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Optimal power flow solution using HFSS Algorithm

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The optimal power flow is a pragmatic problem in a power system with complex behavior that includes many control parameters. Many metaheuristic algorithms with different search methodologies have been proposed for solving the OPF problem. However, existing algorithm faces challenges such as stagnation, premature convergence, and local optima trapping during the optimization process, which provide low-quality and misleading results for real-world problems. In this paper, a novel algorithm which is inspired by the natural foraging phenomenon of the flying squirrel named as Squirrel Search Algorithm is used and it is hybridized with arithmetic crossover operation to enhance its effectiveness and be used for solving the OPF problem. So, the proposed algorithm is named the Hybrid Flying Squirrel Search Algorithm (HFSSA). The capability and performance of the proposed algorithm are observed on benchmark test functions and on the IEEE-30 bus system. Generation fuel cost, emission, and transmission losses are considered objectives of an optimal power flow problem. We got optimal values by handling the control parameters; Generation fuel cost as 799.86 $/h, Emission as 0.20374 ton/h, and transmission loss as 3.1687 MW. The obtained results corroborate that the proposed algorithm outperforms the existing algorithms for solving the OPF problem.

Key words: Emission; Generation fuel cost; Hybrid Flying Squirrel Search Algorithm (HFSSA); Optimal Power Flow (OPF); Power Injection modeling (PIM); Transmission losses.

INTRODUCTION

In recent years, development is taking place at a good pace which has led to an increase in the demand for electricity at a rigorous rate. Establishing new plants to fulfill the demand is not a good alternative, thus there is a need to utilize the existing system to its level best. To identify the optimal control variables in the power system the proposed optimal control technique is used and it helps to automatically adjust to minimize instantaneous generation fuel cost, emission, transmission losses, or any other objectives, and at those control variables power system can be planned and operated (Hermann and Williams, 1968).

Basically, the OPF problem is solved by satisfying considered constraints such as equality, inequality, and device constraints. Lot of conventional and metaheuristic techniques has been proposed for solving OPF problems, in the literature. Xie and Song (2002), Javad et al. (2011), El-Hawary et al. (1999a), El-Hawary et al. (1999b) Alsac

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and Stott (1973) and Sun et al. (1984) described conventional methods such as interior point, linear programming, etc, but these methods are not suitable for big power system networks, and it takes a large time to reach optimal value. The results obtained using these methods sometimes mislead the results. In heuristic optimization techniques, many intelligent algorithms have developed that help to overcome the problem faced in classical approaches. Some algorithms are based on an evolutionary-inspired algorithm like enhanced self-adaptive differential evolution (Pulluri et al., 2017), enhanced genetic algorithm (Kumari and Maheswarapu, 2010), backtracking search optimization (Chaib et al., 2016), and genetic algorithm (Osman et al., 2004]; some are human-inspired algorithms like biogeography-based optimization (Bhattacharya and Chattopadhyay, 2010), tabu search algorithm (Abido, 2002), gray wolf optimizer (El-Fergany and Hasanien, 2015) and some are nature inspired algorithms like particle swarm optimization (Abido, 2002), artificial bee colony algorithm (Jadon et al., 2014), the modified flower pollination (Barocio et al., 2016), hybrid cuckoo search algorithm (Balasubba, 2017), Nature-inspired algorithms have some features in common, firstly they emulate any natural occurring phenomenon, and secondly there is no need of gradient information and thirdly it implicit on random variables (Li et al., 2016). The performance of various metaheuristic techniques for single and multi-objective optimization with different facts devices are described (Mallala et al., 2022; Ahmed et al., 2014; Balasubbareddy et al., 2022; Balasubbareddy et al., 2022:1-9; Ahmed et al., 2022a; Balasubbareddy et al., 2015; Balasubbareddy et al., 2015:1-17; Ijaz et al., 2014; Balasubbareddy et al., 2017:44-53; Balasubbareddy, 2022; Ahmed et al., 2022b; Balasubbareddy et al., 2012; Ahmed et al., 2022c; Dhiraj et al., 2020; Ahmed et al., 2022d; Balasubba, 2016).

In this paper, a nature-inspired algorithm is considered which is the squirrel search algorithm (SSA) (Mohit et al., 2019) inspired by the foraging process of flying squirrels (Thomas and Weigl, 1998), is hybridized with arithmetic crossover operation (Yalcinoz and Halis, 2005; Qun et al., 2014) and proposed a new algorithm named as hybrid flying squirrel search algorithm (HFSSA). This proposed algorithm is tested on benchmark test function and used for solving the single objective problems of OPF that is, generation fuel cost, emission, and transmission loss.

Mathematical problem formulation

The OPF problem formulation with subject to constraints is given mathematically as follows:

Minimize function $F_i(a,b)$ $\quad \forall i = 1,2,\ldots\ldots t$
Sub. to: $m(a,b) = 0$, $n(a,b) \le 0$

The dependent variables:

$$a^T = [P_{G,1}, V_{L,1} \ldots V_{L,NLINE}, Q_{G,1} \ldots Q_{G,NGB}, S_{L,1} \ldots S_{L,NTL}]$$

Control variables:

$$b^T = [P_{G,2} \ldots P_{G,NGB}, V_{G,1} \ldots V_{G,NGB}, Q_{SH,1} \ldots Q_{SH,NC}, T_1 \ldots T_{NT}]$$

Objective functions

The considered objective functions such as cost minimization, emission minimization and power loss minimizations are described below:

a. Fuel cost minimization

$$F_1 = \min(F_p(P_{G,m})) = \sum_{m=1}^{NGB} x_m P_{G,m}^2 + y_m P_{G,m} + z_m \,\$/h \qquad (1)$$

where, x_m, y_m and z_m are the fuel cost coefficients of m^{th} unit.

b. Emission minimization

$$F_2 = \min(E(P_{G,m})) = \sum_{m=1}^{NGB} \alpha_m + \beta_m P_{G,m} + \gamma_m P_{G,m}^2 + \xi_m \exp(\lambda_m P_{G,m}) ton/h \qquad (2)$$

c. Total power loss minimization

$$F_3 = \min(P_{loss})) = \sum_{m=1}^{NTL} P_{loss,m} MW \qquad (3)$$

Constraints

To solve power system problem needs to consider following constraints:

a. Equality constraints:

$$\sum_{m=1}^{NGB} P_{G,m} - P_D - P_L = 0, \sum_{m=1}^{NGB} Q_{G,m} - Q_D - Q_L = 0$$

b. Inequality Constraints:

$V_{G,m}^{\min} \le V_{G,m} \le V_{G,m}^{\max}$ and

$Q_{G,m}^{\min} \le Q_{G,m} \le Q_{G,m}^{\max} \quad \forall m \in NGB$

$V_{G,m}^{\min} \le V_{G,m} \le V_{G,m}^{\max}$ and

$T_m^{\min} \le T_m \le T_m^{\max} \quad \forall m \in NT$

$P_{G,m}^{\min} \le P_{G,m} \le P_{G,m}^{\max} \quad \forall m \in NGB$

$Q_{SH,m}^{\min} \le Q_{SH,m} \le Q_{SH,m}^{\max} \quad \forall m \in NC$

Figure 1. Gliding locomotion of flying squirrel with hickory nut in mouth.
Source: Thomas and Weigl (1998)

$$S_{L,m} \le S_{L,m}^{\max} \qquad \forall m \in NTL$$

Proposed Hybrid Flying Squirrel Search Algorithm (HFSSA)

This paper developed the proposed algorithm with the hybridization of existing squirrel search algorithm and arithmetic crossover operation to enhance the accuracy in dealing with power systems.

Existing Squirrel Search Algorithm (SSA)

SSA basically works on the flying squirrels locomotive mechanism for optimize the problem. According (20), there are two available food sources for flying squirrels, one is hickory nut tree which are in limited numbers. The behavioral routine of flying squirrel is to adapt the changes according to seasons as they become very active and searches for food during summer season while during winter, they become dormant but they do not sleep. Thus, during summer when they are active, they will scrupulously search for food. Flying squirrel's gliding locomotion with hickory nut is shown in Figure 1. In this algorithm n numbers of flying squirrels and n number of total trees are considered with the assumption that one flying squirrel will be on one tree.

Proposed Hybrid Flying Squirrel Search Algorithm (HFSSA)

Random initialization

Initially all the flying squirrels are randomly allocated with any of the tree. Mathematically it can be represented as:

$$S_m = S_{\min} + U(0,1) \times (S_{\max} - S_{\min}) \tag{4}$$

Where, $S_{\min}$ and $S_{\max}$ are the m^{th} flying squirrel min. and max. values and U(0,1) is a random number(0,1).

Generation of new location in order to search food

It can be mathematically modelled according to the three situations which are as follows:

Case A: Flying squirrels which are on acron trees and target to moves towards nut tree. Calculate new location as below equations:

$$S_a^{t+1} = S_a^t + g_d \times g_c \times R_1 \times (S_h^t - S_a^t) \quad \text{if } R_1 \ge 0.1 \tag{5}$$

S_a^{t+1} = Random position will be allocated if $R_1 < 0.1$

where, g_c =1.9 (20) and g_d is the random gliding distance of flying squirrel. S_a^t is the previous position of flying squirrel at acron tree and S_h^t is the current position of flying squirrel at hickory nut tree at t^{th} iteration.

Case B: Flying squirrels and target to moves towards acron trees. So, the new location can be determined as follows:

$$S_n^{t+1} = S_n^t + g_d \times g_c \times R_2 \times (S_a^t - S_n^t) \quad \text{if } R_2 \ge 0.1 \tag{6}$$

S_n^{t+1} = Random position will be allocated if $R_2 < 0.1$

Table 1. Optimal result of Himmelblau's function.

Parameters	PSO	HCSA	HFSSA
X1	3.01744	3.001261	3.584428
X2	1.96808	1.999335	-1.84813
Minimum Function Value	0.01726	4.96e-05	0.0

Source: Balasubba (2017)

Table 2. Optimal result of Booth's function.

Parameters	PSO (Balasubba RM (2017)	HCSA(Balasubba (RM 2017)	HFFA et al (2022))	HFSSA
X1	1.012698676	1.0043728	1.00	1.00
X2	2.989245453	2.9969812	3.00	3.00
Minimum Function Value	0.000292035	3.557e-05	1.2364e−08	2.8075e-10

Source: Balasubba (2017)

where, S_n^t is the previous position of flying squirrel at normal tree at t^{th} iteration.

Case C: Flying squirrels and target to moves towards hickory nut trees. So, the new location can be determined as follows:

$$S_n^{t+1} = S_n^t + g_d \times g_c \times R_3 \times (S_h^t - S_n^t) \quad \text{if } R_3 \geq 0.1 \tag{7}$$

S_n^{t+1} = Random position will be allocated if $R_3 < 0.1$

Seasonal monitoring of flying squirrel

As discussed, the behaviour change of flying squirrel with season changes is modelled as:

$$SC^t = \sqrt{\sum_{m=1}^{d} (S_{a,m}^t - S_{h,m}^t)^2} \tag{8}$$

$$SC_{\min} = \frac{10e^{-06}}{365^{t/iter/2.5}} \tag{9}$$

where, t is the current iteration number. Thus, this condition must be satisfied: quickly. Mathematically arithmetic crossover operation.

$SC^t < SC_{\min}$

At the end of winter season flying squirrel are randomly re-allocated-

As the levy distribution makes exploration more effective so it is calculated by following equation:

$$Levy(x) = 0.01 \times \frac{r_1}{|r_2|^{1/\alpha}} \times \gamma \tag{10}$$

where r_1 and r_2 are random number between (01,1) and

$$\gamma = \left(\frac{\Gamma(1+\alpha) \times \sin(0.5 \prod \alpha)}{\Gamma(\frac{1+\alpha}{2}) \times \alpha \times 2^{0.5(\alpha-1)}}\right)^{\frac{1}{\alpha}}$$

where, α is a constant 1.5(1).

The re-allocation is mathematically modelled as:

$$S_m^{new} = S_{\min} + Levy \times (S_{\max} - S_{\min}) \tag{11}$$

Arithmetic crossover operation

As in existing method Levy distribution control the exploration and to equalize the exploitation and exploration, this arithmetic crossover operation is implemented so that final result can be achieved efficiently in less iteration. As arithmetic crossover operation (38, 39) updates the generated locations and thus convergence occurs faster. Thus, the hybridization helps to get the optimum values can be expressed as (18):

$$S_m^{t+1} = (1-\xi) \times S_h^t + \xi \times S_m^{t+1} \tag{12}$$

where, ξ is a random number between 0 and 1. After

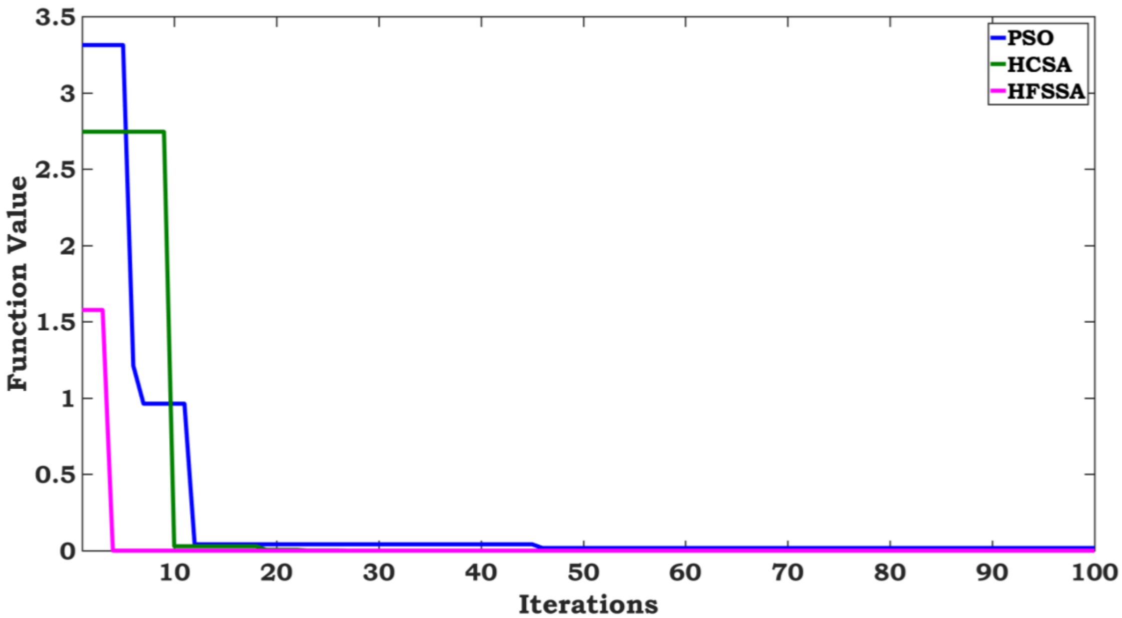

Figure 2. Convergence curve of Himmelblau's function.
Source: Balasubba (2016)

reallocation of flying squirrel the location is updated by Equation (12).

Pseudo code of proposed Hybrid Squirrel Search Algorithm (HSSA)

Step 1: **Input-** Read bus data, line data, generator data and cost data for the given electric system.
Step 2: Set maximum iteration count, flying squirrels.
Step 3: Initially generate the random location for the flying squirrels using Equation (4).
Step 4 Map the algorithm variables with the load flow data and then evaluate them for obtaining the solution of the single objective problems.
Step 5: Calculate each flying squirrels fitness and sort ascending order of their fitness values.
Step 6: The 3 fit values will be of flying squirrel on acron trees and then remaining will be on normal trees.
Step 7: Randomly select one of the flying squirrel which are on normal trees and target them to move toward hickory nut tree and remaining to the acron trees.
While (the condition not satisfied)

Step 8: for ***i=1 to no.of flying*** squirrels

if R1 ≥ 0.1

$$S_a^{t+1} = S_a^t + R_1 \times (S_h^t - S_a^t)$$

else

S_a^{t+1} = Random position will be allocated

end

Step 9: ***for i=1 to fs2***

if R2 ≥ 0.1

$$S_n^{t+1} = S_n^t + R_2 \times (S_a^t - S_n^t)$$

else

S_n^{t+1} = Random position will be allocated

end

Step 10: ***for i=1 to fs3*** (number of flying squirrels which are on normal trees and target to moves towards hickory nut tree)

if R3 ≥ 0.1

$$S_n^{t+1} = S_n^t + R_3 \times (S_h^t - S_n^t)$$

else

S_n^{t+1} = Random position will be allocated

end

Step 11: Find seasonal constant using Equation (8).
Step 12: Verify the seasonal monitoring condition, if it found valid then find levy flight operator using Eq. (10) and randomly relocate the flying squirrel using Equation (10).
Step 13: Update the location of flying squirrels with arithmetic crossover operation using Equation (12).
Step 14: Determine the minimum value of seasonal constant using Equation (9). Go to step 8.
end

Step 15: Output- The flying squirrel which is on hickory

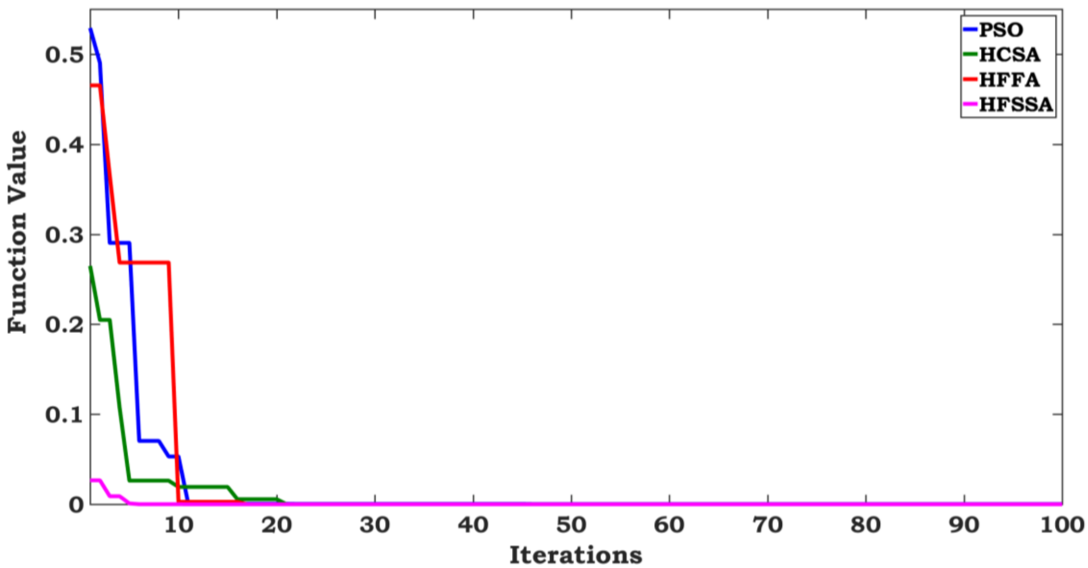

Figure 3. Convergence curve of Booth's function.
Source: Balasubba (2016)

Table 3. OPF result for minimizing generation fuel cost $/h.

Variable	Units	HSCA(Balaa RM (2017)	(Baasub baRM(20 17)	HFFA(Ijaz A et al 2022)	HFSSA
P_1	MW	176.87	178.556	179.312	174.865
P_2	MW	49.8862	48.6032	48.265	46.4864
P_5	MW	21.6135	21.6697	20.9265	21.7241
P_8	MW	20.8796	20.7414	19.8629	18.5053
P_{11}	MW	11.6168	11.7702	23.3402	13.7922
P_{13}	MW	12	12	12	12.5602
V_1	p.u.	1.057	1.1	1.1	1.097
V_2	p.u.	1.0456	0.9	1.057	1.086
V_5	p.u.	1.0184	0.9642	1.067	1.058
V_8	p.u.	1.0265	0.9887	1.07	1.069
V_{11}	p.u.	1.057	0.9403	1.02523	0.97
V_{13}	p.u.	1.057	0.9284	1.09248	1.099
T_{6-9}	p.u.	1.0254	0.9848	1.04532	1.02
T_{6-10}	p.u.	0.9726	1.0299	0.98004	0.945
T_{4-12}	p.u.	1.006	0.9794	1.09611	1.0086
T_{28-27}	p.u.	0.9644	1.0406	10.2131	0.97887
Qc_{10}	p.u.	25.3591	9.0931	5	25
Qc_{24}	p.u.	10.6424	21.665	29.6709	6.8638
fuel cost	$/h	802.034	803.454	800.996	799.86
Emission	ton/h	0.365688	0.3701	NA	0.25822
Power loss	MW	9.466955	9.9403	NA	8.78778

Source: Balasubba (2017)

nut tree will be the optimal value of considered objective function.

Table 4. OPF result for minimizing emission ton/h.

Variable	Units	HCSA (18)	PSO	HFSSA
P_1	MW	63.7401	64.326	67.6486
P_2	MW	68.2844	67.7681	70.6352
P_5	MW	50	50	40.94208
P_8	MW	35	35	25.37218
P_{11}	MW	30	30	21.42841
P_{13}	MW	40	40	35.71543
V_1	p.u.	1.0563	1.06	1.05276
V_2	p.u.	1.0082	1.0448	0.98645
V_5	p.u.	1.0354	1.0062	1.02549
V_8	p.u.	1.0393	1.0086	1.03141
V_{11}	p.u.	1.057	1.0819	0.95834
V_{13}	p.u.	1.0377	1.07079	1.05963
T_{6-9}	p.u.	1.0197	0.9875	0.97565
T_{6-10}	p.u.	0.9594	0.9596	0.98752
T_{4-12}	p.u.	0.9196	0.93	0.93584
T_{28-27}	p.u.	0.9796	0.9699	0.98798
Qc_{10}	p.u.	22.7301	25	24.5614
Qc_{24}	p.u.	24.5998	21.985	17.654
Fuel cost	$/h	946.5282	945.849241	890.455
Emission	ton/h	0.2048	0.20563812	0.20374
Power loss	MW	3.6245	3.6943449	3.5366

Source: Balasubba (2017)

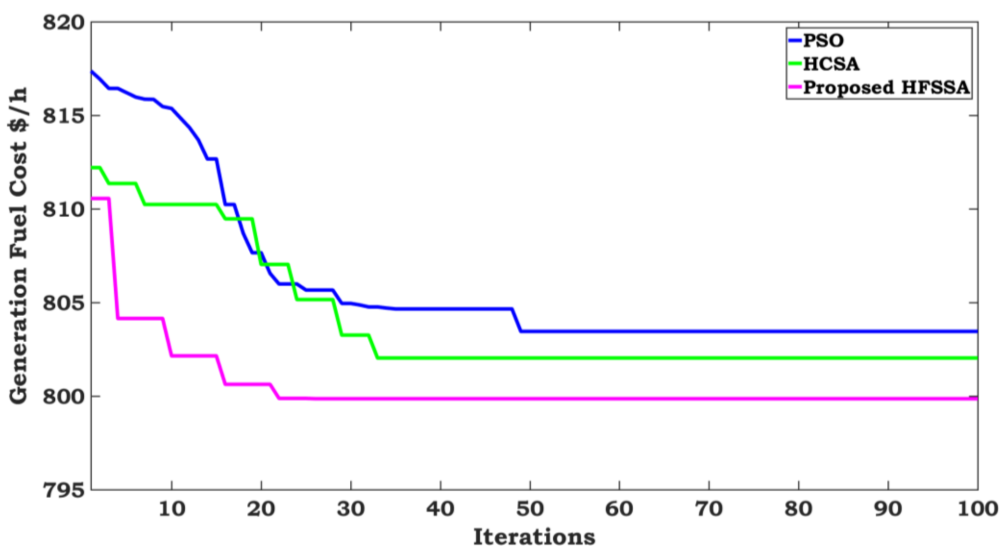

Figure 4. Convergence curve of generation fuel cost.
Source: Balasubba (2016)

RESULTS AND ANALYSIS

Validation of proposed algorithm on benchmark test functions

Two standard test functions were consider to justify the effectiveness of the proposed algorithm, which is mentioned below:

1. Himmelblau's function

$$f(x,y) = (x^2 + y - 11)^2 + (x + y^2 - 7)^2$$

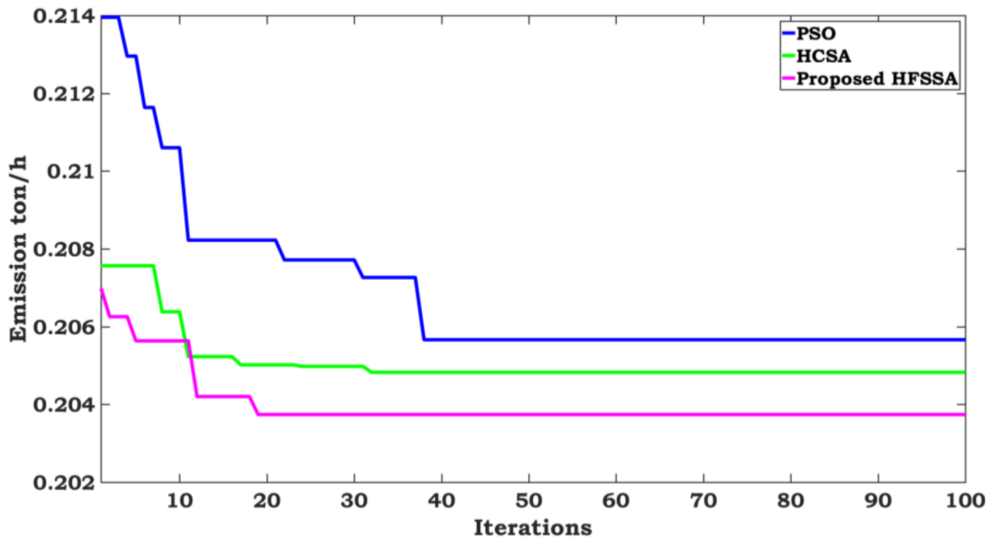

Figure 5. Convergence curve of emission.
Source: Balasubba (2016)

2. Booth's function $f(x, y) = (x + 2y - 7)^2 + (2x + y - 5)^2$

It can be seen from Tables 1 and 2, that the proposed algorithm optimizes the function more efficiently as compared to the other methods available. Booth's function achieves its minimum value that is, 0.0, which is the desired output with best minima and for Himmelblau's function least value i.e. 2.8075e-10 is obtained which is less as compare to the existing methods. The convergence curves are shown in Figures 2 and 3 for both function from which, it can be seen that proposed algorithm converges at lesser number of iterations and initially it starts will less value of function as compared to the existing algorithm. Thus, this validates the robustness and efficiency of the proposed HFSS algorithm.

Electric IEEE-30 bus system

The IEEE 30 bus system is considered to test the proposed HFSA algorithm. In this system total 6 generators and 4 tap changing transformers and 2 shunt capacitors are available. To optimize considered objective functions proposed method runs 100 iterations.

Minimization of generation fuel cost

The considered control variables are optimized for IEEE-30 bus system is shown in Table 3. It could be seen from Table. 3 and Figure 4, that the generation cost obtained by proposed algorithm is 799.86 \$/h which is lower than the generation cost obtained by existing algorithms. It could be analyzed from Figure 4 that proposed algorithm converges at 22nd iteration by which it is proven that its convergence is very fast as compared to other algorithms and least value starts early.

Minimization of emission

Minimization of emission is second objective function. The considered control variables are optimized for IEEE-30 bus system is shown in Table 4. It could be observed from Table 4 and Figure 5, that emissions got minimized to 0.20374 ton/h which is less in comparison to the emissions obtained by existing algorithms. It can also be observe from Figure 5 that convergence curve starts will less value of emission and converge at 18th iteration which is the best result in comparison to the existing observations.

Minimization of transmission losses

Minimization of transmission loss is third objective function. The considered control variables are optimized for IEEE-30 bus system is shown in Table 5. It could be observed from Table 5 and Figure 6, that the transmission loss minimized to 3.167MW which is the best result obtained with the implementation of proposed algorithm. This also converges fast as compared to other algorithms.

Observation can be made from Tables 3-5 that when generation fuel cost is to minimize then power generated

Table 5. OPF result for minimizing transmission loss

Variable	Units	HCSA (Bala RM (2017)	HFFA (et al (2022)	PSO	HFSSA
P_1	MW	51.608	64.5787	98.3715	68.6275
P_2	MW	80	73.1716	80	65.2697
P_5	MW	50	49.1044	50	50
P_8	MW	35	34.6496	20	28.566
P_{11}	MW	30	29.3441	20	30.2568
P_{13}	MW	40	36.3133	20	39.693
V_1	p.u.	1.057	1.035	1.1	1.1
V_2	p.u.	1.0562	1.0295	1.07135	1.0858
V_5	p.u.	1.0383	1.0297	1.06827	1.1
V_8	p.u.	1.0461	1.0217	1.0735	0.9897
V_{11}	p.u.	1.057	1.0249	0.95708	0.9658
V_{13}	p.u.	1.057	1.0293	1.03229	0.9365
$T_{6\text{-}9}$	p.u.	1.0134	1.0648	1	1.0985
$T_{6\text{-}10}$	p.u.	0.9629	0.9786	1.08182	0.9685
$T_{4\text{-}12}$	p.u.	0.9802	0.981	1.1	0.9796
$T_{28\text{-}27}$	p.u.	0.9654	0.9597	1.03477	0.9342
Qc_{10}	p.u.	21.4206	13.1375		20.5299
Qc_{24}	p.u.	16.5347	17.1374		24.0383
fuel cost	$/h	967.9202	940.44	899.618	920.552
Emission	ton/h	0.2072	NA	0.23835	0.2063
Power loss	MW	3.208	3.718	4.97153	3.1687

Souce: Balasubba et al (2022)

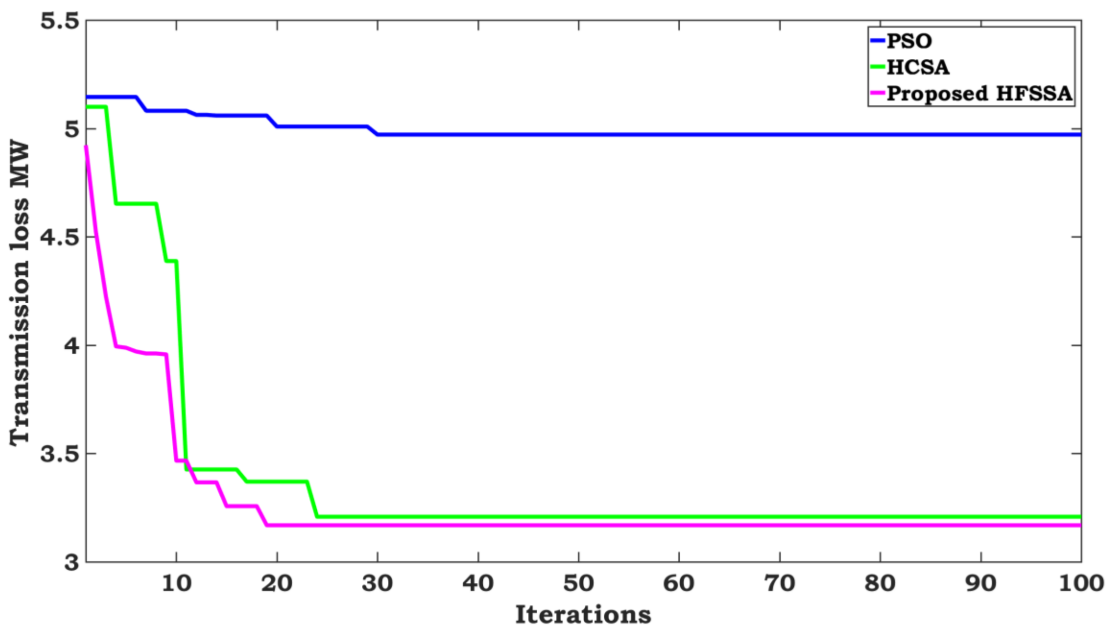

Figure 6. Convergence curve of transmission loss.
Souce: Balasubba (2016)

from slack bus is maximum and power generated for second PV bus is minimum while the minimization of transmission loss and emission power generated from slack bus is minimum and power generated at second PV bus in maximum.

Conclusion

A novel algorithm was proposed by hybridizing SSA and arithmetic crossover operation; proposed named as HFSSA.

The proposed algorithm is validated on benchmark test function that is, Himmelblau's and Booth's functions followed by IEEE-30 bus system, and it has been observed that with the crossover operation the algorithm converges very fast and effectively. It has been observed that the proposed method minimizes the considered objective functions optimally when compared to resent literature. The single objectives of OPF such as generation fuel cost, emission and power losses are optimized to the best value. Thus, the proposed method is superior to the other methods. In future work we extend this work to be implemented to the larger and real power system, so to validate it in more critical and complex situations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abido M (2002). "Optimal power flow using particle swarm optimization", International Journal of Electrical Power and Energy Systems 24(7):563-571.

Ahmed I, Rao AR, Shah A, Alamzeb E, Khan JA (2014). "Performance of Various Metaheuristic Techniques for Economic Dispatch Problem with Valve Point Loading Effects and Multiple Fueling Options", Advances in Electrical Engineering, Hindawi Publishing, https://doi.org/10.1155/2014/765053

Ahmed I, Rehan M, Basit A, Hong KS (2022a). "Greenhouse gases emission reduction for electric power generation sector by efficient dispatching of thermal plants integrated with renewable systems", Scientific Reports 12(1):12380 https://doi.org/10.1038/s41598-022-15983-0

Ahmed I, Rehan M, Basit A, Malik SH, Hong KS (2022b) "Multi-area economic emission dispatch for large-scale multi-fueled power plants contemplating inter-connected grid tie-lines power flow limitations", Energy 261:15-125178 https://doi.org/10.1016/j.energy.2022.125178

Ahmed I, Rehan M, Hong KS, Basit A (2022). "A Consensus-based Approach for Economic Dispatch considering Multiple Fueling Strategy of Electricity Production Sector over a Smart Grid", 2022 13th Asian Control Conference (ASCC) pp. 1196-1201 doi: 10.23919/ASCC56756.2022.9828267.

Ahmed I, Alvi UE, Basit A, Khursheed T, Alvi A, Hong KS, Rehan M (2022d). "A novel hybrid soft computing optimization framework for dynamic economic dispatch problem of complex non-convex contiguous constrained machines", PLoS ONE 17(1):e0261709. https://doi.org/10.1371/journal.pone.0261709

Alsac O, Stott B (1973). "Optimal load flow with steady-state security", IEEE Transactions on Power Systems T 73:484-483.

Balasubba MR (2016). "Multi-objective optimization in the presence of ramp-rate limits using non-dominated sorting hybrid fruit fly algorithm", Ain Shams Engineering Journal pp. 895-905.

Balasubba MR (2017). "A solution to the Multi Objective Optimization problems with FACTS devices using NSHCSA including practical constraints", IEEE International Conference on Power, Control, Signals and Instrumentation Engineering pp. 2615-2624.

Balasubbareddy M (2022). "Optimal Power Flow Solution Using Ameliorated Ant Lion Optimization Algorithm", International Journal of Mechanical Engineering 13(1):1060.

Balasubbareddy M, Divyanshi D (2022). "Salp swarm algorithm for solving optimal power flow problem with thyristor-controlled series capacitor", Journal of Electronic Science and Technology 20(2):1-9.

Balasubbareddy M, Obulesh YP, Sivanaga SR (2012). ''Particle swarm optimization based optimal power flow for volt-var control", ARPN Journal of Engineering and Applied Sciences 7(1):20-25.

Balasubbareddy M, Obulesh YP, Sivanaga SR, Chintalapudi VS (2015). "Mathematical modelling and analysis of generalised interline power flow controller: an effect of converter location". Journal of Experimental and Theoretical Artificial Intelligence 28(4):1-17.

Balasubbareddy M, Sivanaga SR, Ch Venkata S, AV Naresh B, Srilatha D (2017). "A Non-Dominated Sorting Hybrid Cuckoo Search Algorithm for Multi-Objective Optimization in the Presence of FACTS Devices", Russian Electrical Engineering 88:44-53.

Balasubbareddy M, Sivanaga SR, Chintalapudi VS (2015). "Multi-objective optimization in the presence of practical constraints using non-dominated sorting hybrid cuckoo search algorithm", Engineering Science and Technology, an International Journal 18(4):603-615.

Balasubbareddy M, Venkata PP, Ravindra S, Kowstubha P, Venkata K R C (2022), "Multi-Objective Optimal Power Flow Solution Using a Non-Dominated Sorting Hybrid Fruit Fly-Based Artificial Bee Colony", Energies 15(11):1-16.

Barocio E, Regalado J, Cuevas E, Uribe F, Zu´n˜iga P, Torres PJR, (2016). "Modified bio-inspired optimisation algorithm with a centroid decision-making approach for solving a multiobjective optimal power flow problem", IET Generation, Transmission and Distribution 11(4):1012-1022.

Bhattacharya A, Chattopadhyay PK (2010). "Applications of biogeography-based optimization to solve different optimal power flow problems", IET generation, transmission and distribution 5(1):70-80.

Chaib A, Bouchekara H, Mehasni R, Abido M (2016). "Optimal power flow with emission and nonsmooth cost functions using backtracking search optimization algorithm", International Journal of Electrical Power and Energy Systems 81:64-77.

El-Fergany AA, Hasanien HM (2015). "Single and multi-objective optimal power flow using grey wolf optimizer and differential evolution algorithms", Electric Power Components and Systems 43:1548-1559.

El-Hawary JAMME, Adapa R (1999b). "A review of selected optimal power flow literature to 1993. part ii: newton, linear programming and interior point methods". IEEE Transactions on Power Systems 14(1):105-111.

El-Hawary JAMME, Adapa R (1999a). "A review of selected optimal power flow literature to 1993. part i: nonlinear and quadratic programming approaches", IEEE transactions on power systems 14(1):96-104.

Hermann WD, William FT (1968). "Optimal Power Flow Solutions", IEEE transactions on power apparatus and systems (10):1866-1876.

Jadon SS, Bansal JC, Tiwari R, Sharma H (2014). "Artificial bee colony algorithm with global and local neighborhoods", International Journal of System Assurance Engineering 8:1-13.

Javad L, Anders R, Stephen L (2011). "Power flow optimization using positive quadratic programming", 18th IFAC (Italy).

Kumari MS, Maheswarapu S (2010). "Enhanced genetic algorithm-based computation technique for multi-objective optimal power flow solution", International Journal of Electrical Power & Energy Systems 32:736-742.

Li MD, Zhao H, Weng XW, Han T (2016) "A novel nature-inspired algorithm for optimization: virus colony search", Advances in Engineering Software 92:65-88.

Mallala B, Divyanshi D, Garikamukkala VKM, Kotte SK (2022). "Optimal power flow solution with current injection model of generalized interline power flow controller using ameliorated ant lion optimization”, International Journal of Electrical and Computer Engineering 13(1):1060-1077.

Mohit J, Vijander S, Asha R (2019). “A novel nature-inspired algorithm for optimization: Squirrel search algorithm”, swarm and evolutionary computation 44148-175.

Osman M, Abo-Sinna MA, Mousa A (2004). “A solution to the optimal power flow using genetic algorithm”, Applied Mathematics and Computation 15:391-405.

Pulluri H, Naresh R, Sharma V (2017) “An enhanced self-adaptive differential evolution-based solution methodology for multi objective optimal power flow”, Applied Soft Computing 54:229-245.

Qun N, Hongyun Z, Xiaohai W, Kang L, George WI (2014) “A hybrid harmony search with arithmetic crossover operation for economic dispatch”, Electrical Power and Energy Systems 62:237-257.

Singh DK, Srivastava S, Khanna RK, Balasubbareddy M (2020). “Optimal placement of IPFC for solving optimal power flow problems using Hybrid Sine-Cosine Algorithm”, Elementary Education Online 19(4):3064-3080.

Sun DI, Ashley B, Brewer B, Hughes A, Tinney WF (1984) “Optimal power flow by newton approach, IEEE Transaction on Power Apparatus and Systems (10):2864-2880.

Thomas RB, Weigl PD (1998) “Dynamic foraging behavior in the southern flying squirrel (glaucomys volans): test of a model”, The American Midland Naturalist 140(2):264-270.

Xie K, Song YH (2002), “Dynamic optimal power flow by interior point methods”, IET Proceedings Generation, Transmission and Distribution 148(1):76-84.

Yalcinoz T, Halis A (2005), “A new genetic algorithm with arithmetic crossover to economic and environmental economic dispatch”, International journal of engineering intelligent systems 3:173-180.