A Hybrid Model: Combining Ant Lion Optimizer and Genetic Algorithm for Solving Complex Numerical Optimization Problem

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Abstract-
Optimization algorithms play a key role in solving complex numerical optimization problems. In this paper, a new hybrid mode that integrates he Ant Lion Optimizer (ALO) and the Genetic Algorithm (GA) for optimizing and increase performance. The new hybrid model integrates the exploration ability of ALO and the exploitation ability of GAwith the expectation of better convergence and optimal solutions. This hybrid algorithm being tested on twenty-three benchmarking functions and the results indicate that the hybrid model is better than the individual ALO algorithm and generating smaller errors and scores in the area of optimization. The study indicates that the proposed hybrid model offers a feasible solution to solving complex numerical optimization problem.

Keywords: Ant Lion Optimizer (ALO), Hybridization, Benchmark Functions, Exploration, Exploitation

1. Introduction

Optimization is a fundamental mechanism for addressing the complex issues in the areas of science, engineering, and artificial intelligence. While metaheuristic algorithms have proven highly effective in dealing with extensive search spaces, individual algorithm stand to experience problems with premature convergence or poor exploitation [12].In this paper hybrid methodology being implemented to blends the strengths of the Ant Lion Optimizer (ALO) [9] and the Genetic algorithm [10] to facilitate effective search process. By utilizing the exploratory ability of ALO and the enhanced exploitation capabilities of GA, our proposed model optimizes both convergence rate and solution precision [3,4].

The hybrid model was being tested on twenty-three benchmarking functions, and the results were always exceptional to those of the individual ALO and GA, hence indicating an enhancement in optimization andefficiency. These finding syndicate those hybrid methodologies may effectively substitute for addressing complex optimization problems.

2. Literature Review

This figure classifies the meta-heuristics algorithm into four types: nature-based algorithm, evolutionary-based algorithm, physics-based algorithm and human-based algorithm [11]. Each type represents different methods for solving optimization problem effectively.

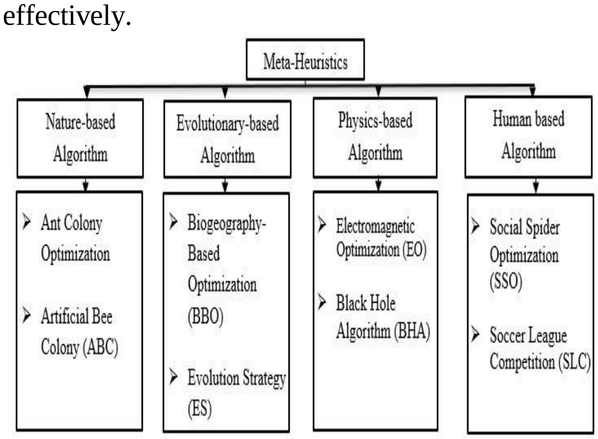

Fig-1: Classification of Algorithms

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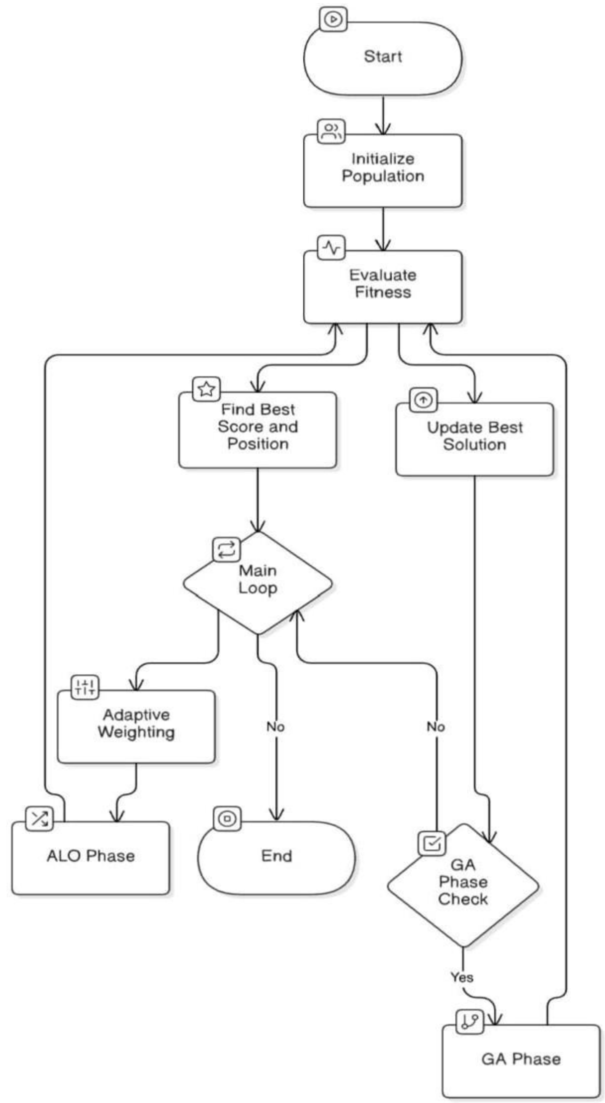
Tabel-1: Algorithm Details

Sr No.	Algorithm	Author Name
1	Ant Colony Optimization (ACO)	Dorigo & Gambardella Et al. (1997)
2	Artificial Bee Colony (ABC)	Karaboga Et al. (2005)
3	Biogeography -Based Optimization (BBO)	Simon Et al. (2008)
4	Evolution Strategy (ES)	Rechenberg Et al. (1973)
5	Electromagnetic Optimization (EO)	Birbil& Fang Et al. (2003)
6	Black Hole Algorithm (BHA)	Hatamlou Et al. (2013)
7	Social Spider Optimization (SSO)	Cuevas, Cienfuegos, Zaldívar Et al. (2013)
8	Soccer League Competition (SLC)	Moosavian& Gholipour Et al. (2015)

The abovetable shows details of various meta-heuristics algorithms developed to solve complex optimization problems.

2.1 Flowchart



2.2 Benchmark Functions

Benchmark function is the mathematical test function which is used to analyze the performance of an algorithm. Each function test algorithm in different aspects.

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Table 2: Standard UM benchmark functions

Functions	Dimensions	Range	f_{min}
$F_1(S)=\sum_{m=1}^{z} S_m^2$	(10,30,50,100)	[-100 , 100]	0
$F_2(S)=\sum_{m=1}^{z} \lvert S_m\rvert + \prod_{m=1}^{z} \lvert S_m\rvert$	(10,30,50,100)	[-10 ,10]	0
$F_3(S)=\sum_{m=1}^{z} (\sum_{n=1}^{m} S_n)^2$	(10,30,50,100)	[-100 , 100]	0
$F_4(S)=max_m\{\lvert S_m\rvert, 1\leq m\leq z\}$	(10,30,50,100)	[-100 , 100]	0
$F_5(S)=\sum_{m=1}^{z-1}[100(S_{m+1}-S_m^2)^2+(S_m-1)^2]$	(10,30,50,100)	[-38 , 38]	0
$F_6(S)=\sum_{m=1}^{z}([S_m+0.5])^2$	(10,30,50,100)	[-100 , 100]	0
$F_7(S)=\sum_{m=1}^{z} mS_m^4+random\,[0,1]$	(10,30,50,100)	[-1.28, 1.28]	0
$F_8(S)=\sum_{m=1}^{z} -S_m sin(\sqrt{\lvert S_m\rvert})$	(10,30,50,100)	[-500,500]	-418.98295
$F_9(S)=\sum_{m=1}^{z}[S_m^2-10cos(2\pi S_m)+10]$	(10,30,50,100)	[-5.12,5.12]	0
$F_{10}(S)=-20exp\left(-0.2\sqrt{\left(\frac{1}{z}\sum_{m=1}^{z} S_m^2\right)}\right)-exp\left(\frac{1}{z}\sum_{m=1}^{z} cos(2\pi S_m)\right)+20+d$	(10,30,50,100)	[-32,32]	0
$F_{11}(S)=1+\sum_{m=1}^{z}\frac{S_m^2}{4000}-\Pi_{m=1}^{z} cos\frac{S_m}{\sqrt{m}}$	(10,30,50,100)	[-600, 600]	0
$F_{12}(S)=\frac{\pi}{z}\left\{10\,sin(\pi\tau_1)+\sum_{m=1}^{z-1}(\tau_m-1)^2[1+10sin^2(\pi\tau_{m+1})]+(\tau_z-1)^2\right\}+\sum_{m=1}^{z} u(S_m,10,100,4)$ $\tau_m=1+\frac{S_m+1}{4}$ $u(S_m,b,x,i)=\begin{cases} x(S_m-b)^i & S_m>b \\ 0 & -b<S_m<b \\ x(-S_m-b)^i & S_m<-b \end{cases}$	(10,30,50,100)	[-50,50]	0
$F_{13}(S)=0.1\{sin^2(3\pi S_m)+\sum_{m=1}^{z}(S_m-1)^2[1+sin^2(3\pi S_m+1)]+(x_z-1)^2[1+sin^2 2\pi S_z)]$	(10,30,50,100)	[-50,50]	0
$F_{14}(S)=[\frac{1}{500}+\sum_{n=1}^{2} 5\frac{1}{n+\sum_{m=1}^{z}(S_m-b_{mn})6}]^{-1}$	2	[-65.536, 65.536]	1
$F_{15}(S)=\sum_{m=1}^{11}[b_m-\frac{S_1(a_m^2+a_m S_2)}{a_m^2+a_m S_3+S_4}]^2$	4	[-5, 5]	0.00030
$F_{16}(S)=4S_1^2-2.1S_1^4+\frac{1}{3}S_1^6+S_1S_2-4S_2^2+4S_2^4$	2	[-5, 5]	-1.0316
$F_{17}(S)=(S_2-\frac{5.1}{4\pi 2}S_1^2+\frac{5}{\pi}S_1-6)^2+10(1-\frac{1}{8\pi})cosS_1+10$	2	[-5, 5]	0.398
$F_{18}(S)=\left[1+(S_1+S_2+1)^2\left(19-14S_1+3S_1^2-14S_2+6S_1S_2+3S_2^2\right)\right]\times$ $\left[30+(2S_1-3S_2)^2\left(18-32S_1+12S_1^2+48S_2-36S_1S_2+27S_2^2\right)\right]$	2	[-2,2]	3
$F_{19}(S)=-\sum_{m=1}^{4} d_m\,exp\left(-\sum_{n=1}^{3} S_{mn}(S_m-q_{mn})^2\right)$	3	[1, 3]	-3.32
$F_{20}(S)=-\sum_{m=1}^{4} d_m\,exp\left(-\sum_{n=1}^{6} S_{mn}(S_m-q_{mn})^2\right)$	6	[0, 1]	-3.32
$F_{21}(S)=-\sum_{m=1}^{5}[(S-b_m)(S-b_m)^T+d_m]^{-1}$	4	[0,10]	-10.1532
$F_{22}(S)=-\sum_{m=1}^{7}[(S-b_m)(S-b_m)^T+d_m]^{-1}$	4	[0, 10]	-10.4028
$F_{23}(S)=-\sum_{m=1}^{7}[(S-b_m)(S-b_m)^T+d_m]^{-1}$	4	[0, 10]	-10.5363

2.3 Search Spaces

The following figures present the search spaces for the twenty-three benchmarking function.

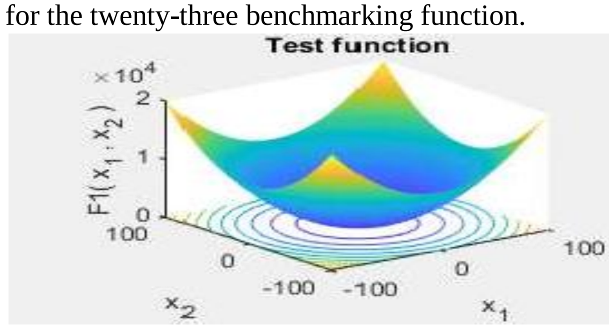

Fig. 1: Function 1

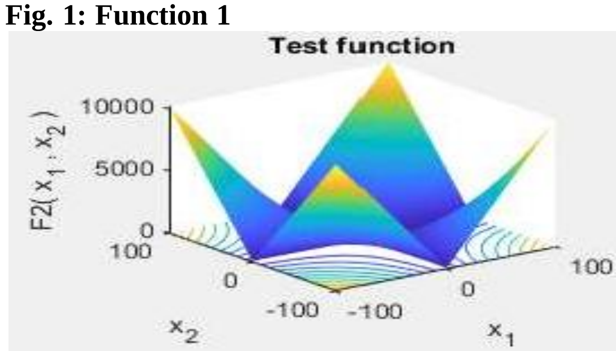

Fig. 2: Function 2

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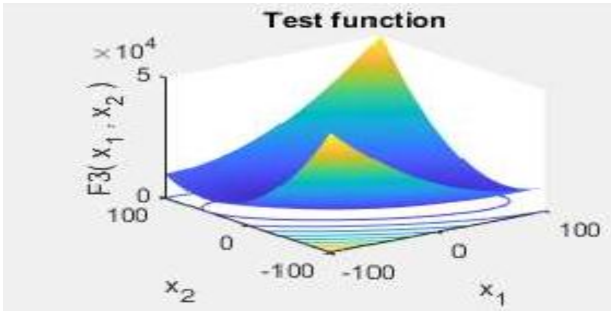

Fig. 3: Function 3

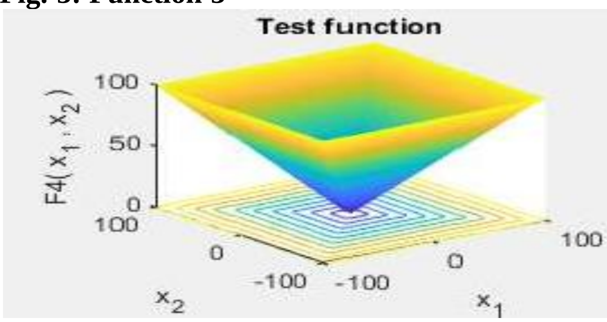

Fig. 4: Function 4

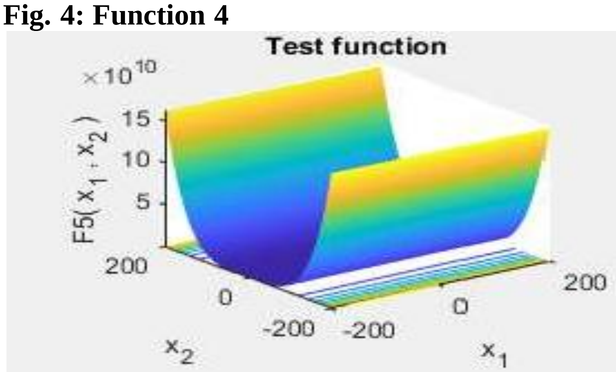

Fig. 5: Function 5

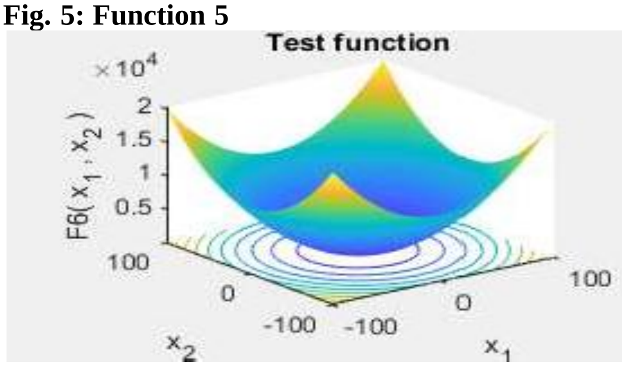

Fig.6: Function 6

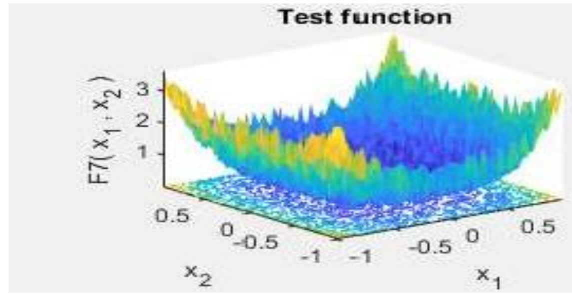

Fig. 7: Function 7

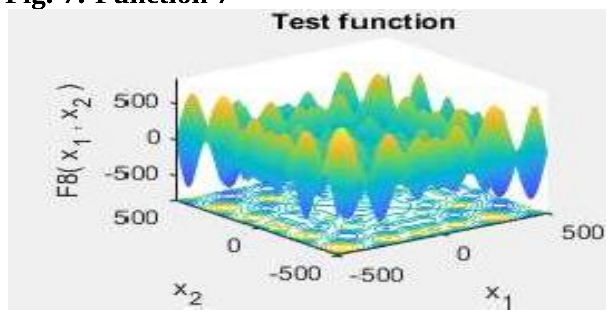

Fig. 8: Function 8

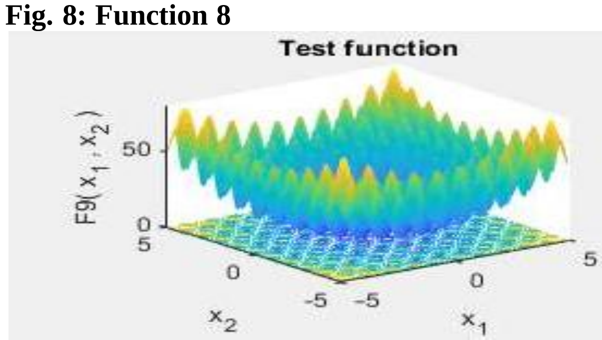

Fig. 9: Function 9

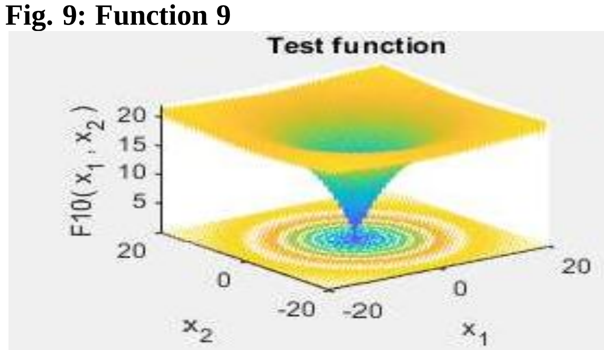

Fig. 10: Function 10

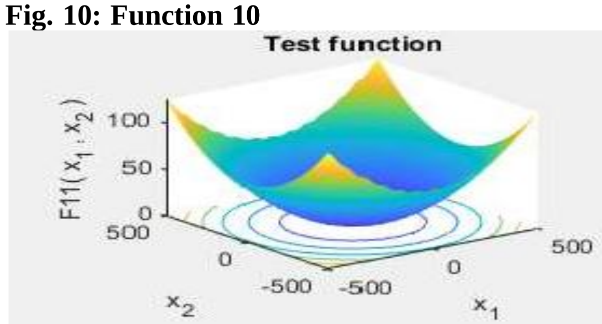

Fig. 11: Function 11

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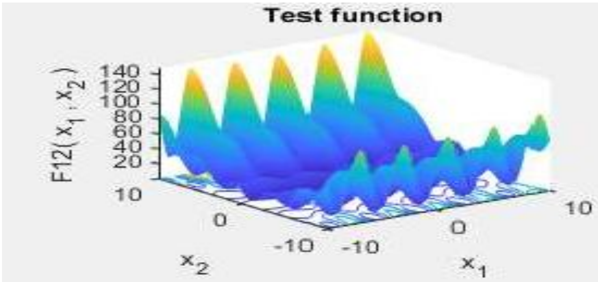

Fig. 12: Function 12

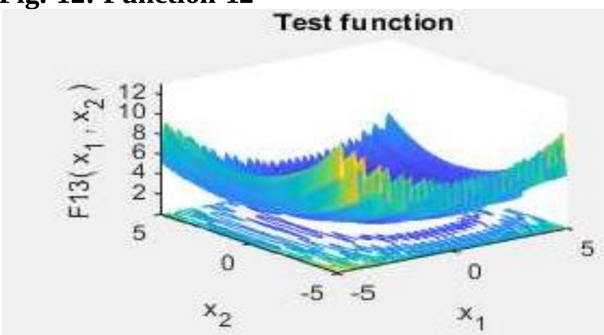

Fig. 13: Function 13

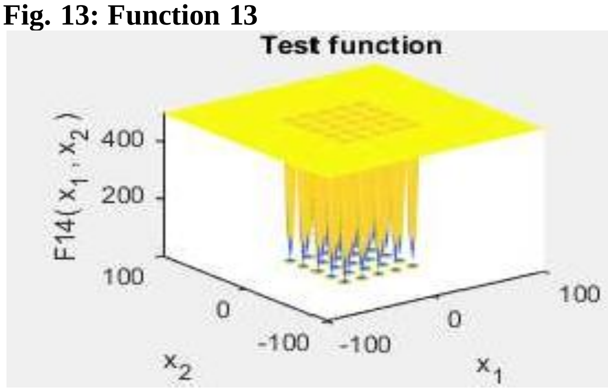

Fig. 14: Function 14

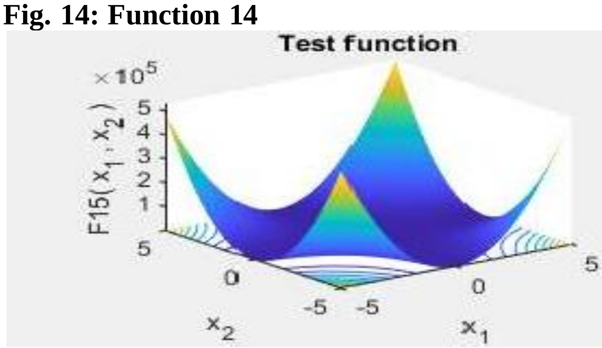

Fig. 15: Function 15

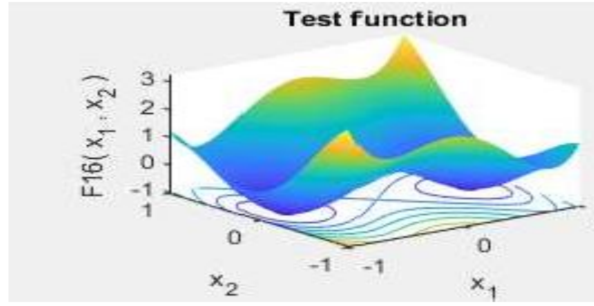

Fig.16: Function 16

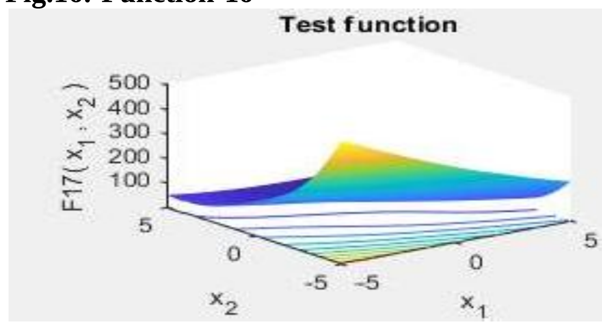

Fig. 17: Function 17

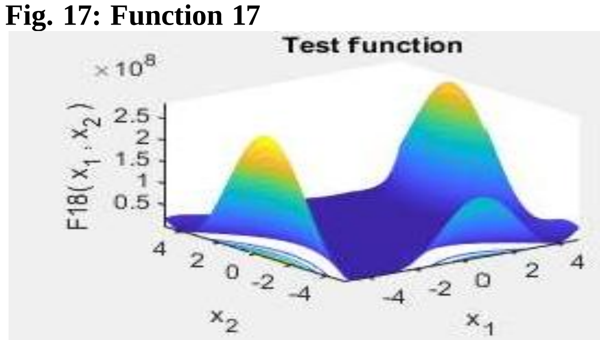

Fig. 18: Function 18

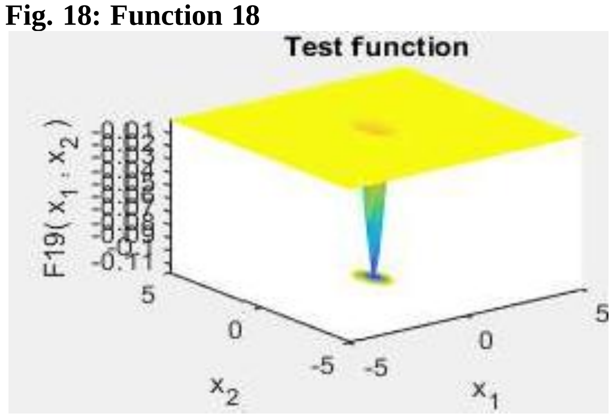

Fig. 19: Function 19

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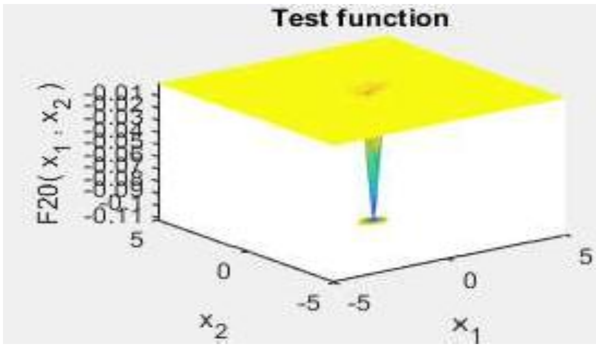

Fig.20: Function 20

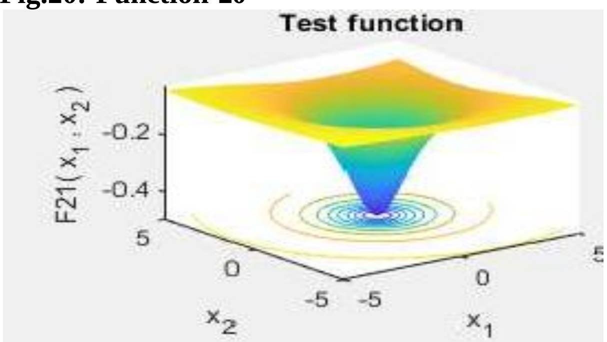

Fig. 21: Function 21

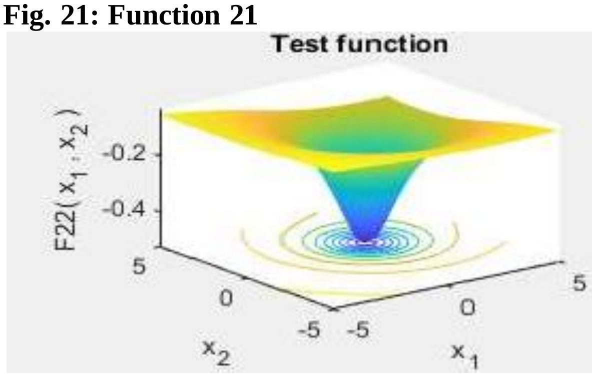

Fig. 22: Function 22

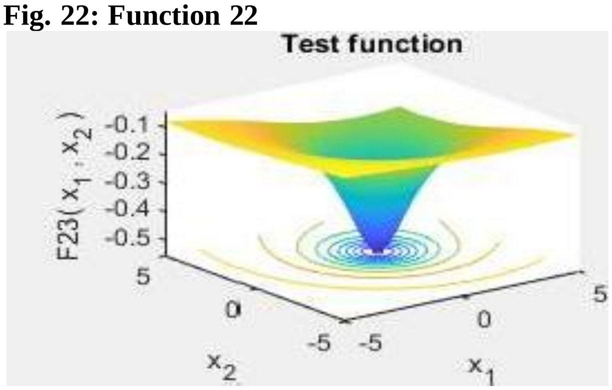

Fig. 23: Function 23

3. Results and Discussion

The proposed hybrid algorithm being tested on twenty-three benchmarking functions to determineits performance.

Function	**Ant Lion Optimizer**	**Hybrid of Ant Lion Optimizer with Genetic Algorithm**
F1	-1.03E+00	0.0014293
F2	7.73E-05	0.014322
F3	6.40E+00	0.0081235
F4	8.60E-05	0.027812
F5	8.75E+02	8.7406
F6	1.46E-08	0.00056108
F7	0.016035	0.012942
F8	-2039.08	-3897.0635
F9	20.8941	4.9801
F10	1.1551	0.017075
F11	0.5952	0.082671
F12	8.58E-09	0.0003813
F13	9.62E-09	0.00019925
F14	0.998	0.998
F15	0.00094243	0.00073664
F16	-1.0316	-1.0316
F17	0.39789	0.39789
F18	3	3
F19	-3.8628	-3.8628
F20	-3.2027	-3.322
F21	-5.0552	-10.1531
F22	-10.4029	-10.4029
F23	-10.5364	-10.5364

From above table, concludethat hybridALO-GA provide more relevant and optimize value as compared to individual ALO algorithm. Some values remainedunchanged, and some are showing fluctuation in values and functions such as F3, F5, F7, F8, F9,F10,F11, F15, F20 and F21give the optimized value.

4. Conclusion

This study evaluates and improves the performance ofAnt Lion Optimizer usinghybridization approach of (ALO+GA), the hybrid algorithm being tested on twenty-threebenchmarkingfunctions out of which10 functions provide a best optimal value compared to the original algorithm which consider as an improvement in performance of Ant Lion Optimizer.

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