Optimal Foraging Algorithm (OFA) for Solving Constrained Optimization Problems

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Abstract **- Performance optimization algorithm, the Optimal Foraging Algorithm (OFA) method to test Constrained Optimization problems for thirteen test functions from (g01) to (g13) to 30 runs then calculates the results and discussion of the comparison results between these problems. The OFA algorithm tested before for unconstrained optimization problems which it shows the perfect performance to solve these problems. In this research applying OFA to solve Constrained problems and compare the performance of this algorithm with another optimization algorithm to assess how to working.**

Keywords **Optimal -Foraging- algorithm - OFA- Optimization - Constrained Problem.**

I. INTRODUCTION

These days Constrained Optimization problems issues CO are encountered among numerous in many types of applications such as VLSI designing, Structural optimization, location problems and economics. The CO has two functions, the constraint function and the objective function [2]. Generally, the constrained problem computes x so as to

$$\min_x f(x), \quad x \in S \subset \mathbb{R}^n ,$$

And the subject function of the linear or nonlinear constrained problems

$$\mathcal{J}i(x) \le 0 \quad , i=1,\ldots,m.$$

The constraint problem has method of the of Eq [2]. is now not restricting, due facts that disparity constraint over the forms so $\mathcal{J}i(x) \ge 0$, execute additionally stay to represent namely $\mathcal{J}i(x) \le 0$, After equality, $\mathcal{J}i(x) = 0$, be able stand represented by using pair odds constraints

$$\mathcal{J}i(x) \le 0 \text{ and } \mathcal{J}i(x) \le 0$$

The CO problem may keep addressed the use of both deterministic and stochastic methods. However, deterministic techniques certain as much Feasible Direction or Gen-realized Gradient Descent, edit intense Expectations on the stretch then more different for regarding to the goal functions □(x) [1], [2].So, at that place Is continuous in attention because of this algorithms to do tackled the CO hassle electively. While the Evolutionary Algorithms (EA) bear has been advanced mostly as like un-constrained methods, it viewed namely a strong choice to solve CO problems. Talented outcomes talked about throughout the previous few times in the last of century, or countless variations on the Genetic Algorithms (GA) [3], development of programming [6], then Evolution Strategy (ES) [9], bear proposed after dealing with CO problem [9].The most communed strategy because fixing constraint issues makes to use the penalty function. Tus restrained hassle is distorted in accordance with an unconstrained one, by penalizing the constraints and creating an odd objective function, as in turn is minimized the use of UN problems [4], furthermore almost possibly another reason beside that reputation concerning the Penalty Function approach so EAs is old in imitation of tackle the CO problem [8], [6]. OFA) [1] into solve the CO problems is investigating by it. also the CO problems are tackling via the minimization for non-stationary multi stage is an employment to penalty function. The aim of this paper updated OFA algorithm for solving 13 CO problem and the results are reported and discussed in comparison by other algorithms. Also look at problems as much nicely so the empiric results are represented. The research ends including conclusions or ideas in the last Section.

II. The Optimal Foraging Optimization Method

In this research shows the working The Optimal Foraging Algorithm is studied by the animal Behavioral Ecology Philosophy, also it's worked to solve the global optimization problems to follow the animal behavior [7]. When the animal looking for the food, it needs two things: short paths to find the food and energy. Moreover this research, those problems are defining as pursues: $x = [x1, \cdots , xi , \cdots xd]$ and □(x) = min $x \in R$ $f(x)$, $R = \{ x \ |xi\ L \le xi \le xi\ U\}$, $i = 1,2, \cdots , d$, so the $f(x)$ is the objective function, x, a d-dimensional state vector, one solution of the objective function, xi , the i and component of x, □(x), objective function value and □(x) is the optimal objective function value, SO x is the optimal vector, called the best solution, R, is constructed by constraints, xiL,xiU Indication, respectively, the minimum and upper bound of the itch case, maximizing f(□) is equal to the minimizing $-f$(□). This method is similar to solve these problems of international acceleration, according to many things in search of monster food [6] [5]. Living on the larger international solution, called the native best answer concerning characteristic f(□) computes constraint area do stay careful so the a range of patches between the beast foraging habitat. In an optimization system can be viewed or showed by the animal behavior, also it's very closer to the (OFT) Optimal Foraging Theory, Feed between the special someplace in conformity with found the optimal patch where the net degree of power intake can stand maximized [6][8]. Next the choicest slap is found, the animal will look for the best position inside the box in accordance in accordance with the model regarding superior prey. The most reliable answer about the global optimization problem is finished then the last gold standard role is found. Inspired by means of most advantageous foraging theory, OFA is represented as much a foraging animal whose role into a pat describe the answer about the goal unction. Consistent in imitation of the useful energy (or resource) between OFT, the resource on OFA additionally lies into twain aspects:

1) the quantity over the near-optimal solutions. Inside the particular area (or patch), the close ideal choices exclusively show up in complete position. Then, it's thought the number that is very close to optimal solutions among a region is associated along resource, the larger range capability an Ette resource.

2) Function virtue regarding answer is considered as the strength about the solution, a greater worth means a higher electricity on the solution that role is bigger. Its capacity the characteristic [5], in addition the OFA can work by some steps below:

- Precedes the role of searching for primary feed in each quarantine and achieves the restricted "test optimization" compliance area.
- Then the objective characteristic price regarding every single is calculated and well-ordered.
- Then, the status of modern food was reached on each unit alone
- Below is verified as a solution represented through the modern position along with the method [6] consistent with the determination of exit from a better assumption of the answer.
- If the result is better, the instant role is stock to the subsequent foraging, in any other case the modern function is omitted yet the past function is worked for the next foraging. Repeating the upon spoke of process.
- The good function nearby way of each time regarding foraging is recorded at some point of the search.
- Therefore, so he algorithm is terminated, and the previously registered role is studied the most suitable final solution. Addicted code corresponding to OFA between Figure 2.
- How many times about operations performed via the OFA is $N \times d + N + NlogN +$ $((N \times d + N) + N + N\ log\ N) \times Max\_t$, so the period complexity concerning OFA is $O(N \times d \times Max\_t)$.
- aimed at OFA, the tankage areas wanted are $O(N \times d)$ of initial segment yet the tankage spaces are needed $O(N \times d \times Max\_t)$ between the algorithm jogging phases. The total tankage spaces is $O(N \times d) + O(N \times d \times Max\_t) = O(N \times d \times (Max\_t + 1))$ [8][6].

III. CONSTRAINED OPTIMIZATION

Most optimization issues in the world some limitations on connection variables. While diminishing or maximizing the specific objective of this issue is aimed at the issues of improving freedom, the constraints are equally important with the objective of working on the issues of abnormal improvement (COPs) as a result of the specific constraints on the selection variables that will best modify the purpose of this issue for typical COPs Square box 2 Different equations are quite different from those measuring box of equality and difference. The CO defined as computing the vector x minimizes an objective function subject (Optimize $f(x)$) which it effected for inequality, equality by constraints:

$$
\begin{array}{lll}
\text{minimize } f(\vec{x}), & \vec{x} = (x_1, \ldots, x_n) \in \mathbb{R}^n & \\
 & l_i \le x_i \le u_i, & i = 1, \ldots, n \\
\text{subject to :} & g_j(\vec{x}) \le 0, & \text{for } j = 1, \ldots, q \\
 & h_j(\vec{x}) = 0, & \text{for } j = q+1, \ldots, m
\end{array}
$$

Where the objective function f defined as which it defined $F \subseteq \mathbb{S}$ as a n- Domains rectangle $\mathbb{R}^n$ $(\mathbb{S} \subseteq \mathbb{R}^n)$. SO dimensional of variables were defined by their upper and lower bounds. Also a possible region is defined by a set of m additional constraint ($m \ge 0$) and x vector defined on feasible space ($x \in F \in \mathbb{S}$). And for any points $x \in F$, constraints gi that content $gi(x) = 0$ it's called active constraints at x. By extension, equality constraints $hi(x)$ also called active at all points of $\mathbb{S}$ [1]. Likewise, CO issues had parallel significance with an objective function, for the reason that while the fitness of the solution is calculated by way of using objective function, achievability of the arrangement relies upon the infringement of the querulents as a result, attainability for an answer could really compare to its wellness esteem [6]. The arrangement space can be looked by the swarm insight or transformative strategies however there some limitation taking care of techniques are required for these strategies Constraint dealing with strategies can be gathered given as pursues Method based on:

- a penalty functions
- rejection of unfeasible candidate solutions
- multi-objective optimization
- repairing
- special operators
- selection
- Hybrid technique

Essentially, for the most part utilized technique for conquering the limitations is punishment work since its usage is extremely straightforward and any adjustment for the advancement algorithmic program isn't needed [6]. when objective perform is figured for an answer, the infringement of limitations is computed and furthermore the aggregate of goal performs worth and imperatives infringement of a given goals is reflected as target perform worth. The static and dynamic renditions of punishment perform are decided inside the writing. these algorithms program is so utilized for venture down or expansion of the composite goal perform. the contrary strategy for dealing with requirements is that the dismissal of unworkable arrangements. On the off chance that the conceivable area on goals place of the COP is in thin field, these ways will be computationally sincerely won. In multi-target advancement of COP, the objective performs and limitation capacities are pondered in multi-target improvement system. Repairing systems are utilized in advancement algorithmic program to change over unworkable goals to conceivable one. Half and half strategies utilize 2 or a great deal of courses amid this class to determine a COP. The last strategy intended to beat limitations in COP depends on decision. {the decision the choice} might be a style of ravenous determination anyway utilizes 3 rules named as Deb's standards [3]. In the event that the decision are completed between tow arrangements: - Any plausible arrangement is wanted to unfeasible arrangement. On the off chance that two arrangements are achievable, better arrangement dependent on wellness (target work esteem) is favored If two arrangements are infeasible, the arrangement with less infringement is favored. The punishment work is utilized in TSA calculation to take care of weight vessel plan issue (PVD) in [2] however the underlying execution tests on the benchmark issues demonstrate that the punishment work isn't suit for TSA and Deb's tenets is in this manner utilized in TSA. The utilization of different strategies in swarm knowledge or transformative calculation can be found in.

Table 1: Main features of the 13 CO problems

Problem	n	Function	P(%)	LI	NI	LE	NE	Descriptions
G1	13	Quadratic	0.0111	9	0	0	0	G1. G2. G3. G7 . G9 are active
G2	20	Nonlinear	99.8474	1	1	0	0	G1 is close to being active
G3	10	Polynomial	0.0000	0	0	0	1	G1. G6 are active
G4	5	Quadratic	52.1230	0	6	0	0	Three Constraints are active
G5	4	Cubic	0.0000	2	0	0	3	All problems are active
G6	2	Cubic	0.0066	0	2	0	0	G1.G2.G3.G4. G5. G6 are active
G7	10	Quadratic	0.0003	3	5	0	0	The optimum lies within the feasible region
G8	2	Nonlinear	0.8560	0	2	0	0	G1. G4 are active
G9	7	Polynomial	0.5121	0	4	0	0	All problems are active
G10	8	Linear	0.0010	3	3	0	0	
G11	2	Quadratic	0.0000	0	0	0	1	
G12	3	Quadratic	0.7713	0	[illegible]	0	0	The optimum lies within the feasible region
G13	5	Nonlinear	0.0000	0	0	0	3	

The table 1 shows the Benchmark of CO problems. So, the LI and NI are the numbers of variety of linear or nonlinear in equilibrium constraints also, the LE and NE are the wide variety of linear or nonlinear parity constraints is the range concerning dimensions [4]. Moreover, the table above presents which each CO problems used the type of functions [3].

IV. DISCUSSION EXPERIMENTAL RESULTS

Table 1: The average results OFA to algorithm solve 13 problems over 30 run times

Problem	Optimal	Best	Worst	S.D
G1	-15	-14.7953	-14.6598	0.030109
G2	0.803619	-0.49468	-0.24186	0.057052
G3	1	62419.11	8.719401	12259.51
G4	-30665.5	-30577.3	-30228.7	80.40764
G5	5126.498	2.9E+12	9134133	6.03E+11
G6	-6961.81	-6911.07	-5576.42	381.2259
G7	24.306	24.72997	26.34954	0.457345
G8	0.095825	-0.09582	-0.02914	0.012165
G9	680.63	681.4179	680.8321	0.158335
G10	7049.25	7129.531	8614.091	321.1311
G11	0.75	0.992123	67.68198	16.9322
G12	1	-0.99985	-0.99999	2.73E-05
G13	0.05395	1471649	7.63E+11	1.98E+11

The Global Best Value, mean and worst are found by OFA in all 30 runs, for all methods and problems. Experimental consequences on OFA algorithm are found as seen from Table 1, although OFA algorithm found the global minimum very close to the optimal results for over the seven problems (G01, G04, G06, G07, G08, G09, G10). However, some problems, such as G02, G03, OFA algorithm ought to no longer locate the global optimum among the special maximum variety of cycles. future more the Worst variable showed the stoical results for (G03) constraint function (G01,G04, G06, and G12) had the Worst variable very close to best solution .Also the last Colum shows the standard deviation for each problems .

V. SIMPLE COMPARISON BETWEEN OFA RESULTS WITH ANOTHER OPTIMIZATION ALGORITHM

Table 2: The OFA best solution compares with another algorithm

P	Optimal	PSO [13]	DE [14]	ABC [3]	GA [12]	OFA
G1	-15.000	-14.710	-14.555	-15.000	-14.236	-14.7953
G2	0.803619	0.419960	0.665	0.792412	0.788588	-0.49468
G3	1.000	0.764813	1.000	1.000	0.976	62419.11
G4	-30665.539	-30665.539	-30665.539	-30665.539	-30590.455	-30577.3
G5	5126.498	5135.973	5264.270	5185.714	-	2.9E+12
G6	-6961.814	-6961.814	-	-6961.813	-6872.204	-6911.07
G7	24.306	32.407	24.310	24.473	34.980	24.72997
G8	0.095825	0.095825	0.095825	095825	0.095799	0.09582
G9	680.63	680.630	680.630	680.640	692.064	681.4179
G10	7049.25	7205.5	7147.334	7224.407	10003.225	7129.531
G11	0.75	0.749	0.901	0.750	0.75	0.992123

G12	1.000	0.998875	1.000	1.000	1.000	-0.99985
G13	0.053950	0.569358	0.872	0.968	-	1471649

The table 2 shows a simple comparison between OFA algorithm and GA, DE, PSO, ABC algorithms for thirteen tests CO problems from g01 to g13 over thirty self-governing runs and totally successful. Beside that the other algorithms had different results for each problem as the table 2 dispelled above. Moreover, the OFA algorithm It is a regarded truth so much the performance regarding somebody evolutionary algorithm over confined optimization is noticeably affected by means of the constraint handling method employed. In that work, in view that our aim was in conformity with evaluate the performance about the modified OFA algorithm on restricted optimization problems, we saved the modification to OFA algorithm minimum [9]. The change is related mostly with choice process. Instead regarding a greedy determination ancient between the standard OFA algorithm because unconstrained problems, Deb's guidelines. according in conformity with the best results, that may remain viewed that ABC performs higher than GA, PSO, ABC show amount performances; DE exhibit better performance than ABC does [3]

Table 3: comparing between OFA with another algorithm

P	OFA-DE		OFA-ABC		OFA- GA		OFA-PSO	
G1	+	+	-	+	+	+	+	+
G2	-	-	-	+	-	+	-	-
G3	-	+	+	-	-	+	-	+
G4	+	+	+	+	+	+	+	+
G5	-	+	-	+	+	-	-	+
G6	+	-	-	+	+	-	+	+
G7	-	+	+	+	+	-	+	+
G8	+	+	+	+	+	-	+	+
G9	-	+	-	+	+	-	-	+
G10	+	+	+	-	+	-	+	-
G11	+	+	-	+	-	+	-	+
G12	-	+	-	+	+	-	+	+
G13	-	-	-	-	+	-	-	-
Total	6	10	5	10	8	5	7	9

Achievement rates of calculations when contrasted and that of the OFA, in this table ((+)) mark shows the algorithm is better than other and ((−)) mark means it has worst result than the other. In the event that the two calculations demonstrate comparative execution, they are both. As the table 3 shows the OFA is worked better than only Ga but with the other it needs to improve in some constrained problems.

VI. Conclusion and Further Working

The functionality regarding the OFA technique to 13 CO problems are investigated by the performance regarding many experiments over well generally used take a look at many problems or known. OFA for constrained problems introduced and presented also, compared with another algorithms. A statistical analysis of the parameters of the modified OFA algorithm conducted and suitable values recommended. Moreover, To conclue that OFA algorithm needs to improve to solving constraint optimization problems especially in so problems. Beside that the overall performance of OFA algorithm also tested for real engineering problems issues existing in the literature and compared with famous algorithms. Furthermore, the affection and regarding discipline handling strategies on the performance of OFA algorithm be improve investigated in future works.

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