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Solving Environmental Economic Load Dispatch with Line Losses in Power System using Lion Pride Optimization Algorithm

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Abstract: *The alarming environmental pollution from the emission produced by the coal based power plants, has converted the economic load dispatch that minimizes only the total fuel cost into a multi objective function for emission minimization . The Lion Pride Optimization algorithm simulates the lion pride behavior based on lion pride evolution process and group livingstrategy and can be used to solve economic, emission and line losses problems by a single equivalent objective function. In this work LPOA is used for solving economic load dispatch problem and the result produced by LPOA algorithm are compared with the result obtained by other optimizing techniques like Particle Swarm Optimization, Genetic Algorithm Optimization, etc. Results shows that LPOA has better performance than other bio inspired algorithms various multimodal optimization problem. LPOA is robust and it is affected by pride update strategy and brutal competition of individual lions.*

Keywords: *Environmental Emission load Dispatch, Lion Pride Optimization Algorithm, Transmission line losses, Survival of Fittest.*

1. INTRODUCTION

Environment impact of any human action is of great concern including power generation and thus primary objective in the planning and operation of power systems is not only to provide reliable and quality power to consumers but also at economical cost with less carbon footprints. The increasing energy demand and the decreasing energy resources and use of solar, wind power have made optimization a great necessity in power system operation and planning.

Economic Load Dispatch (ELD) is principally an optimization scheme of computing the best generation schedule to supply a predetermined load, with minimum cost while satisfying the essential constraints like power balance and generation limits. Coal based thermal power stations are a major cause of atmospheric pollution, due to the high concentration of pollutants emitted. The purpose of Enviroment Economic Load Dispatch (EELD) is to obtain the optimal generation schedule by minimizing the fuel cost and the emission level simultaneously while satisfying load demand and other operational constraints.

Several classical optimization approaches were proposed to solve the traditional ELD problem, including like lambda iteration method, gradient-based method, Bundling method [2], nonlinear programming [3], mixed integer linear programming [4],

dynamic programed method (DPM) [6], linear programming (LPM) [7], quadratic programming (QPM)[9], Lagrange relaxation method (LRM) [8], Newton-based techniques [10], reported in the literature are used to solve economic load dispatch problem but these methods are workable on ideal systems only with continuous functions.

Many natural computing algorithms have recently shown the efficiency in dealing with many discreet optimization constrained problems for finding the optimal solution in various engineering problems evolutionary programming (EPA) [11], simulated annealing (SA) [12], Tabu search (TS) [14], pattern search (PS) [15], Genetic algorithm (GA) [16], Differential evolution (DE) [17], Ant colony optimization [18], Neural network [19], particle swarm optimization (PSO) [20]. In this paper Lion Pride Optimization Algorithm is being proposed to solve constrained engineering problems is proposed by B R Rajkumar [21] and Wang [24].Until now many researches have been carried out to find the solution of optimization problem using LPOA like community detection problem by Babers[22] and it was inferred that the LPOA is more robust and efficient in determining the optimization. So far in the literature survey it was found that LPOA is not used in solving Environment economic Load dispatch with transmission line losses , thus it is attempted for study purpose in this paper.

2. PROBLEM FORMULATION

The mathematical modeling of power generation considers total cost of operation includes the fuel cost, cost of labour, supplies and maintenance. The present formulation treats the environmental economic dispatch problem as a multi-modal optimization problem which simultaneously optimizes various related objectives as well as satisfying both equality and inequality constraints. The objectives can be incorporated are fuel cost, emission objectives like sulphur, nitrogen and carbon dioxide and system losses. With these multiple objectives and constraints, the Multi-Objective Environmental is modelled. The total fuel cost in terms of real power output can be expressed with the function

$$F_F(P) = \sum_{j=1}^{N}\left(a_j P_j^2 + b_j P_j + c_j\right) \qquad (1)$$

Emission Objective: The atmospheric pollutants such as sulphur, nitrogen and carbon dioxide and system lossescan be modeled separately and are discussed below:

$$F_S(P) = \sum_{j=1}^{N}\left(\alpha_{sj} + \beta_{sj} P_j + \gamma_{sj} P_j^2\right)$$

$$F_N(P) = \sum_{j=1}^{N}\left(\alpha_{nj} + \beta_{nj} P_j + \gamma_{nj} P_j^2\right)$$

$$F_C(P) = \sum_{j=1}^{N}\left(\alpha_{cj} + \beta_{cj} P_j + \gamma_{cj} P_j^2\right) \qquad (2)$$

where Fs is the total SO(x) emission; Fn is the total NO(x) emission; Fc is the total CO(x) emission; sj , sj and sj are the SOX emission coefficients of the jth generator; nj , nj and nj are the NO(x) emission coefficients of the jth generator; cj , cj and cj are the CO(x) emission coefficients of the jth generator.

Problem constraints: The objective functions formulated so far should be optimized while considering the power balance constraint and generation limit constraints so that generation must supply the demand and compensate the transmission losses in the system. where PD is the total load demand and PL is the total transmission loss.The transmission losses must be taken into account to achieve true environmental economic load dispatch. Transmission loss is a function of unit generations using B-coefficients methods (Wood and Wollenberg 1996 is expressed as follows.

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N} P_i B_{ij} P_j + \sum_{i=1}^{N} B_{i0} P_i + B_{00} \qquad (3)$$

Generator Capacity constraint: The power output of each committed unit must be within limits both upper and lower power permitted on that particular unit. This inequality constraint may be framed as shown.

$$P_j^{\min} \le P_j \le P_j^{\max}, \quad for\ j = 1,2,\ldots N \qquad (4)$$

3. OVERVIEW OF LION OPTIMISATION

The LPOA is natural computing based algorithmicapproach wherein the adaptation of a special organism to its environment is considered. In Lion Pride Optimization Algorithm (LPOA), an initial population is formed by a set of randomly generated solutions called Lions. Some of the lions in the initial population (%Nx) are selected as nomad lions and rest population (resident lions) is randomly partitioned prides. S percent of the pride's members are considered as female and rest are cubs, while this rate in nomad lions is vice versa. For each lion, the best obtained solution in passed iterations is called best visited position,. In LPOA, a pride territory is an area that consists of each member best position. If the strong nomad male invade the resident male, the resident male is driven out of the pride by the nomad lion USING TERRITORIAL takeover. The nomad male becomes the resident lion by defeating laggard lion.

4. IMPLEMENTATION OF LOA IN SOLVING EELD

In this work, the dimension of the problem is the number of generators taking part in the EELD problem with losses. The inequality constraints are transformed to the penalty functions and these penalty functions are added to the objective function to construct the lion fitness function. In this work, the equality constraints and there active power inequality constraints and the real power inequality constraints are being dealt during the course of iteration.

The EELD problem with transmission line losses solved using following algorithm for finding survival of fittest lion

Algorithm for Lion Pride Optimization Algorithm(Nomad Coalition and territory takeover)

Define objective function f(x) ,x=(x1,x2,…..)
Initialize the first population of Lion Nomad and Pride randomly within limits corresponding to generators
Calculate the fitness of Lion in Pride and Nomad lion
Find the best Lion and assume it part of Pride
While (t<Max Generation of any unit)
For i=1:n
Select an Male using Roulette wheel selection
Get nomad coalition which is cost and emission and transmission loss minimization determination at any point of time
If Xe nomad wins
Kill all the Cubs corresponding to Generation
Update the position of Lion in new Pride
End for
Calculate the fitness of all the Male Lions
Create a nomad coalition if fitter Nomad lion is found
Update Pride using step one
End while

The Survival fight takes place between one of the two lions of nomad coalition and pride update after removing it from nomad coalition and this approach is used in solving cost minimization problem considering generator constraints with minimization of Emission and Power losses.

5. RESULTS AND DISCUSSIONS

The coding of LPOA was written in MATLAB to solve Economic Load Dispatch Problem with 6 generating units.

Table 1. Generator data

Unit	Pmax (MW)	Pmin (MW)	a($/MW^2)	b($/MW)	c(MW)
1	125	10	0.15240	38.53973	756.79886
2	150	10	0.10587	46.15916	451.32513
3	225	35	0.02803	40.39655	1049.9977
4	210	35	0.0354	38.30553	1243.5311
5	325	130	0.02111	36.32782	1658.5596
6	315	125	0.01799	38.27041	1356.6592

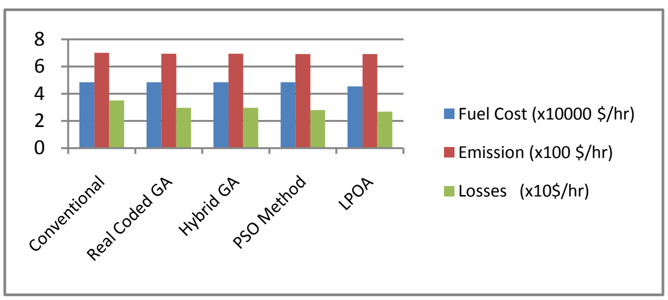
Table 2. Line Losses data

$$B_{ij} = \begin{bmatrix} 0.000140 & 0.000017 & 0.000015 & 0.000019 & 0.000026 & 0.000022 \\ 0.000017 & 0.000060 & 0.000013 & 0.000016 & 0.000015 & 0.000020 \\ 0.000015 & 0.000013 & 0.000065 & 0.000017 & 0.000024 & 0.000019 \\ 0.000019 & 0.000016 & 0.000017 & 0.000071 & 0.000030 & 0.000025 \\ 0.000026 & 0.000015 & 0.000024 & 0.000030 & 0.000069 & 0.000032 \\ 0.000022 & 0.000020 & 0.000019 & 0.000025 & 0.000032 & 0.000085 \end{bmatrix}$$

Table 3. Comparison of EELD with line losses optimization solution with Sudhakaran (2005) with Conventional method, Real coded and hybrid Genetic Algorithm , PSO with proposed LPOA

Method	Fuel Cost	Emission	Losses
	$ / hr	Kg / hr	PL(MW)
Conventional (Sudhakaran et al 2005)	48567.9	701.428	35.23
Real Coded GA (Sudhakaran et al 2005)	48567.7	694.169	29.725
Hybrid GA (Sudhakaran et al 2005)	48567.5	694.172	29.718
Method (Sudhakaran et al 2005)	48556.034	692.229	27.959
Proposed LPOA	45464	691.2	26.8

Table 4. Comparison of optimization solution



It is observed that optimal result obtained by LPOA is minimum in terms of cost , emission and power losses cases of load compared to other optimization algorithm methodsConventional method, Real coded and hybrid Genetic Algorithm , PSO taken from [23] Sudhakaran (2005) with compared to the proposed LPOA. It is also reported that convergence charteristics of the proposed LPOA is also very fast and results are stable for various power demand for 6 bus systems.

6. CONCLUSION

This paper reports an basic study focusing on the use of the Lion Pride Optimization Algorithm for solving EELD problem with transmission line losses. Several basic models dealing with the problem of EELD are implemented for a simple case for 6 Bus . The LOA algorithm showed superior features including high quality solution, stable convergence characteristics as found out in Matlab simulation. The solution may be close to that of the conventional method and PSO but tends to give better solution in case of higher order systems .The LOA algorithm can be used for solving EELD with renewables like Wind , Solar and Geothermal in future as the inclusion of renewable energy in the power system will have impact on generation mix during the day and night , cost, the variability of load seen by other plant, and reserves.

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