A NEW HYBRID FRUIT FLY OPTIMIZATION ALGORITHM FOR SOLVING BENCHMARK PROBLEMS

Mustafa DANACI
ERU, Engineering Faculty, Computer Eng. Dept. Kayseri / TURKEY
Mamadou Alimou DIALLO
ERU, Computer Eng., Grad. School of Natural and Applied Sciences, Kayseri / TURKEY

ABSTRACT
The process of finding the best element (solution) to a given problem is called optimization. Many algorithms such as GA (John Holland, 1975), PSO (Eberhart & Kennedy, 1995), ABC (Karaboğa, 2005) etc. have been developed to fix optimization issues. The Fruit Fly Optimization Algorithm (FOA) is a part of these algorithms, it's a new category of global optimization evolutionary algorithm with a potential to solve complex optimization issues. The FOA is developed by Wen Tsao Pan in 2011, totally built on the foraging characteristics of Fruit Fly. The algorithm has several varieties of search specially based on vision and olfactory. It has a specific technique to find food quickly, after determine the position, and then fly to the object. FOA is used in many applications, especially in the Wireless Sensor Network Coverage Optimization proposed (Ren, Zhichao and Liu, 2018), travelling salesman problem (Nitin S. Choubey, 2014), Short-term Traffic forecasting (Yuanyuan and Yongdong, 2017), and so on. To avoid falling into a local optimum and to overcome the weakness of the updating strategies which are used to find optimal solution. We have developed a new hybrid Fruit Fly Optimization algorithm (HFOA) which uses Sine Cosine Algorithm (SCA) and it powerful updating and excellent search capabilities. The developed hybrid is tested on a set of 13 Benchmark test functions and its performance is compared with other optimization algorithms. The results obtained showed the successfulness and efficacy of the new hybrid algorithm HFOA, it outperforms the other meta-heuristics algorithms.

Keywords: Optimization, Fruit Fly optimization algorithm, Sine Cosine Optimization Algorithm, Hybrid Fruit Fly Optimization Algorithm.

1. INTRODUCTION

Meta-heuristics is one of the last generation methods suggested to fix difficult issues. All meta-heuristic method is a set of search agents that seek suitable location according to some stated criterions [1].The purpose of the existing issue is generally about to minimize the wastes, or maximize the benefits, and performances. It is the action to get the best , to improve an operation or a performance. These last years modern developed meta-heuristics optimization algorithms are being improved and are earning lot of attention and popularity [2]. The optimization algorithms can be classify as follows: Physics based, Swarm based, Biology-based, Social based etc.[3], for example, Particle Swarm Optimization (PSO) [4], Ant Colony Optimization (ACO) [5], Harmony Search (HS) [6], Artificial Bee Colony (ABC) [7], Genetic Algorithm (GA) [8] and so on. Fruit-Fly Optimization Algorithm (FOA) is one of these algorithms, it's a simple and efficient algorithm to solve several continuous optimization problems. In this study, it is developed a hybrid algorithm which gives better solutions in solving some benchmark problems by taking the position updating advantages of the basic SCA.

2. FRUIT-FLY OPTIMIZATION ALGORITHM

It is an approach for determining suitable result generally build on foraging behavior of fruit flies developed by Wen Tsao Pan in 2011. Compared to other algorithm the fruit fly has an evident dominance in terms of vision and olfactory. They usually have an appropriate technique to find food very quickly, after determine the position, and then fly to the object. [9]. FOA consists of the following steps:

1-This step determines the location and numbers of the flies group (x_0, y_0); and also the number iteration used.
2-Settle the unplanned direction and distance.
$$X_i = x_0 + RandomValue \quad (1)$$

$Y_i = y_0 + RandomValue$.
3-Since the flies groups don't know the real place of the optimal solution, the distance between the group and the source (dist) is basically calculated. The smell concentration is known by the value *S*.

$$dist_i = \sqrt{X_i^2 + Y_i^2} \quad (2)$$

$S_i = 1/\ dist_i$
4-By replacing the fitness function *S*, the smell concentration of the fruit fly is obtained as following:

$$Smell_i = Function\ (S_i) \quad (3)$$

5-Determines the individual that has the most high smell in the flies group.

$$[bestSmell\ bestIndex] = \max\ (Smell) \quad (4)$$

6-Carry the best amount of concentration (x_i, y_i), of the position, so that fruit flies will fly toward it.
7- Repeat the steps (2)–(5) to insert iterative optimization, in case the taste concentration number at the present time is better than the iterative flavor concentration number at the precedent moment. If yes, then execute step (6).

$$Smellbest = bestSmell$$
$$xi = (bestIndex) \quad (5)$$
$$yi = Y(bestIndex)\ .$$

3. SINE COSINE ALGORITHM (SCA)

It is an easy and efficient optimization procedure, lately proposed by Seyedali Mirjalili (2016). As shown, this algorithm uses a numerical equations axed on sine and cosine functions. In this proposed method, a set of agents is used to find the space of possible solutions. The following equations are used to determine the updated position of an agent [10]:

$$X_{i,j}^{(t)} = \begin{cases} X_{i,j}^{(t-1)} + r_1 \times \sin(r_2) \times | r_3 \times S_j - X_{i,j}^{(t-1)} |, & r_4 < 0.5 \\ X_{i,j}^{(t-1)} + r_1 \times \cos(r_2) \times | r_3 \times S_j - X_{i,j}^{(t-1)} |, & r_4 \geq 0.5 \end{cases}$$

(6)

Where $X_{i,j}^{(t)}$ is the *j*-th size of the *i*-th solution in the population at the *t*-th iteration; *Sj* is the *j*-th dimension of the actual best solution; r_1, r_2,r_3, r_4 are random numbers and || express the absolute value. As can be appreciated from the above equation, r_1, r_2, r_3 and r_4 are the principal parameters of SCA. The factor r_1 is used to find the direction of the movement generated by the search agent *i* which can eventually be in the area between X_i and the actual best solution or outwards. It's important to notice that the search between the solutions is the exploitation section, whereas the movement far from them designates the exploration of the search space. For balancing exploitation ($r_1 < 1$) and exploration ($r_1 >$ 1) the factor is settled as [11]:

$$r_1 = a - t\frac{a}{T} \quad (7)$$

T indicates the number of iterations and *a* is a constant value. The factor r_2 is in the interval [0, 2π] and describes how far the agents moves around the optimal solution. The weighting factor r_3 is a random number in [0, 2] which stochastically emphasizes or understates the effect of the best solution in defining the distance. Lastly, the parameter r_4 takes random values in [0, 1] and switches between the sine and cosine components in (6).

4. A NEW HYBRID FRUIT FLY OPTIMIZATION ALGORITHM

Fruit fly optimization algorithm (FOA) in an efficient algorithm for determining an optimal solution to a given problem, it find the best position of an agent at each iteration. All the other agents are therefore gathered at the position that agent which leads the population. In this case if the agent is not the global optimum, the algorithm can surely lose it convergence speed, it precision and end up falling into the local optimum.

Sine Cosine algorithm generates several random initial solutions, revolving around the best solution and using the equations essentially based on sine and cosine functions. To also increase exploitation and exploration in different areas of optimization, many variables are integrated into the algorithm.

In this work the basic FOA is associated with position updating equations in SCA algorithm. These equations guarantee the exploitation and exploration capabilities to make the developed hybrid algorithm more efficient. It updates the position of solution with respect to destination.

The hybrid Algorithm is implemented by using the following equations:

$X_i = x_0 + RandomValue+$ SCA position updating equations (using sinus) (8)

$Y_i = y_0 + RandomValue+$ SCA position updating equations (using cosinus)

Establish the random direction and distance of an agent. To develop the new hybrid Fruit Fly optimization algorithm (HFOA), FOA uses SCA to operate the optimal position. The position of the Fruit Fly is updated in combination of the update method used by Sine cosine algorithm.

5. RESULTS

To determine if the developed **HFOA** demonstrates high performance, this work uses 13 Benchmark functions shown in **Table 1**. FOA (Fruit Fly Optimization Algorithm) SCA (Sine Cosine Algorithm), PSO

(Particle swarm optimization algorithm), BA (Bat algorithm), WOA (Whale Optimization Algorithm), GA (Genetic Algorithm) and GWO (Grey Wolf Optimizer) are used as competitors in this testing.

Table 1: The Benchmark functions

Functions	Names	Unimodal	Multimodal	Range (lb, ub)	Fmin	Separable	Inseparable
F1	Sphere	✓	x	[-100,100]	0	✓	x
F2	Schwefel 2.22	✓	x	[-10,10]	0	x	✓
F3	Quartic	✓	x	[-1.28,1.28]	0	✓	✓
F4	Rosenbrock	✓	x	[-30,30]	0	x	✓
F5	Ackley	x	✓	[-32,32]	0	x	✓
F6	Griewank	x	✓	[-600,600]	0	x	✓
F7	Rastrigin	x	✓	[-5.12,5.12]	0	✓	x
F8	Penalized 2	x	✓	[-50,50]	0	x	✓
F9	Foxholes	x	✓	[-65,65]	1	✓	x
F10	Kowalik	x	✓	[-5,5]	0.0003	x	✓
F11	SHCB	x	✓	[-5,5]	−1.03160	x	✓
F12	Branin	x	✓	[-5,5]	0.3980	✓	x
F13	Goldstein P.	x	✓	[-2,2]	3	✓	x

In this work it is used 13 well-known functions. The size of the presented optimization functions are settle to 30 and the number of iteration 500. The numerical description is shown in Table 1, where lb and ub represent the lower and upper bounds of the solution *X*, respectively.

In this test, to evaluate the searching performance of the eight algorithms, it is used statistical measures such as average, these algorithms are used to determine the search ability of eight algorithms. It is used eight algorithms to perform 30 separate runs for each optimization function and obtain the statistical results, which are averaged.

Table 2: Statistical results of the algorithms

FN	NAMES	FMIN	HFOA	FAO	SCA	PSO	BA	BOA	GWO	GA
			AVERAGE							
F1	**Sphere**	0	2.52E-04	0.0015	7.65	66.312	1.53E+ 01	1.41E −30	6.59E-28	0.118
F2	**Schwefel 2.22**	0	3.30E-01	5.245	1.33E-02	8.463	1.84E+ 01	1.06E −21	7.18E-17	0.145
F3	**Quartic**	0	7.42E-04	43.496	6.57E-02	0.008	1.01E+ 01	0.001425	0.002213	0.014
F4	**Rosenbrock**	0	0.4070	29.174	1.84E+ 05	935.188	4.07E+ 03	27.86558	26.81258	0.714
F5	**Ackley**	0	3.70E-02	0.114	1.20E+ 01	3.405	4.94E+ 00	7 .4043	1.06E-13	0.956
F6	**Griewank**	0	5.43E-07	2.81E-06	8.30E-01	1.599	5.98E-01	0.000289	0.004485	0.487
F7	**Rastrigin**	0	25.978	106.585	3.65E+ 01	64.511	2.65E+ 02	0	0.310521	0.659
FN	**NAMES**	**FMIN**	**HFOA**	**FAO**	**SCA**	**PSO**	**BA**	**BOA**	**GWO**	
F8	**Penalized2**	0	0.235	6.18E-01	4.49E+ 04	2.61E+ 01	2.47E+ 00	1.889015	0.654464	
F9	**Foxholes**	1	1.145	1.27E+ 01	1.53E+ 00	2.71E+ 00	4.84E+ 00	2.111973	4.042493	
F10	**Kowalik**	0.0003	0.0003	8.04E-04	1.01E-03	1.37E-03	5.15E-03	0.000572	0.00033	
F11	**SHCB**	−1.0316	-0.340	−1.68E-01	−1.03E	−1.03E	−1.03E	−1.03163	-1.0316	
F12	**Branin RCOS**	0.398	35.329	1.98E+ 00	0.399	0.399	0.398	0.397914	0.39788	
F13	**Goldstein Price**	3	499.443	6E+ 02	3.00	3.10	3.06	3.00	3.00002	

The results of the FAO, SCA, PSO, BA, BOA, GA and GWO algorithms used in the comparison of the HFOA in Table 1 are taken from [12], [13], [14], [15] and [16]. As shown in Table 2 for the function SCHB the algorithms SCA, PSO, BA, BOA and GWO gave optimal results, in the same way for the function Goldstein Price, CA, BOA, and GWO also gave efficient results, and for the Rastrigin function only BOA gave an optimal Result.

Moreover, HFOA showed more good performance than the other 7 algorithms in terms of average while solving 6 benchmark functions. Also, HFOA is shown to be an efficient and powerful algorithm for solving optimization problems. Looking at the results of the HFOA algorithm Kowalik function HFOA was able to reach the optimal value of the function while the other algorithms did not. Quartic, Rosenbrock, Griewank, Penalized2 and Foxholes functions gave the best results in comparison to the results obtained by the other algorithms and the algorithm was able to get the closest results to the optimal values of the functions. Sphere and Ackley gave a good result and came as second best as we can see in the Table 2. The results obtained proved that the HFOA can potentially solve real optimization problems in like manner the other algorithms.

6. CONCLUSION

Optimization is a vast and complex field. In recent years, scientists have developed many algorithms to solve this optimization issue, but unfortunately few of them have given reliable solutions. In this study, a hybrid HFOA is developed to solve Benchmark optimization problems. The algorithm takes advantage of the position updating capabilities of sine cosine algorithm and also the exploration and exploitation abilities to obtain optimum solutions. This was done by testing the proposed algorithm with 13 Benchmark functions and comparing them with the basic FOA, SCA, PSO, BA, WOA, GA and GWO algorithms. The results showed that the HFOA produced good performance into some functions and have outperformed the other algorithms in solving Benchmark problems.

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