A Primal Dynamic Neural Network for Solving a Multi-objective Environmental/Economic Dispatch

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ABSTRACT

This paper explores the performance of Gradian-based Dynamic Neural Networks (G-DNN), to solve one of the most important energy problems called the "Environmental-Economic Dispatch (EED)". The idea behind the Combined Economic Emission Dispatch (CEED) formulation is to reduce costs, save energy, and reduce environmental pollution. By adopting the maximum / maximum price penalty factor, the multi-objective CEED optimization problem is transformed into a single- objective optimization problem. The proposed approach has a good performance in finding a diverse set of solutions and in converging near the desired optimal generated powers. To highlight the performance of the proposed technique, it is tested on the test system with three units. The numerical results of several case studies are compared with other published methods in the literature and confirm the effectiveness of G-DNN against other existing methods.

Keywords: Economic Dispatch, Dynamic Neural Network, Environmental-Economic

1 Introduction

Economic load dispatch (ELD) problem is a computational process to determine the generation contribution of each unit at minimum fuel cost while satisfying the total load demand and all operational constraints. The emission dispatch (ED) plays a critical role in the minimization of fuel cost. .Due to the fact that fuel cost and emission are in conflict with each other (minimizing one increase the other), system operation with either mini- mum fuel cost or minimum emissions will be unworkable. To address this issue, a load dispatching technique has been developed and improved that reduces fuel costs and emissions at the same time, known as the Combined Economic Emissions Dispatching (CEED). Various neural network models have been developed for solving linearly constrained nonlinear optimization problems, and convex optimization problems, for example, those based on the penalty parameter method [1], the Lagrange method [2], the gradient and projected method [1], , the primal-dual method [3], and the dual method [4], In this paper, a Gradian-based Dynamic Neural Networks (G-DNN) is designed for solving the CEED problem considering the reduction of SO_2 and NO_X as two independent objectives are studied. Thus, The CEED becomes a three-objective optimization problem after adding the ELD with the two objective emissions functions. This technique is performed on the three-unit test system. The results obtained by this technique are compared with other algorithms.

2 Methodology

The CEED multiobjective issue is converted to a single optimization issue using a price penalty factor ω_i:

$$Min\ (P) = (P) + \omega_S E_S(P) + \omega_N E_N(P) \qquad (1)$$

where $F(P) = \sum_{i=1}^{n}(a_{iP_i^2} + b_{iP_i} + c_i)$ is the total fuel cost, $E_S(P) = \sum_{i=1}^{n}(\alpha_{iP_i^2} + \beta_{iP_i} + \gamma_i)$ and $E_N(P) = \sum_{i=1}^{n}(\rho_{iP_i^2} + \sigma_{iP_i} + \delta_i)$ are total SO_2 and NO_X emissions releases, respectively. ω_S and ω_N are price penalty factors for SO_2 and NO_X. The generated power optimized is subject to the following constraints: $\sum_{i=1}^{n} P_i = P_D + P_L$ and $P_{imin} \le P_i \le P_{imax}$. The simplest way to handle inequality

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constraints is to convert them to equality constraints using slack variables and then use the Lagrange theory. The dynamical equation of the proposed DNN for solving the problem (1) is described by:

$$\mu \dot{P} = \sum_{j=1}^{n} \psi_{ij} P_i - b_i + \eta_2 \left(P_i - P_{imax} \right)^+ - \eta_2 (P_{imin} - P_i)^+ \quad , \quad i = 1,2,..,n \qquad (2)$$

with $\psi_{ij} = \begin{cases} -(a_i + \mu_1 & i = j \\ -\mu_1 & i \neq j \end{cases} \quad i,j = 1,2,..,n.$

where η is the scaling positive parameter controls the convergence rate.

3 Results and Discussion

In order to validate the proposed G-DNN method, the environmentally constrained economic dispatchwas solved for a 3-unit system with 850 MW demand and with transmission losses. The cost and emission functions coefficients are given in [5]. The following parameters have been employed: $\eta_1 = 10^5$, $\eta_2 = 10^6$. The transmission loss coefficients B are given by [5]. $B = 10^{-5}[3 \quad 9 \quad 12]$. The convergence characteristics of the NO_X ED, CEED objective also, the dynamic equation described by (2) can be easily realized by a DNN shown in Figure 1.

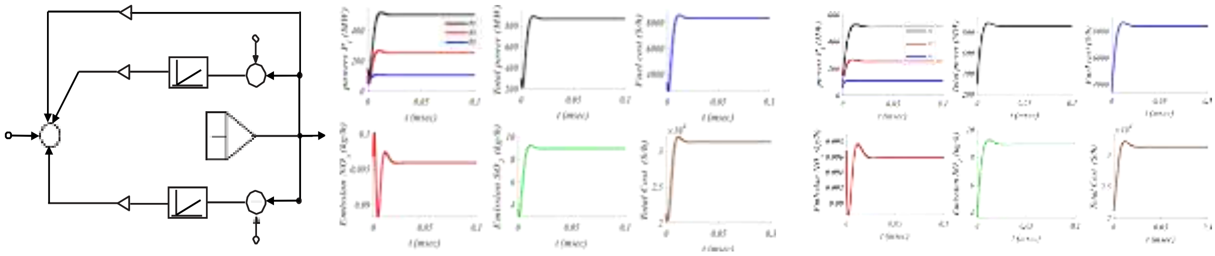

Figure 1: *A simplified NN diagram for model(2), Best NO_X Emission and CEED for 850 MW*

Table 1 show the comparison of simulation results for the best fuel cost, best NO_X and. SO_2 emission dispatch with a load of 850 MW.

Table 1: *Comparison of simulations results*

	Methods	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_L (M)	SO_2(ton/hr)	NO_X (ton/hr)	Total Cost ($/hr)
Best fuel cost	TS [5]	435.690	298.828	131.28	15.798	9.02146	0.0987	8344.598
	NSGA-II [6]	436.366	298.187	131.228	15.781	9.02083	0.09866	8344.606
	G-DNN	448.123	284.621	132.682	15.427	9.01053	0.09823	8345.584
Best NO_X ωN= 147582.7	TS [5]	502.914	254.294	108.592	15.800	8.986	0.0958	8371.143
	NSGA-II [6]	505.810	252.951	106.023	14.784	8.9747	0.0959	8363.627
	G-DNN	507.765	251.409	105.585	14.761	8.9739	0.0959	8364.669
Best SO_2 ωS = 790.03	TS [5]	549.247	234.582	81.893	15.722	8.9740	0.09769	8403.485
	NSGA-II [6]	541.308	223.249	99.919	14.476	8.9665	0.0964	8387.518
	G-DNN	545.900	232.721	22133	54.454	276978	7.75435	8395.499

4 Conclusion

In this paper, the G-DNN algorithm has been successfully implemented to solve different CEED problems with different kinds of cost functions and constraints. The multi-objective problem is converted into a single objective form utilizing the price penalty factor with the consideration of problem constraints and transmission losses. The proposed method has been examined on a 3-unit system. After comparing the

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results with other algorithms it is observed that G-DNN is well suited for obtaining the best solution so that both fuel cost and emission effect are decreased for different load demands.

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