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Hybrid GSA-MFO Technique for Solving Unit Commitment Problem

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ABSTRACT

Nature-inspired algorithms are among the most powerful algorithms for optimization. This paper intends to provide hybrid optimization algorithms for solving unit commitment problem. We will compare the different algorithm with one another. In this paper firstly the MFO is compared with the results obtained after implementation of Hybrid GSA-MFO technique for IEEE 4 and 10 unit system. From the above comparison we shall see the difference in the overall cost of running the units as the cost function is less by using the Hybrid algorithms.

INTRODUCTION

Optimization is a substitute with the most cost effective or highest reachable performance under the given constraints, by maximizing desired factors and minimizing undesired ones.

The various solution methods divided for unit commitment problem are divided two classes:

- Priority list methods, dynamic programming, Lagrangian relaxation methods branch-and-bound methods and mixed-integer programming (Numerical optimization technique).
- Genetic algorithms, evolutionary programming, simulated annealing and particle swarm optimization (Stochastic search methods).

Out of these two methods of optimization the stochastic search methods are nowadays used as these techniques gives the better results for the unit commitment problem [1-5]. In this paper we discuss the Gravitational search algorithm and Moth flame optimization technique and after implementation of these techniques the results have been shown as a graphs and tables.

Mothe Flame Optimization

Moths are fancy insects, which are highly similar to the family of butterflies. Basically, there are over 160,000 various species of this insect in nature. They have two main milestones in their lifetime: larvae and adult. The larvae is converted to moth by cocoons. The most interesting fact about moths is their special navigation methods in night. They have been evolved to fly in night using the moon light. They utilized a mechanism called transverse orientation for navigation. In this method, a moth flies by maintaining a fixed angle with respect to the moon, a very effective mechanism for travelling long distances in a straight path. Since the moon is far away from the moth, this mechanism guarantees flying in straight line. The same navigation method can be done by humans. Suppose that the moon is in the south side of the sky and a human wants to go the east. If he keeps moon of his left side when walking, he would be able to move toward the east on a straight line.

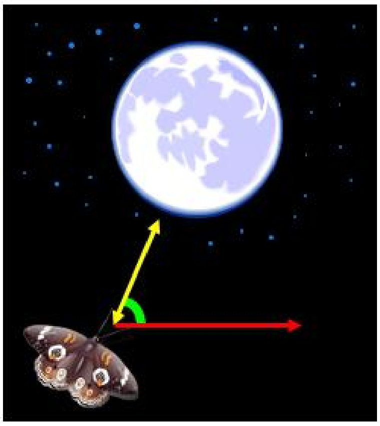

Fig 1.1 Moth flying at angle with moon

Despite the effectiveness of transverse orientation, we usually observe that moths fly spirally around the lights. In fact, moths are tricked by artificial lights and show such behaviours. This is due to the inefficiency of the transverse orientation, in which it is only helpful for moving in straight line when the light source is very far. When moths see a human-made artificial light, they try to maintain a similar angle with the light to fly in straight line. Since such a light is extremely close compared to the moon, however, maintaining a similar angle to the light source causes a useless or deadly spiral fly path for moths [9]. A conceptual model of this behaviour is illustrated as follows in fig 1.2.

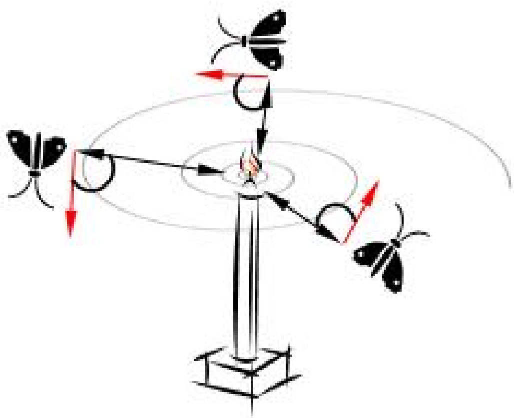

Fig 1.2

The moth eventually converges towards the light. I mathematically modeled this behaviour and proposed an optimizer called Moth-Flame Optimization (MFO) algorithm.

Gravitational search algorithm

GSA is a heuristic optimization algorithm which has been gaining interest among the scientific community recently. GSA is a nature inspired algorithm which is based on the Newton's law of gravity and the law of motion. GSA was introduced by Rashedi et al. in 2009 and is intended to solve optimization problems. The population-based heuristic algorithm is based on the law of gravity and mass interactions. The algorithm is comprised of collection of searcher agents that interact with each other through the gravity force. The agents are considered as objects and their performance is measured by their masses. The gravity force causes a global movement where all objects move towards other objects with heavier masses. The slow movement of heavier masses guarantees the exploitation step of the algorithm and corresponds to good solutions. The masses are actually obeying the law of gravity as shown in Equation (1) and the law of motion in Equation (2).

F = G (M1M2 / R2) …(1)

a = F/M….. (2)

Based on Equation (1), F represents the magnitude of the gravitational force, G is gravitational constant, M1 and M2 are the mass of the first and second objects and R is the distance between the two objects. Equation (1) shows that in the Newton 3 A Review of Gravitational Search Algorithm law of gravity, the gravitational force between two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between the objects. While for Equation (2), Newton's second law shows that when a force, F, is applied to an object, its acceleration, a, depends on the force and its mass, M. In GSA, the agent has four parameters which are position, inertial mass, active gravitational mass, and passive gravitational mass [8]. The position of the mass represents the solution of the problem, where the gravitational and inertial masses are determined using a fitness function. The algorithm is navigated by adjusting the gravitational and inertia masses, whereas each mass presents a solution. Masses are attracted by the heaviest mass. Hence, the heaviest mass presents an optimum solution in the search space.

In this Hybrid moth flame optimization technique first of all the Gravitational Search Algorithm runs to find the optimum solution after this the Moth Flame optimization technique is used to set this solution as its input value for finding its best optimum solution. Thus this hybrid algorithm is used to cut the cost function for running the generators units and this hybrid algorithm is applied to IEEE 4 and 10 unit system [6] and the results have been discussed as an graphs and tables as shown below.

RESULTS

Following graph in fig 2 shows the total cost of generation for IEEE 4 unit system [6] when we applied different techniques and we see from the results that the hybrid moth flame optimization algorithm gives the best results for the constrained unit commitment problem.

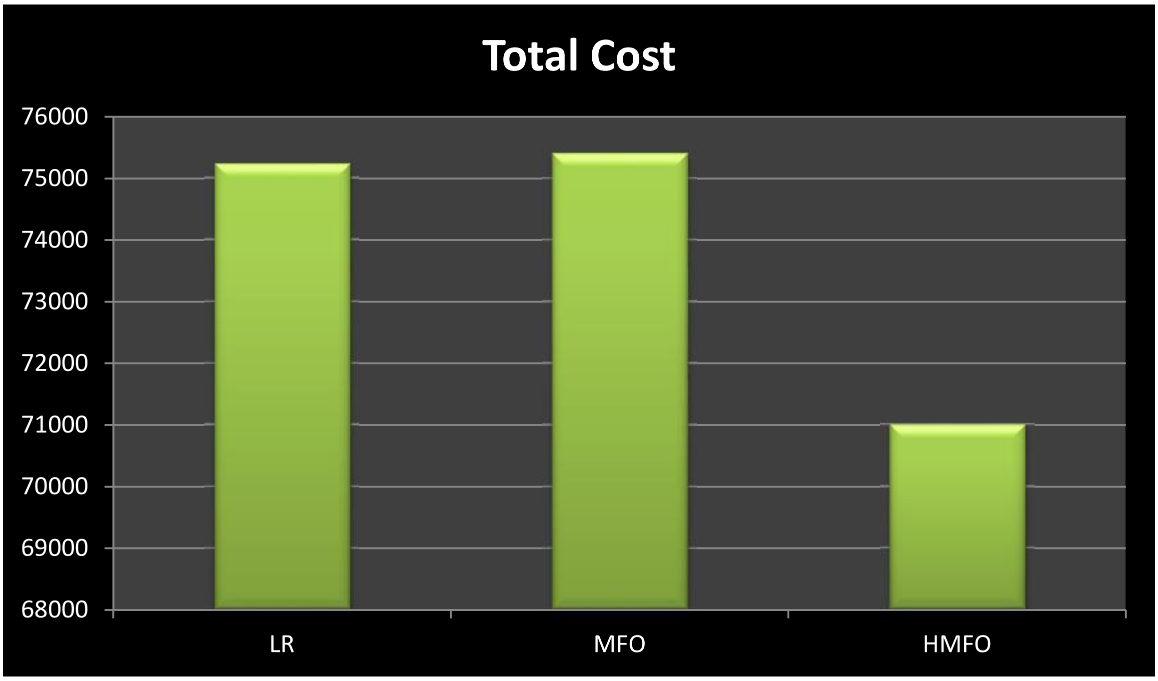

Fig 2. Bar graph showing the total cost of generation in 4 unit system for different techniques.

Whereas table 1 showing the power generated in MW for MFO and HMFO generation scheduling for an IEEE 4 unit system in hourly basis and similarly table 2 and table 3 gives the power generated for IEEE 10 unit system when different algorithm is applied and we see that the Hybrid MFO technique gives the minimum operating cost of generation.

Hour	Load(MW)	MFO Generation schedule				MFO operating Cost	HMFO Generation Schedule				HMFO operating Cost
		P1	P2	P3	P4		P1	P2	P3	P4	
1	400	157	230	0	61	9601	146	303	0	0	8984
2	530	172	357	0	0	10116	259	270	0	0	10165
3	600	129	470	0	0	11422	109	449	0	41	11900
4	540	165	374	0	0	10299	117	422	0	0	10316
5	400	25	207	192	20	9434	84	315	0	0	7777
6	280	25	60	239	40	6985	64	187	0	28	6058
7	290	98	0	191	0	6796	66	199	0	24	6213
8	500	230	0	269	0	10742	135	364	0	0	9573

Table 1.

Hour	Load(MW)	MFO Generation schedule										MFO operating Cost
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1	700	150	364	107	20	73	60	25	47	45	10	25463
2	750	150	434	129	20	45	48	25	10	41	49	18165
3	850	0	534	80	0	68	78	0	21	0	66	20055
4	950	0	525	104	0	76	0	0	25	66	51	22607
5	1000	0	620	157	0	76	0	0	25	68	51	23116
6	1100	0	555	0	87	264	0	0	0	99	92	25959
7	1150	0	885	0	136	127	0	0	0	0	790	22504
8	1200	0	739	0	221	212	0	0	0	0	26	24627
9	1300	659	284	0	184	165	0	0	0	0	54	31080
10	1400	462	550	0	217	97	0	0	0	0	71	28605
11	1450	604	415	0	134	122	0	0	23	72	77	31859
12	1500	783	469	0	71	81	0	0	0	94	0	30328
13	1400	461	514	0	99	0	78	80	72	44	0	32704
14	1300	563	558	0	77	0	32	67	0	0	0	26420
15	1200	564	423	0	53	0	47	48	0	0	61	25932
16	1050	439	443	20	79	25	20	56	10	10	31	22479

17	1000	496	0	0	134	0	0	177	112	78	0	24075
18	1100	754	0	0	90	0	0	142	88	0	24	24522
19	1200	790	0	0	244	0	0	78	86	0	0	24535
20	1400	836	0	0	308	0	0	78	93	82	0	29630
21	1300	616	0	223	271	0	0	71	116	0	0	28301
22	1100	780	0	101	167	0	49	0	0	0	0	21514
23	900	573	0	32	200	0	93	0	0	0	0	18274
24	800	372	0	103	113	0	95	0	28	0	86	19261

Table 2

Hour	Load(MW)	HMFO Generation schedule										HMFO operating Cost
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1	700	459	0	0	82	0	79	0	14	64	0	22117
2	750	590	0	0	90	0	68	0	0	0	0	14855
3	850	586	0	0	92	0	50	0	32	41	46	19794
4	950	789	0	0	48	0	111	0	0	0	0	18518
5	1000	645	0	0	205	0	71	0	0	0	78	20677
6	1100	882	0	0	206	0	70	0	0	0	0	20802
7	1150	790	0	0	144	0	135	79	0	0	0	23674
8	1200	693	0	0	208	0	88	96	112	0	0	25930
9	1300	767	0	0	179	0	124	128	0	99	0	28170
10	1400	1067	0	0	101	0	231	0	0	0	0	27099
11	1450	1116	0	256	0	0	76	0	0	0	0	27439
12	1500	857	0	488	0	0	154	0	0	0	0	28491
13	1400	840	0	288	0	0	142	104	0	0	72	29809
14	1300	755	0	230	0	0	83	145	0	0	84	27988
15	1200	751	0	229	0	0	49	82	0	87	0	25399
16	1050	869	0	0	0	0	0	180	0	0	0	20952
17	1000	796	0	0	0	0	0	53	23	60	65	22388
18	1100	1000	0	0	0	0	0	66	0	0	32	21596
19	1200	1000	0	0	0	0	0	0	0	199	0	23905
20	1400	1216	0	0	0	0	0	0	64	119	0	27758
21	1300	1086	0	0	0	0	0	0	0	84	128	26457
22	1100	666	0	0	0	0	145	150	0	71	66	26008
23	900	723	0	0	0	0	102	73	0	0	0	18227
24	800	536	0	0	0	0	114	91	0	0	56	18160

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Table 3

Following is the bar graph in figure 3 showing the comparison of operation cost of MFO and HMFO for hourly basis for an IEEE 4 unit and 10 unit systems.

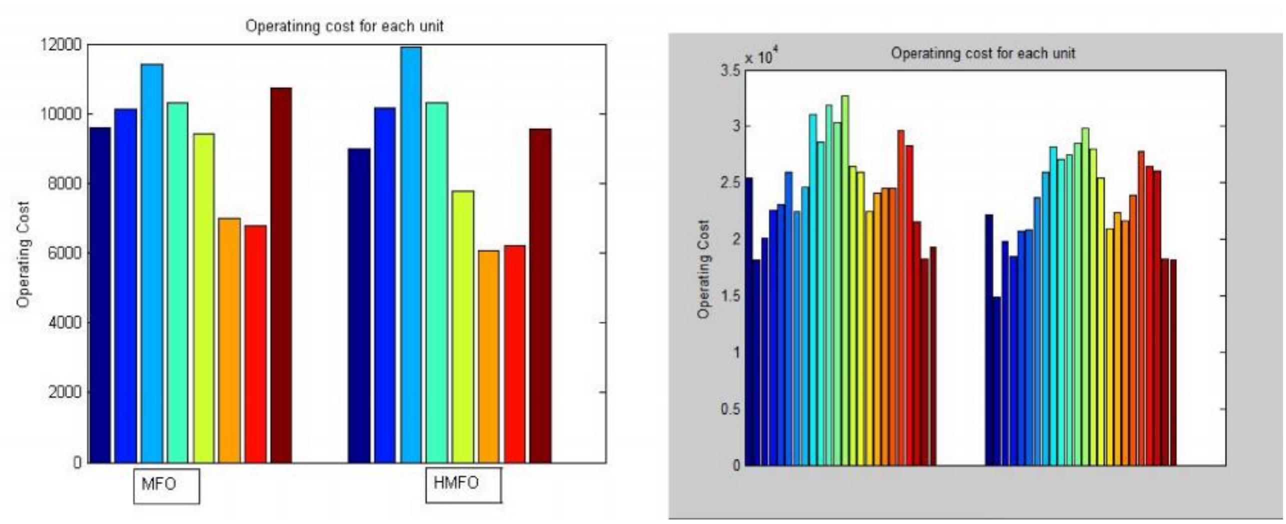
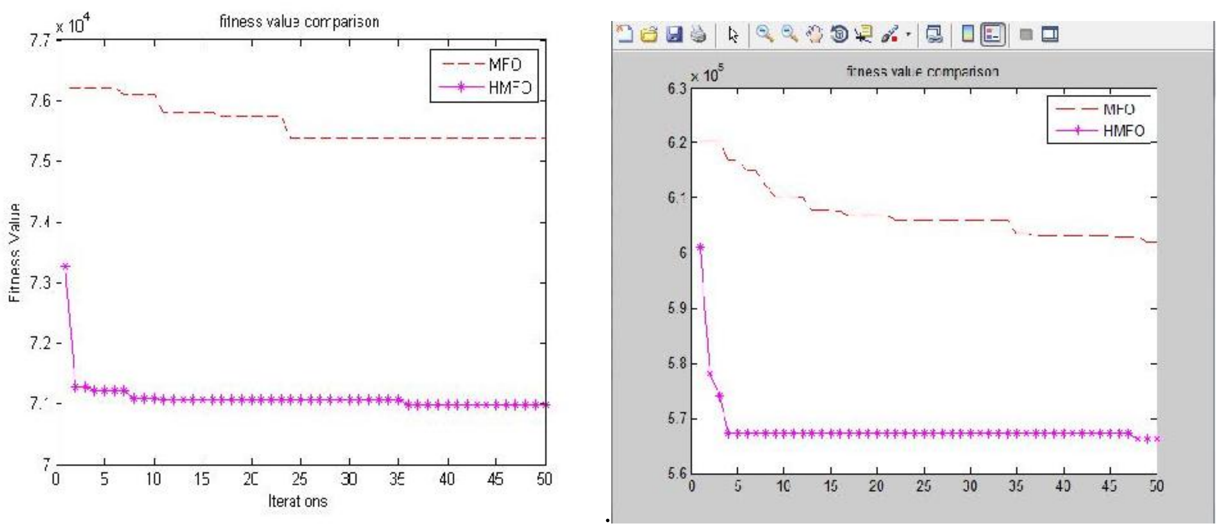


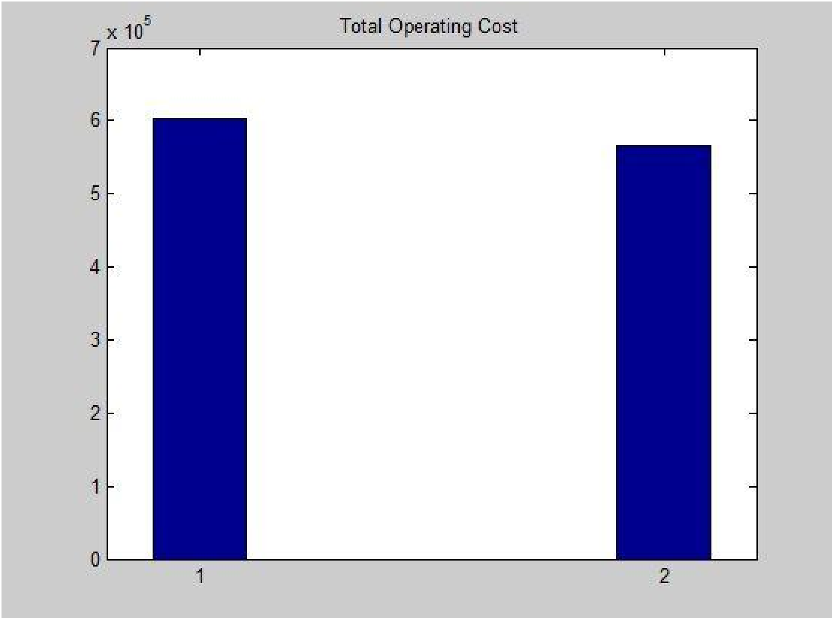
Fig. 3

Graph 1 showing comparison of cost in MFO and HMFO technique for IEEE 4 and 10 unit system.



Graph 1

Similarly the bar graph shown in figure 4 shows the IEEE 10 unit operating cost results for an MFO (bar graph 1) and HMFO (bar graph 2) technique and it is clear that by using hybrid Moth flame optimization technique we can decrease the cost of running the units to an certain extend.



CONCLUSION

This paper presents a new methodology for solving UC problem. The proposed algorithm is the hybrid method which incorporates GSA into the MFO technique and improve the performance of MFO method. Four and ten unit test systems are simulated to demonstrate the effectiveness of the proposed method compared with other methods. From the results, it can be concluded that the proposed method provede a cheaper cost than those obtained from LR, GA, GSA and MFO methods, In an addition, the proposed method could be extended to solve new profit based unit commitment problem under the competitive environment.

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