of a solution. Fitness function describes how fit or how good the good solution.

5. Rosenbrock Function

The Rosenbrock function also known as the Banana function or Valley. It is one the famous function which test the performance of gradient-based optimization algorithms [6]. It can be treated as a unimodal function and its global minimum occur in a narrow, parabolic valley. The mathematical model having some problem to identify the valley is trivial & for solving these techniques, convergence of the problem is required [6]. Since, convergence of a problem to a global optimal solution is a difficult task. Therefore, Rosenbrock function is used to evaluate the performance of optimization problems.

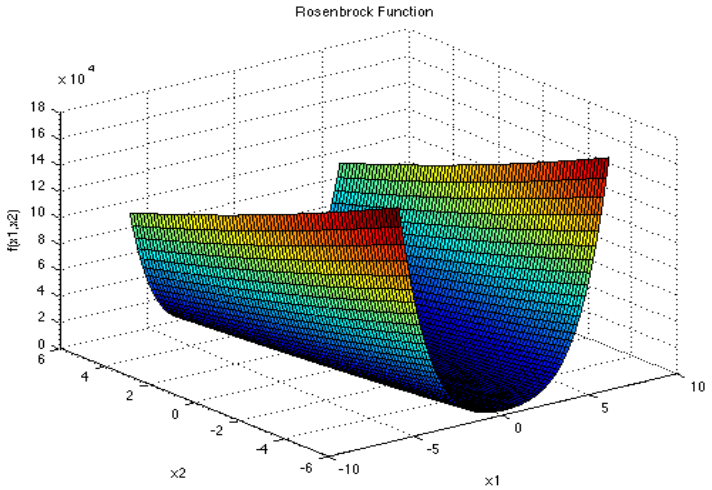

Fig. 1. Rosenbrock function

Mathematical definition:

$$f(x,y) = \sum [b(x_{i+1} - x_i^2)^2 + (a - x_i)^2]$$

$$-2.048 <= x_i <= 2.048$$

The parameters a and b are constants and are generally set toa=1 and b=100.

6. Experimental Results

In this paper, python is used to implement the performance of Rosenbrock function using Genetic Algorithm. Genetic Algorithm uses five phases to implement the code: Initialization, Fitness Evaluation, Selection, Crossover and Mutation.

Parameter	**Value**
Encoding	Real Encoding
Fitness Function	Rosenbrock function
Selection	Roulette wheel selection
Crossover Probability	0.8
Mutation Probability	0.01
Population Size	10

TABLE I: PARAMETER SETTINGS

Number of Iterations	**Fitness Function F(x)**
30	1578
60	979
100	693
150	285
200	356
250	197
300	451
350	346
400	451
450	349
500	451
550	451
600	271

Table-II
Iteration Analysis of Rosenbrock function

In initialization phase, initial population is generated using random chosen chromosomes. Rosenbrock function is selected to calculate the fitness score of each individual. Based on these scores, best parents are chosen using Roulette Wheel in initialization phase, initial population is generated using random chosen chromosomes. In initialization phase, initial population is generated using random chosen chromosomes. Rosenbrock function is selected to calculate the fitness score of each individual. Based on these scores, best parents are chosen using Roulette wheel selection. To perform the crossover, arithmetic crossover is used where the crossover probability is taken as 0.8. At last, mutation is applied with mutation probability 0.01. Finally, old population is replaced with the new population. Then, all the phases are applied in next generation. The whole process continues until a termination condition is not met.

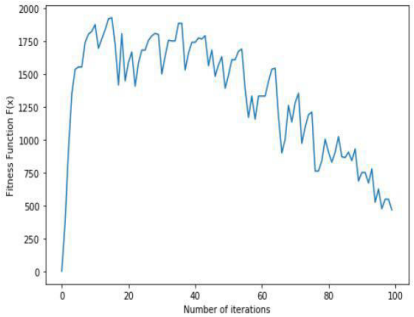

Fig. 2. Simulation of Rosenbrock Function

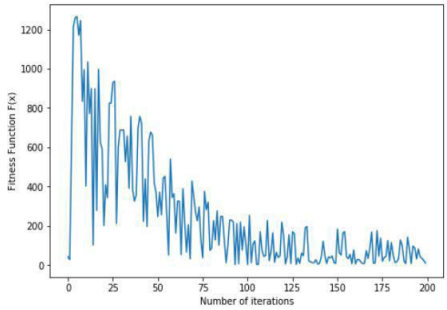

Fig. 3. Simulation of Rosenbrock Function

Rosenbrock function has been implemented to perform the optimization. The results obtained are shown in Fig.2 and Fig.3 for 100 and 200 iterations respectively.

7. Conclusion

In this paper, the optimization of Rosenbrock function is performed using Genetic Algorithm. The work is about the implementation of phases of Genetic Algorithm using Dejong function 2 as the fitness function. It is observed that as the number of iterations increase, values of fitness function decrease. Based on the findings, Genetic Algorithm has been proved to provide optimal results in the optimizationproblems. So, as to achieve better performance of Genetic Algorithm, other optimization techniques can be used and tested using different Benchmark functions. In future, other Dejong functions can be implemented and their results can be compared and analysed.

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