A STUDY OF GENETIC, FIREFLY, PARTICLE SWARM OPTIMIZATION ALGORITHMS AND ITS APPLICATIONS

Abstract

Computers are sometimes used to locate a solution when an issue is vast or difficult to solve. But when the issue grows too big, conventional approaches to solving it might not be sufficient. The solution to such challenging difficulties can be found by looking to environment for inspiration. Artificial intelligence attempts to imitate natural phenomena and processes by turning their methods for problem-solving into algorithms. Although many of these metaheuristic algorithms have been created, the search for quicker, more efficient algorithms is ongoing. In this paper, the basics and applications of genetic, firefly, and particle swarm optimization algorithms are included.

Keywords: Genetic Algorithm, Firefly Algorithm, Optical Swarm Optimization Algorithm (PSO), Travelling Salesman Problem (TSP), Vectors and Matrices.

Authors

Dr. Senbagavalli M
Associate Professor
Alliance University
Bangalore, Karnataka, India.

Saswati Debnath
Assistant Professor
Alliance University
Bangalore, Karnataka, India.

Rajagopal R
Associate Professor
Alliance University
Bangalore, Karnataka, India.

Vijayalakshmi R
Assistant Professor
Vemana Institute of Technology
Bangalore, Karnataka, India.

Swetha Shekarappa S G
Assistant Professor
Alliance University
Bangalore, Karnataka, India.

I. INTRODUCTION

We train the model iteratively through optimization, which yields an assessment of the maximum and minimum function. One of the most significant phenomena in machine learning is the desire for improved outcomes. Until we achieve the best results, we analyze the outcomes in every iteration while tweaking the hyperparameters at each stage. We develop a reliable model with a lower error rate. There are numerous techniques we may use to optimise a model. Let's talk about two key optimization techniques in this essay. Generally, there are two categories of optimization. First one is Local optimization and the second one is global optimization. In contrast to local optimization, which discovers the optimal value inside the nearby set of candidate solutions, global optimization means to discovering the best quantity of a given function among all feasible solutions. Total Value Optimization is achieved when a company is animatedly capable to foresee and satisfy need due to the coordination of its plan-buy-make-move-fulfill digital supply chain to provide the best benefit to consumers and stakeholders at the lowest cost and risk to the company. Below is a mathematical underpinning for optimization approaches and algorithms.

II. LITERATURE SURVEY

They suggested genetic algorithm which is used to improve expert credit card rating model. It also demonstrates that it is possible to reduce the reliance on human judgement alone in the model selection and optimization process without turning it into a black box [1]. Proposed a new feature selection method based on a correlation guided genetic algorithm to reach the best outcome [2]. presented a unique genetic algorithm-based system for medical treatment scheduling [3]. The implementation of the newly proposed approach is compared to that of the PSO algorithm and the progressive optimality algorithm (POA), which employ the clearance flow process as the decision variables [4]. Cuckoo Search and Particle Swarm Optimization which effectively mixes the capacities from both strategies to produce trustworthy and appropriate results in order to effectively carry out global optimization. [5].

III. GLOBAL SEARCH OPTIMIZATION ALGORITHMS

Searching for the global optima is referred to as global optimization or global search. A global optima is to be found through a global search algorithm, also known as a global optimization algorithm. It works well for navigating the full input search space and locating the function's extrema within a certain distance (or precisely).

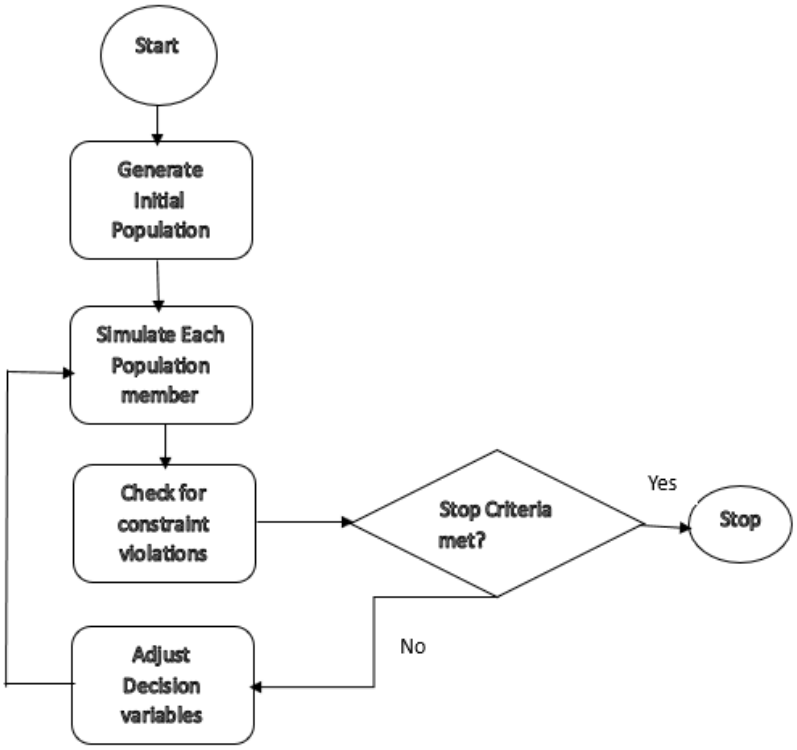


Figure 1: General Flow Diagram of Optimization Algorithms

Optimization is the process of producing the results as maximum or minimum function evaluation by finding a set of responses to an objective function. It is the difficult challenge that underpins many machine learning algorithms, from logistic regression model fitting to artificial neural network training. Figure 1 depicts the overall flow of diagram of general optimization algorithms.

- Genetic Algorithms
- Firefly Algorithm
- Particle Swarm Optimization

Detailed information and applications of the above algorithms are discussed below.

1. **Genetic Algorithms:** The Genetic Algorithm is a computational approximation of how evolution searches, which is to produce new individuals with variable fitness by altering the parent genomes in their children[6]. Similar to the neuron, another mathematical model, it makes an effort to abstract away everything, but the crucial elements required to comprehend how evolution works.

   The following are the requirements for modelling simple genetics in a computer and using it to solve problems:
   - a technique for converting problems into chromosomes
   - a method for determining the fitness of a solution
   - a method for selecting parents
   - a technique for producing offspring by mating the parents.

The knapsack issue is an NP-complete problem that will be used as an example to demonstrate the approaches. If you are unfamiliar with the phrase NP-complete, it means that the problem runs exponentially slowly or worse as the number of inputs increases (a knapsack is a rather old name for a rucksack or bag). The knapsack problem is simple to state, but generally challenging to solve.

- **Steps of Genetic Algorithm:**
  - Prepare or initialize the population
  - Choose the parents by assessing their fitness value
  - Crossover parents to reproduce the new value
  - Mutate the offspring
  - Merging of the offspring with the main population value and perform sorting.

2. The Main Applications of Genetic Algorithms are:

- **Traveling Salesman Problem (TSP):** The primary goal of this problem is to determine the best path for the salesman to take within the confines of a given map that shows routes and distances between places. Applications for TSP include manufacturing, logistics, and planning.
- **Manufacturing System:** The use of genetic optimization in the production of goods is widespread (variation of production parameters or comparison of equipment layout). By taking into account dynamic conditions like inventory, capacity, or material quality, genetic optimization is primarily used to create an optimal production plan.
- **Financial Markets:** Choosing the best values for all parameters and parameter combinations is essential to trading success. Using genetic algorithms, it is possible to identify both the ideal and undesirable combinations of parameters. We can also determine the nearly ideal value from the set of combinations using genetic optimization.
- **Data Clustering and Mining:** Data segmentation based on the characteristics of data points is what is referred to as data clustering, which is an unsupervised learning process. We can apply evolutionary algorithms in data clustering and mining to identify a data centre with the best error rate.
- **Image Processing:** Image segmentation is one of the main tasks involved in the genetic approach to image processing. Nevertheless, these genetic optimizations can be used to a variety of image analysis applications to address challenging optimization issues.
- **Neural Networks:** neural network is the one of the most significant applications of genetic algorithms in machine learning. Finding the optimal set of parameters for a neural network is one of the most basic applications of genetic optimization in neural networks.
- **Wireless Sensor Networks:** We can mimic the sensors using genetic algorithms in WSNs, and all of the operational phases of WSNs can be optimized and tailored using a fitness function from GA.
- **Medical Science:** Genetic algorithms may be used in the creation of a medicine to identify any ailment in the body.

3. **Firefly Algorithm:** The Firefly algorithm (FA) is a method motivated by nature that was initially created to address issues with continuous optimization. Numerous methods currently in use FA as a foundation for resolving discrete optimization issues, particularly the "travelling salesman problem" (TSP)[7].

   Steps of Firefly Algorithm:
   - Create initial value that is initial population of fireflies
   - Calculate intensity for every firefly member
   - Revise the step of each firefly and the step is calculated by using the next two steps
   - Push each firefly in the direction of other brighter fireflies and the position of each firefly value is updated by step3.
   - Update the value of solution set
   - If termination criteria are fulfilled, then terminate the process otherwise move to step2.

   The Main Applications of Firefly Algorithms are:

   - **Firefly Algorithm in Structural Optimization**
     Because the firefly method is so reliable at handling complicated issues, the majority of research in recent years has been directed toward solving structural optimization problems. There are various kinds of structural optimization issues that can arise in practise. They depend on the chosen objective functions, the variables employed, the kinds of constraints, and the complexity level.
   - **Firefly Algorithm in Truss Optimization**
     Complex structural challenges include the truss optimization problem. It has a number of variables, restrictions, and loading types with the goal of reducing structural weight.

4. **Particle Swarm Optimization:** The PSO algorithm shows social behavior in a variety of animals, including insects, herds, birds, and fish. These swarms adopt a cooperative approach to food gathering, and each swarm member continuously modifies the search pattern in response to its own and other members' growing experiences [8]. The PSO algorithm's central concept is strongly related to two studies: In the same way that PSO utilizes a swarm mode to concurrently look for a wide area in the solution space of the improved objective function, one is an evolutionary method [9]. The other is artificial life, which examines artificial systems that exhibit life-like traits. PSO has numerous uses, including in biomedicine, robotics, networking, and other fields [10].

   Steps of Particle Swarm Optimization Algorithm: Make an evenly dispersed "population" of agents (particles) over X.

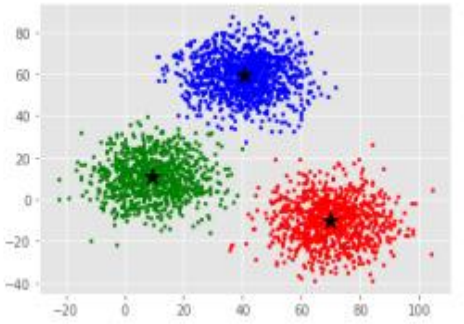
   - Consider the objective function when assessing the position of each particle
   - Update a particle's position if it is currently at a better location than it was previously.
   - Identification of best particle which is based on the particle's latest best locations.
   - Updating the velocities of every particle.
   - Move the corresponding particles to their new positions.
   - Move to step 2 until the conditions are satisfied.

The main applications of PSO Algorithm are:

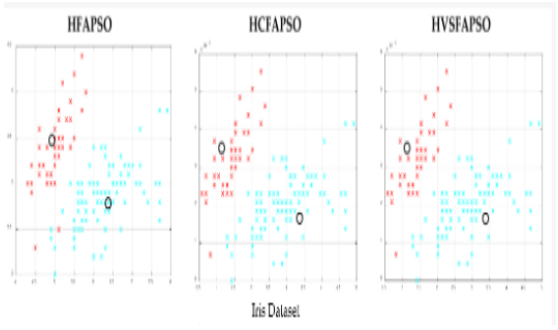
Particle swarm optimization mechanisms can be used to resolve a variety of optimization issues, including Energy-Storage Optimization. PSO can be used to create visual effects that resemble the special effects in Hollywood movies by simulating the movement of a particle swarm. PSO is widely used in a plethora of optimization problems.

IV. Results and Discussion

The comparison analysis shows that, in conditions of algorithm complexity, computational effectiveness, and outcome quality, the simple discrete firefly algorithm (SDFA) surpasses the GA. To place sensors in a structural health monitoring system, the firefly algorithm and a genetic algorithm have been contrasted. There is the potential to use the FA's optimization mechanism to a variety of optimization issues [11]. For noisy non-linear optimization problems, the firefly technique and particle swarm optimization have been contrasted. With each algorithm, a number of computation experiments were carried out. To arrive at the best answer, the experiment results were studied and compared to the best solutions previously discovered based on methods of execution time. For larger levels of noise, the Firefly algorithm tends to perform better [12].



(a)



(b)

Figure 2: a) The Firefly technique is used to cluster the data into three clusters[13]. b) HFAPSO, HCFAPSO, and HVSFAPSO clustering algorithms on a few chosen datasets based on DB index, where the number of clusters produced is indicated by the black hollow circle[14].

The FireFly-Algorithm for automatic clustering in Python programming was implemented using the Xclara dataset.The speed of convergence is faster for the suggested opposition-based FA than for conventional FA. Additionally, it selects the best across all dimensions[13]. IRIS Datasets were used by the authors. Figure 2a[14] shows the clustering examples for each unique dataset of the HFAPSO, HCFAPSO, and HVSFAPSO automatic data clustering based on both the CS(Compact Separated) index and the DB(Davis-Bouldin) index.

V. CONCLUSION

In this paper, the characteristics and uses of the Genetic Algorithm, Firefly Algorithm, and Particle Swarm Optimization Algorithms are included. We have concluded that the above-mentioned optimization algorithms are employed to deliver the answer in a useful and simple manner.

REFERENCES

[1] RemyEstran. AntoineSouchaud. DavidAbitbol.(2022). Using a genetic algorithm to optimize an expert credit rating model. Expert Systems with Applications. Volume 203.
[2] JianZhou, ZhongshengHua," A correlation guided genetic algorithm and its application to feature selection", Applied Soft Computing, Volume 123, July 2022.
[3] MatthewSquires, XiaohuiTao, SomanElangovan, RajGururajan, XujuanZhou, Udyavara RajendraAcharya," A novel genetic algorithm based system for the scheduling of medical treatments", Expert Systems with Applications, Volume 195, 1 June 2022
[4] Yong-GunKim, Bai-QingSun, PyolKim, Myong-BongJo, Tong-HoRi, Gyong-HoPak,"A study on optimal operation of gate-controlled reservoir system for flood control based on PSO algorithm combined with rearrangement method of partial solution groups", Journal of Hydrology Volume 593, February 2021.
[5] ManojIshi, JayantraoPatil and VaishaliPatil,"An efficient team prediction for one day international matches using a hybrid approach of CS-PSO and machine learning algorithms", Array Volume 14, July 2022.
[6] FengWen, DashangZhang, ChenHan, GuoqiZhang, GuofengLi, XiangZhang, JianxingMa, ZhijunYao, KaimingYu,"Anti-offset performance optimization of coupling coils in wireless power transfer system based on genetic algorithm", Energy Reports Volume 8, Supplement 10, November 2022.
[7] JunLi, XiaoyuWei, BoLi, ZhigaoZeng,"A survey on firefly algorithms", Neurocomputing Volume 500, 21 August 2022.
[8] J. Kennedy; R. Eberhart,"Particle swarm optimization",IEEE,1995
[9] Hong Zhang & Masumi Ishikawa, "Evolutionary Particle Swarm Optimization: A Metaoptimization Method with GA for Estimating Optimal PSO Models",Springer,2008.
JinGou, Yu-XiangLeiWang-PingGuoChengWangYi-QiaoCaiWeiLuo," A novel improved particle swarm optimization algorithm based on individual difference evolution", Applied Soft Computing Volume 57, August 2017.
[10] Guang-Dong Zhou, Ting-Hua Yi, Huan Zhang, and Hong-Nan Li," A Comparative Study of Genetic and Firefly Algorithms for Sensor Placement in Structural Health Monitoring", in Shock and vibration-Hindawi, Volume 2015.
[11] Saibal K. Pal, C.S Rai, Amrit Pal Singh," Comparative Study of Firefly Algorithm and Particle Swarm Optimization for Noisy NonLinear Optimization Problems", I.J. Intelligent Systems and Applications, pages 50-57, 2012.
[12] Afroj Alam. Mohd Muqeem. (2021). Hybridization of K-means with improved firefly algorithm for automatic clustering in high dimension. https://arxiv.org/ftp/arxiv/papers/2302/2302.10765.pdf.
[13] Mandakini Behera. Archana Sarangi et. At. (2022). Automatic Data Clustering by Hybrid Enhanced Firefly and Particle Swarm Optimization Algorithms. Mathematics. 10(19). https://doi.org/10.3390/math10193532.

