10.48047/jocaaa.2024.33.08.74

IMPACT OF FITNESS SCALING FUNCTIONS ON A BASIC GENETIC ALGORITHM

Suman Rani[1], Pushpa Yadav[2], Sarita Kumari[3], Mohit Sharma[4]
[1]*M.Tech Student Yaduvanshi College of Engg & Tech., IGU, Meerpur (Haryana)*
[2]*Assistant Prof. Yaduvanshi College of Engg & Tech, IGU, Meerpur (Haryana)*
[3]*Assistant Prof. RPSCET, IGU, Meerpur (Haryana)*
[4]*Assistant Prof. RPSCET, IGU, Meerpur (Haryana)*

***Abstract*- One of the heuristic search and optimization strategies still in use today is the genetic algorithm. The task of minimizing or maximizing the function with several variables while adhering to equality or inequality limitations is known as optimization. However, we utilize fitness scaling functions with GA to achieve better optimal outcomes. We can examine different types of fitness scaling functions in this study and attempt to figure out which one is most appropriate for each application.**

Keywords-Genetic algorithm (GA), Fitness function, Fitness scaling, premature convergence, Mutation, Crossover, Selection.

` 1.INTRODUCTION

Today, GA is the most widely used search algorithm. It shows the greatest results when combined with other types of functions and other local or global search methods, such as fitness functions, fitness scaling functions, hill climbing, and other stochastic methods. In the realm of computation and search issues, it can offer the most accurate solution, or as we might say, the actual solution. For that reason, it belongs to the category of global methods of optimization. It is a type of evolutionary algorithm that may search using crossover, mutation, inheritance, selection, and more.

The best chromosomes from the initial population can be chosen by a selection process, and these chosen chromosomes can create intermediate populations. Some chromosomes are chosen many than once, while others are not chosen based on their relative fitness. The most popular kind of selection is roulette wheel selection. After that, crossover is done to the chosen chromosomes, which may result in a new population with higher efficiency and fitness than the original stage. Crossover is not always required since, depending on their predetermined probability, parents can occasionally be directly passed down from one generation to the next. There is a 60–70% chance that the crossover will be applicable. This new population is then subjected to mutation, which either modifies it by a tiny amount or substitutes a new value for it.

In each iteration, new population is used and same process is repeated until the maximum generation is achieved or the fitness value is derived. In this paper we just focus on fitness scaling functions, how they affect the searching of GA and how much extent they affect the output. Various kind of fitness scaling functions is there like linear scaling, power scaling, sigma truncation scaling, exponential scaling. Here we first check that where to apply fitness scaling and then check and compare output produced by using each type of fitness scaling and their accuracy.

10.48047/jocaaa.2024.33.08.74

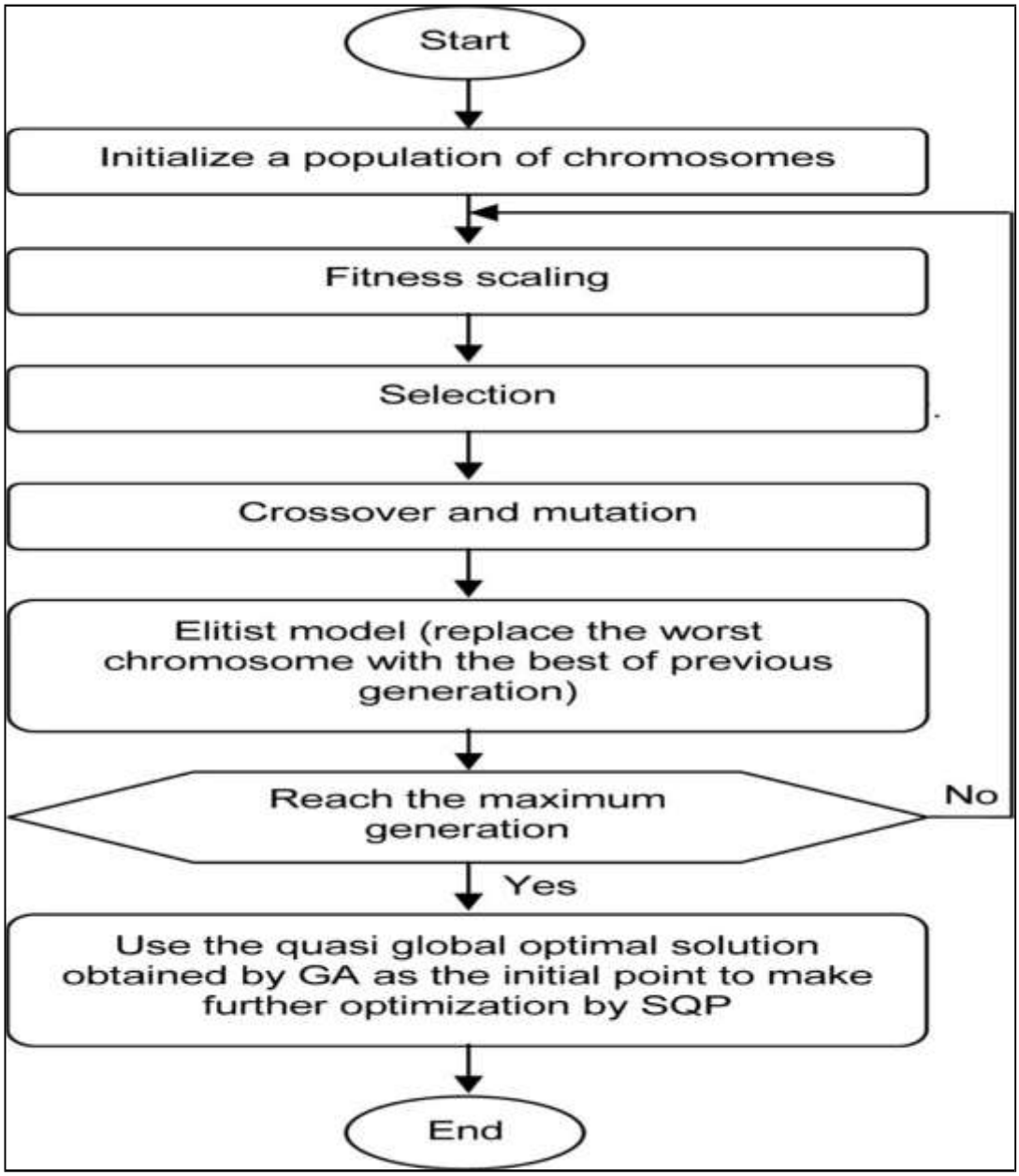

Fig. 1 Genetic Algorithm with Scaling Flowchart

Here Fig. 1 describes that the scaling can be applied at the initial stage of genetic algorithm and which can effectively enhance the results of simple genetic algorithm and gently reduce the problem of premature convergence. After applying fitness scaling the selection, crossover and mutation applied on the resultant population which can provide much optimized results as compared to simple GA.

I. FITNESS SCALING

It is a technique which can be applied at initial stage of evolution and can highly affect the searching results. It can help to generate more optimized results or we can say fittest population by eliminating premature convergence.

A. Advantages And Types of Fitness Scaling

Fitness scaling converts the raw fitness scores that are returned by the relative fitness function to their values in a that range that is suitable for the selection function. One of the problems with GA is premature convergence which can be somehow reduced by fitness scaling. By using scaling the GA can select only the highly scaled

10.48047/jocaaa.2024.33.08.74

values to the next generation which can helps to compare

the results between good result and best result.

There are numerous fitness scaling methods. Various kind of obstacle that are faces during deriving the fittest output. To overcome these problems we can scale the value provided by fitness function and after scaling apply that value gently to the fitness function using algorithm. Some of the fitness scaling functions are –

B. Linear scaling, Sigma truncation scaling, Power scaling, Exponential scaling, Linear Rank scaling, Nonlinear rank scaling, Boltzmann scaling, Top scaling, Transformed ranking.

1) *Transform Rank Scaling*-The results of this scaling progress from linear to nonlinear. The results of this scaling can totally improve the quality of search of linear Griewank function and probability nonlinear function of Schwefel function.
2) *Top Scaling*- It is the simplest scaling method. In this method, many of the top best individuals have set their fitness to the same value, while others having set their fitness values to zero. So this method gives several individuals an identical fitness levels, the diversity of the succeeding generations is increased.
3) *Linear Rank Scaling*- In the linear rank scaling, the scaled finesses are distributed based on the rank ordering of the chromosomes from the best fit to the least fit.
4) *Sigma Scaling*-Sigma scaling is a variant of linear scaling method where a single fitness is scaled according to its variation from the mean fitness of the whole population, measured in standard deviations.
5) *Nonlinear Rank Scaling*-This is a nonlinear type of rank scaling that helps in increases the chances of fittest population selection pressure.
6) *Boltzmann Scaling*-Boltzmann scaling is also a nonlinear scaling that uses the idea of a ―temperature (T) that drops slowly from one generation to next generation.
7) *Linear Scaling*-This is a very simple linear relationship between the scaled fitness (*sf*) and raw fitness (*ff*). Kreinovich et al [2] have demonstrated that linear scaling is the most optimal type of scaling, but if and only if optimal scaling parameters are well known.

II. RELATED WORK

There is a lot of research work carried out in the context of fitness scaling function. Some of them are worth discussed here-

Vladik kreinovich, Chris Quintana from university of Texas, can conclude that the performance of the genetic algorithm can be very effected by applying scaling function on it. Paper presented by him can formulate that the problem of choosing any function as a mathematical optimization problem under the various criterion. He can conclude that the different function proves to be best for different criterion [2].

Yan Yi introduced in the fitness scaling genetic algorithm (FSGA) functioning as a heuristic search as the parameter optimization for rule-based classifier. This algorithm i.e. (FSGA) was compared with genetic algorithm(GA),simulated annealing (SA), and ant colony algorithm(ACA), and the results concluded that the proposed FSGA rule-based classifier was the most robust and rapid[13]. Farzad A Sadjadi, conclude that the dynamic optimization can be used by applying it on compacted genetic algorithm (CGA). CGA needs for the fitness scaling. CGA applies on the optimized variable controls the fitness scaling in simple GA. By this the fullest realization can be achieved [1].

HAO Guo-Sheng et al. Concluded in there paper that several kind of problems occur during finding the fitness scaling. They conclude two new kind of scaling techniques during selecting the parameters of the fitness scaling with roulette wheel selection in their research. These two new scaling techniques are logarithm and

trigonometric scaling [5].

Nitin S. Choubey et al. describe that Genetic algorithms are meta-heuristic algorithms and these algorithm are find the most approximated optimum output for NP complete problems. But here also GA suffers from premature convergence. Hybrid approaches provide optimum result because it does not struck in the local optima.

P. Darwen et al. proves that Fitness sharing when used with a scaling function suffers from a serious dilemma. He concluded that for many other problems, the best scaling function is a power function, and applying too much high a power means an individual chromosome is slightly closer to an optimum so it becomes a "super-individual" and drives that other individuals not as close to their optimum. Thus, lower optima are found. Too low a power means that result stay around the optimum because any single individual at the optimum must share with more individuals[12].

Anamika taya in her paper concluded that GA's are well suited for optimization tasks even when the fitness or scaling functions which they map are fairly complicated. This can occur when the optimal point is in a region (area) like a plateau, where all

surrounding points are of very close the same fitness. This type of algorithm will not efficiently perform "hopping" from one point to the other point, if there are multiple peaks available in close proximity. One way to solve this is to scale the fitness values given by the fitness function, and then effectively modifying the fitness function with respect to the algorithm [14].

Hopgood, A. et al. Can discover a new type of scaling which is transform rank scaling. The results of transform rank scaling goes from linear scaling to nonlinear scaling which is highly influence the previous scaling to great extent. The results of this scaling can totally improve the quality of search of linear Griewank function and probability nonlinear function of Schwefel function [15].

III. CONCLUSION

After reading various studies it can be concluded that there is no doubt that fitness scaling plays an essential role in the genetic algorithm optimization. GA's are well suited for optimization tasks even when the fitness or scaling functions which they map are fairly complicated. The comparison of various types of fitness scaling by applying complex function will be done and it will lead to enhancement in the searching which is more optimized than simple scaling functions. Also, the best suitable in given condition and parameters can be find out.

The major motive of this paper is to apply same complex function on different kind of scaling and try to get best minimum and maximum output values which are more optimized. As a result both diversity and stability of the population is maintained. By this we will also try to reduce the limitation of simple genetic algorithm which is premature convergence.

REFERENCES

[1] F. Sadjadi, "Comparison of fitness scaling functions in genetic algorithms with applications to optical processing," in Optical Science and Technology, the SPIE 49th Annual Meeting, 2004, pp. 356–364.

[2] V. Kreinovich, C. Quintana, and O. Fuentes, "Genetic algorithms: what fitness scaling is optimal?," Cybernetics and Systems, vol. 24, no. 1, pp. 9–26, 1993.

[3] J. H. Holland and D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning. Addison-Wesley, Reading, MA, 1989.

[4] M. Zhou, S. D. Sun, "Theory and application of genetic algorithm," presented at National defense press, Beijing, 1996.

[5] G.-S. Hao, Y. Yu-Chen, K.-X. Wei, G. Gong, and X.-T. Hu, "Parameters selection of fitness scaling in genetic algorithm and its application," presented at the 2010 Chinese Control and Decision Conference, 2010, pp. 2475–2480.

[6] L. Nolle, A. Armstrong, A. Hopgood, and A. Ware, "Optimum work roll profile selection in the hot rolling of wide steel strip using computational intelligence," in International Conference on Computational Intelligence, 1999, pp. 435–452.

[7] S. Hill, J. Newell, and C. O'Riordan, "Analysing the effects of combining fitness scaling and inversion in genetic algorithms," presented at the Tools with Artificial Intelligence, 2004. ICTAI 2004. 16th IEEE International Conference on, 2004, pp. 380–387.

[8] J. H. Holland and D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning. Addison-Wesley, Reading, MA, 1989.

[9] S. N. Sivanandam and S. N. Deepa, Introduction to Genetic Algorithms. Springer Science & Business Media, 2007.

[10] N. Surajudeen-Bakinde, X. Zhu, J. Gao, and A. K. Nandi, "Effects of fitness scaling and adaptive parameters

on genetic algorithm based equalization for DS- UWB systems," presented at the Computers and Devices for Communication, 2009. CODEC 2009. 4th International Conference on, 2009, pp. 1–4.

[11] B. Sareni and L. Krahenbuhl, "Fitness sharing and niching methods revisited," IEEE Transactions on Evolutionary Computation, vol. 2, no. 3, pp. 97–106, Sep. 1998.

[12] P. Darwen and X. Yao, "A dilemma for fitness sharing with a scaling function," presented at the Evolutionary Computation, 1995, IEEE International Conference on, 1995, vol. 1, pp. 166-171.

[13] Nitin S. Choubey and Madan U. Kharat ,"Performance Evaluation of Methods for handling Premature Convergence in GA - Case of Grammar Induction," in International Journal of Computer Applications, vol. 79, no. 2, pp. 9-13, Oct. 2013.

[14] Anamika Taya," Performance Improvement of Genetic Algorithm by Fitness Scaling and Diversity Maintenance," in International Journal for Research in Technological Studies, vol. 2, Issue 7, June 2015.

[15] A. A. Hopgood and A. Mierzejewska, "Transform ranking: a new method of fitness scaling in genetic algorithms," in Research and Development in Intelligent Systems XXV, Springer, 2009, pp. 349–354.