Journal of Scientific & Industrial Research
Vol. 79, October 2020, pp. 894-897

Hybridization of ALO and GOA for Combined Economic Emission Dispatch

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Received 20 December 2019; revised 27 August 2020; accepted 4 September 2020

A hybrid algorithm is presented for CEED problem with generation, emission and combustion of fuel & emission cost as an objective. The proposed algorithm is combined with both ant lion optimizer and grass hopper optimizations called as integrated ant lion grasshopper optimization algorithm (IALGOA). To find an optimal solution for a CEED, the IALGOA is proposed in this paper. The IALGOA performance is compared and analyzed with conventional hybrid algorithms like PSO, GSA and Adaptive Wind Driven Optimization (AWDO) under standard IEEE 30-bus test system. The presented numerical results explain IALGOA algorithm's excellent convergence characteristics.

Keywords: CEED, EED, Hybrid algorithm, IALGOA

Introduction

Nowadays, researchers are looking for some new techniques and algorithms to solve power system problems. From all the research, it has concluded that optimization is the only method in dealing with CEED problem.[1] The innovations for problem solving, the optimization techniques came from the nature inspired algorithms. Researchers started taking a close look at all the species and rounded off a solution from their characteristics.[2] In today's world, the fascinating thing is natured inspired algorithms are like Genetic Algorithm (GA), Differential Evolutionary Algorithm (DEA) and Swarm Intelligence Algorithm.[3] In literature with some improvements in conventional algorithms, Particle Swarm Optimization (PSO) is also developed.[4] There are several optimization techniques are presented in the literature to specify the issues like simulated annealing, genetic algorithms and tabusearch.[5] However, combination algorithms, so called as hybrid algorithms.[6]

Economic Load Dispatch (ELD)

The ELD process is essentially designed, to achieve load productivity. However, this implementation is not quite easy, because of highly nonlinear constrained optimization process.[7–9] Both the cost and minimization of emissions with ED is known as CEED. There are two contending objectives of the CEED issue. The main objective can be depicted as deciding the optimum power generation plan from an assortment of online based units to satisfy the load demand subject to a few physical and operational requirements to decrease fuel costs. The second objective is to decide the optimal power generation plan from an assortment of internet creating units to fulfill the load demand to decrease the pollutant emission produced by the producing units. All contending objectives must be adjusted simultaneously as running the system at low cost would bring about higher emissions and considering just the restricted ecological effect which brings about high system production costs isn't sensible. This segment talks about the essential elements of the CEED issue together with the limitations of decency and inequalities to maintain exacting standards to meet the useful requirements of the power system. The ED is utilized to reduce the total cost of fuel at the CEED problem can be controlled by minimization of emission and fuel cost with respect to their constraints.[10–14] This paper concentrated on solving the CEED by using proposed hybrid algorithm using MATLAB environment and the numerical results are compared with conventional algorithms.

Experimental Details

Problem Formulation

CEED is a multi-objective problem; Using Penalty Factor (PF), it can be changed to a single objective problem.

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The CEED problem is expressed using the following expressions,

$$Min[C_T = Min[W * F_i(P_{Gi}) + (1-W) * h \; * E_i] \quad \ldots (1)$$

$$F_i(P_{Gi}) = a_i P_{Gi}^2 + b_i P_{Gi} + C_i P_{Gi} + |e_i X \sin(f_i X (P_{Gi}^{min} - P_{Gi})| \quad \ldots (2)$$

$$E_i = \alpha_i + \beta_i P_{Gi} + \gamma_i P_{Gi}^2 + \zeta_i \exp^{\lambda_i P_{Gi}} \quad \ldots (3)$$

Where, α_i, β_i, γ_i, ζ_i, λ_i and a_i, b_i, c_i, e_i, f_i are defined as the i_{th} generator emission and fuel coefficients respectively, C_T is total operational cost in ($/hr), h is price penalty factor ($/ton) and W is weighting factor lies in between 0 −1.

Hybridization of ALO and GOA

The proposed approach is a shared execution of IALGOA and Grasshopper Optimization Algorithm (GOA). The ALO's seek out behavior improves the quality of ALO parameters by integrating with GOA technique called as Integrated ALO (IALO). The steps involved for hybridization of ALO and GOA is as follows,

Implementation of ALO

Step 1: Initialization

Initially, each bus voltage and power loss are given as input for implementation of an algorithm.

Step 2: Ant-lion's Trapping

The arbitrary walk of ants can be impacted by the ant lions pit trapping. So to meet assumptions mathematical equations are developed for the model.

Step 3: Trap Construction

The chasing limit of ALO is displayed by utilizing Roulette Wheel (RW). For improving fitness, ant lions RW operator is utilized in ALO calculation. This technique provides, the fitter in ant lions as a superior possibility of getting ants.

Step 4: Ants sliding

The snares random are essential to move comparable to their fitness and ants. In any case, when they understand that the pit mid ant lions shoots the dirt in a snare outward. The slide conduct in the insect as attempting to get away.

Step 5: Pit re-constructing and catching prey

The last phase of chasing is arrived at insect arrived at the base at which the pit is for the most part caught in jaw of the subterranean insect lion. The insect lion pulls the subterranean insect inside the sand and consumes it. The consumed position of ant will update the position of ant lion. It further improves the catching of new prey chances.

Step 6: Fitness Evaluation

The fitness function is characterized by the current and power parameter variation, in order to limit an error. The fitness function is expressed as, Fit = Maximization [PL_{line}].

Step 7: Elitism

The position of ant lion's is spared as best solution at each phase to protect the best arrangement acquired. The ant moment is impacted by thinking best insect lion. By using roulette wheel, elitism expected that every arbitrary stroll of insect around ant lion as follows, especially and simultaneously for the first class.

Step 8: Mutation

The salps are mutated randomly in the mutation process.

Step 9: Final Process

In the final step, the termination process will start when only if an iteration count is reached to the maximum value. So that, it determines the chromosomes voltage, cost and power chromosomes are obtained.

Implementation of GOA:

Step 1: Initialization

In the first step, GOA's adjustable parameters need to be initialized.

Step 2: Random Solution Generation

In this step, the random solutions are generated from the following expressions,

$$SI = \sum_{\substack{j=1 \\ j \neq 1}}^{N} m_1(u_{v,ij})\overline{u_{v,ij}} \quad \ldots (4)$$

$$\Re_i = RAND_1 SI_1 + RAND_2 GF_2 + RAND_3 WA_3 \quad \ldots (5)$$

$$OF_i = Minimization(mof_1, mof_2, mof_3, mof_4, mof_5) \quad \ldots (6)$$

Where $\Re_i$ is the random solution generation.

Step 3 & 4: Social Interaction & Fitness Function

In Eq. (4), m_1 function explains the social forces strength, which means grasshopper repulsion and attraction, $u_{v,ij}$ denotes the vector of $i^{th} - j^{th}$ grasshopper.

The population's fitness is assessed by the grasshopper's position. The multi-objective function (mof) and the random solution generation are given in Eq. (5).

In Eq. (6), mof_1, mof_2, mof_3 and mof_4 are specified as economic cost, emission cost, power loss and voltage deviation respectively.

Step 5: Gravity Force

An arrangement of fascination, safe place and aversion locale will be determined from the space in between the m_1 function and two grasshoppers. The estimation of function gets zero, in particular if the separation surpasses value of 10.

Step 6: Wind Advection

The course of wind will exceptionally impact on development of youthful grasshoppers. The gravity force is measured for estimation. It is also expected that, wind consistently focused on value of T.

Step 7: Exploitation and Exploration

The exploitation and exploration are two ordered stages in optimization method. Exploration implies that answers for profoundly randomized practices are fundamentally altered. More prominent arrangements changes leads to further exploration.

Step 8: Position Updating

The position of grasshopper is updated by a value of W.

Step 9: Termination

In termination step, check for the stopping condition or move to step no. 3. If, it isn't fulfilled or else finish the inquiry, when the termination condition is met, it gives best memory position by accounting the problem.

Results and Discussion

The hybrid IALGOA algorithm is proposed and tested under the standard IEEE 30 bus system. The testing is carried out in two test cases of the CEED problem (i) without valve point effect (ii) with valve effect. In this paper, the minimization is carried out with three values of weight factors: W=1; W=0; W=0.5.

From the results seen in the Table 1, are best solutions obtained by an IALGOA with and without valve point effect. From the Table 1, it is clear that the value of W=0.5 gives the optimal solution when compared with remaining values of weight factor (W).

The results of various algorithms: IALGOA, AWDO and PSOGSA with valve point effect are shown in Table 2. Among all algorithms, the IALGOA shows best results in view of fuel cost and Emission. It shows that the fuel cost obtained by using IALGOA is 1.23$/hr which is less than the valve obtained by using the AWDO is 1.24$/hr.

The results of various algorithms: IALGOA, AWDO and PSOGSA with valve point effect are shown in Table 3. Among all IALGOA shows best results, in view of fuel cost and emission.

Table 1 — Solutions obtained by IALGOA for an IEEE 30 bus system

Generation (MW)	Without Valve point Effect			With Valve point Effect		
	W=1	W=0	W=0.5	W=1	W=0	W=0.5
P_1 (MW)	120.656	150.626	129.634	174.326	150.684	160.56
P_2 (MW)	57.582	47.852	58.894	49.642	50.354	51.256
P_3 (MW)	37.303	27.135	39.267	21.859	35.015	40.652
P_4 (MW)	29.910	25.984	23.687	21.791	20.672	20.689
P_5 (MW)	21.88	18.594	20.564	13.145	20.546	15.543
P_6 (MW)	22.903	20.231	19.687	12	15.456	12.96
Fuel Cost($/hr)	888.978	900.468	898.892	887.115	903.345	897.115
Emission cost(Ton/hr)	0.090291	0.191246	0.098456	0.09329	0.190246	0.097456
CEED(($/Ton)	905.389	1057.90	1050.69	900.345	1059.78	1044.42
P loss	2.5964	3.6330	2.5985	1.8979	3.5933	1.94561

Table 2 — Best solution comparisons for the test system with valve point effect for various algorithms

Algorithm	W=1				W=0				W=0.5			
	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr)	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr)
IALGOA	899.115	0.09329	1.8979	900.345	903.345	0.190246	3.593	1059.78	897.115	0.097456	1.965	1044.42
AWDO	894.215	0.09897	1.879	905.456	906.158	0.199578	3.533	1060.15	899.254	0.099658	1.954	1045.89
PSOGSA	893.248	0.09978	1.880	907.315	907.548	0.198947	3.523	1067.15	899.324	0.099789	1.961	1047.57

Table 3 — Best solution comparisons for the test system without valve point effect for various Algorithms

Algorithm	W=1				W=0				W=0.5			
	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr)	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr)	Fuel cost ($/h)	Emission (ton/h)	P_{loss} (MW)	CEED (Ton/hr)
IALGOA	888.978	0.090291	1.8979	905.389	900.468	0.191246	3.593	1057.90	898.892	0.098456	1.965	1050.69
AWDO	890.784	0.099489	1.879	908.456	905.795	0.198689	3.533	1064.89	899.798	0.099659	1.954	1055.99
PSOGSA	895.145	0.0999879	1.880	910.315	909.178	0.199678	3.523	1066.97	899.567	0.099987	1.961	1059.57

Conclusions

The proposed hybrid IALGOA is flourished to resolve CEED problem. The effectiveness of the IALGOA has been investigated by comparing with conventional algorithms like AWDO and PSOGSA. The emission, fuel cost and power loss are determined for different weight factors. From the results, it is concluded that the proposed algorithm gives excellent convergence characteristics, which can be applied to other power system problems, to get optimum results.

References

1 Elvira-Ortiz D A, Morinigo-Sotelo D, Romero-Troncoso R J & Osornio-Rios R A, Photovoltaic power generation estimation using statistical features and artificial neural networks, *J Sci Ind Res*, **78(04)** (2019) 212−215.

2 Debnath S, Sastry G R K & Rai R N, Multi-Objective decision making optimization for electro discharge machining process of al-4.5cu-sic composite using fuzzy-topsis, *J Sci Ind Res*, **78(02)** (2019) 86−90.

3 Kuppuswamy C L & Raghavendiran T A, FPGA implementation of carrier disposition PWM for closed loop seven level diode clamped multilevel inverter in speed control of induction motor, *J Sci Ind Res*, **77(09)** (2018) 504−509.

4 Auxillia D J, Parallel tuning of fuzzy tracking controller for deep submergence rescue vehicle using genetic algorithm, *Ind J Geo Mar Sci*, **46(11)** (2017) 2228−2240.

5 Reddy J N, Lenine D & Kumar M V, experimental study of seven level magnetic coupled impedance source inverter, *J Sci Ind Res*, **77(12)** (2018) 705−709.

6 Moghaddam M J H, Kalam A, Shi J & Gandoman F H, A model for reconfiguration and distributed generation allocation considering reduction of network losses, *J Sci Ind Res*, **77(11)** (2018) 615−620.

7 Chaithanya Seetha, V Naga Bhaskar Reddy & R Kiranmayi, Modeling & analysis of grid-tied PMA based Offshore Wind Energy System using PSCAD/EMTDC, *Ain Shams Eng Journal*, **10(2)** (2019) 411−417.

8 Tanisha & Majumdar M, Optimization of an antihyperglycemic triherbal formulation using response surface methodology, *J Sci Ind Res*, **78(01)** (2019) 39−45.

9 Claret S P A & Alex M G, Estimation of power distribution in substation components using object oriented analysis and design, *J Sci Ind Res*,**76(04)** (2017) 239−243.

10 Joshi M R & Dhanasekaran R, Power factor improvement in switched reluctance motor drive, *J Sci Ind Res*, **76(01)** (2017) 63−67.

11 Adhikari S & Sinha, N, Optimal coordination of directional overcurrent relays using bacteria foraging algorithm, *J Sci Ind Res*, **75(09)** (2016) 557−561.

12 Pungut N A F Bt, Hannoon N M S & Ibrahim P Bin, Power analysis of autonomous microgrid, *J Sci Ind Res*, **76(10)** (2017) 626−630.

13 Seetha Chaithanya, V N B Reddy & R Kiranmayi, Performance evaluation of PMSG-based LFAC system for offshore wind power, *Int J Amb Energy*, (2019) 1−6.