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ARTIFICIAL NEURAL NETWORK ALGORITHM FOR ECONOMIC LOAD DISPATCH

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Abstract
Artificial Neural Networks (ANN) are gaining popularity in various fields of engineering including electrical power systems due to their high computational rates and robustness. One of the ANN models extensively used for power system application is the multilayer perception model based on back propagation algorithm. However, its training requires large number of input-output data sets which increases with system size and may become prohibitively large and time extensive. Moreover, the Back propagation algorithm offers slow convergence with random initial weights. This paper presents a new approach to minimize the number of training patterns for ANN by using variable slope of the sigmoidal function for different test cases. In addition, the paper suggests the use of new functions for generating initial weights for training. The ANN models so developed have been tested to solve economic load dispatch (E.L.D.) problem on IEEE-14 bus test system and 89-bus Indian system. The proposed approach provides tremendous saving in the training time of ANN and provides fast and accurate results of E.L.D.

1.Introduction

Power system is highly complex and non-linear, therefore its analysis and control in real time environment requires highly sophisticated computational skills. The ED problem is to determine the optimal combination of power outputs for all generating units which minimizes the total fuel cost, while satisfying load demand and operational constraints. In recent years, a number of approaches using neural networks have been proposed for solving ED problem.

Artificial Neural Network (ANN) models are composed of many nonlinear computational elements operating in parallel arranged in patterns reminiscent of biological neural nets. Recently they are getting wide attention in various engineering and scientific fields. Various models of ANN based on supervised as well as unsupervised learning exist in the literature. Some of them are described in ref. [1-31]. ANNs due to their massive parallel architecture and non algorithmic approach make them suitable for solving the problems having large application programs such as power system optimization and security analysis and also the problems having no clear cut model for representation, an example being the load forecasting. Most of the applications of artificial neural network to power system problems are found from 1988 onwards.ANN have been applied to several power system problems. Most of the Artificial Neural Network applications to electrical power system utilize multilayer feed forward preceptor model based on back propagation algorithm for training. The back propagation algorithm is based on steepest descent technique and thus suffers from convergence difficulties if a valley or local minima is encountered or weights are assigned a random initial values far away from the optimum point. Moreover, it requires large number of input-output data sets for training.

2.Economical load dispatch

ECONOMIC dispatch is a computational process where the total required generation is distributed among the generation units in operation, by minimizing the selected cost criterion, subject to load and operational constraints. Economic dispatch is used in real-time energy management power system control by most programs to allocate the total generation among the available units, unit commitment and in some other operation function. In the area of economic dispatch, several methods have been proposed. Recent advances were achieved by using gradient method, the recursive method, the Newton-Raphson method. These methods are required more time to converge to the correct results. Other researches in field of expert system, the unit-based genetic algorithm method, neural networks, fuzzy set theory and approximate reasoning have been investigated. However, in the conventional methods, it is difficult to solve the optimal economic if the load is changed. It needs to compute the economic dispatch each time which uses a long time in each of computation loops. In this paper, an application of neural networks to economic dispatch is proposed. The method used a feed-forward back-propagation type of neural networks to learn different condition in operation of each unit. By changing total load condition in one day, the minimum cost operation of each unit should be selected. So, the minimum operation condition is selected with less iteration and time.

3.ECONOMIC DISPATCH PROBLEM

Figure 1 shows the configuration that will be studied in the section. This system consists of *m* generating unit connected to a single bus-bar serving a received electrical load . The input to each unit, show as *C;'* represents the cost rate of the unit. The output of each unit, *PG;* is the electrical power generated by that particular unit. The total cost rate of this system is, of course, the sum of the costs of each of the individual units. The essential constraint on the operation of this system is that the sum of the output powers must equal load demand.

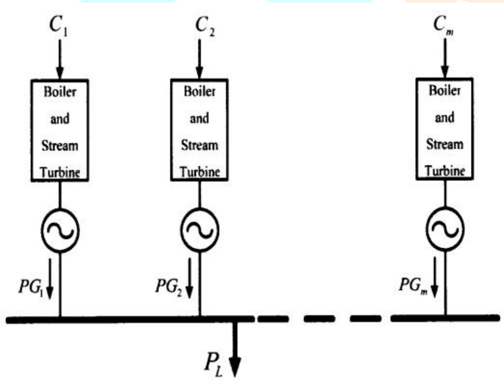

Fig. 1 Generator unit committed to serve a load

Mathematically speaking, the problem may be stated very concisely. That is, an objective function is equal to the total cost for supplying the indicated load. The problem is to minimize *CT* subject to the constraint that the sum of the power generated must equal the received load. Note that any transmission losses are neglected and any operating limits are not explicitly stated when formulating this problem. [1314]. The objective of economic dispatch is to minimize the total generation cost throughout the target time interval by evaluation the following objection function. The economic dispatch problem can be mathematically described as follows.

$$C_T = C_1 + C_2 + \ldots + C_m = \sum_{i=1}^{m} C_i(PG_i) \quad (1)$$

$$PG_T = PG_1 + PG_2 + \ldots + PG_m = \sum_{i=1}^{m} PG_i \quad (2)$$

$$\phi = 0 = P_D - \sum_{i=1}^{m} PG_i \quad (3)$$

$$\underset{PG_i}{Min} \sum_{i=1}^{m} C_i(PG_i) = \underset{PG_i}{Min} \sum_{i=1}^{m} (a_i + b_i PG_i + c_i PG_i^2) \quad (4)$$

where

m : The number of generator units

i : Index of dispatchable units

C_i :The fuel generation of unit i [\$/h]

C_T :The total fuel cost generation in system [\$/h]

PG_i :The power generation of unit i [MW]

PG_T :The total power generation in system[MW]

a_i, b_i, c_i : Coefficients for power generation cost of unit i

4. ARTIFICIAL NEURAL NETWORK

Neural networks have self adapting capabilities which makes them well suited to handle non-linearity, uncertainness and parameter variations which may occur in economic dispatch [14]. Back propagation network is an example of nonlinear layered feed forward networks. Back propagation neural networks construct global approximations to nonlinear input-output mapping. There are capable of generalization in regions of the input space where little or no training data are available. The structure of the proposed neural network used for calculate economic dispatch is shown in Fig. 3

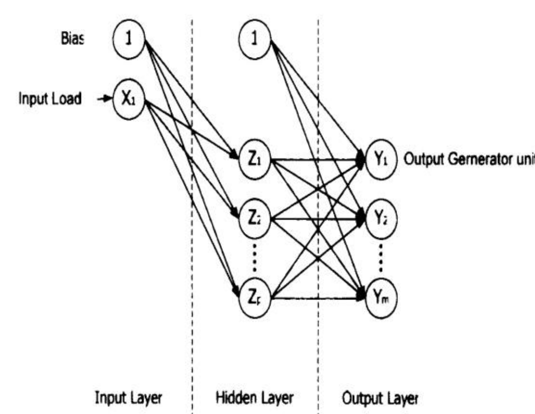

Fig. 3 Artificial neural networks structure for economic dispatch

The proposed neural networks have three layers, i.e. input

$P_{i\min}$ MW	$P_{i\max}$ MW	a_i	b_i	c_i	d_i	e_i	f_i
35	210	.0355	38.30	1243	0.0068	-0.550	40
130	325	.0211	36.33	1658	0.0046	-0.512	42
125	315	.0180	38.27	1356	0.0046	-0.512	42

layer, hidden layer and the output layer. The input layer has only one neuron which is the number of total load. The output layer has m neurons represented the number of generated power of each generators. If the system has only 3 generators, the output layer will have only neurons. The hidden layer has 30 neurons. The network is fully connected, i.e. the output of

S. No.	No. of Hidden nodes	Training time	No. of Epochs
1	12	1.1 s	8
2	19	.3 s	6
3	22	.8 s	17
4	25	.5 s	8
5	30	2.2 s	37

each neuron is connected to all neurons in them hidden layer through a weight which is not shown in the figure. Also a bias signal is coupled to all the neurons through a weight. All the layers of neural network have a hyper tangent sigmoid transfer function. The algorithm used for training is back propagation. The back-propagation training algorithm needs only inputs and the desired outputs to adapt the weights. A gradient descent minimization can be performed on the error function. Back-propagation training is referred to as supervised training. The input-output data for training neural networks is the variation of load as input and the optimal generated power of each generator as output which is calculated by using Lamda-iteration.

5. CONCLUSION AND RESULT

A-Three Generating Units System

The cost, emission coefficient and generation limits of three unit system are given in table 1. Transmission losses are calculated using B matrix . To establish the effectiveness of developed LMNN for combined economic load dispatch, the neural network models are trained for 3-generating unit system. The load patterns are generated by varying the load at each bus respectively of the system randomly. The conventional lambda iteration method has been applied for each load pattern to obtain the optimum value of lambda and real power sharing at different generating units, for minimum cost and environmental pollution. Total 300 patterns were generated by changing load (P_D) between 400MW to 600 MW and then 240 patterns were used for trainings LMNN while remaining 60 patterns were used for the testing.

The developed LMNN has one input node and 4 output nodes. The optimum size of the neural network has been obtained by training LMNN models having different no. of hidden nodes for the training error goal of 1×10^{-3} pu. The training performance of the neural networks having different structures has been shown in Table 2. As can be observed from Table 2, the LMNN model having 19 hidden nodes (1-19-4) is the most efficient structure, as it required the least training time for the same error goal

TABLE 1 Cost, Emission Coefficients and Generation Limits of Three Unit System

TABLE 2 Training Performance of LMNN Having Different Structures for a 3-Units System

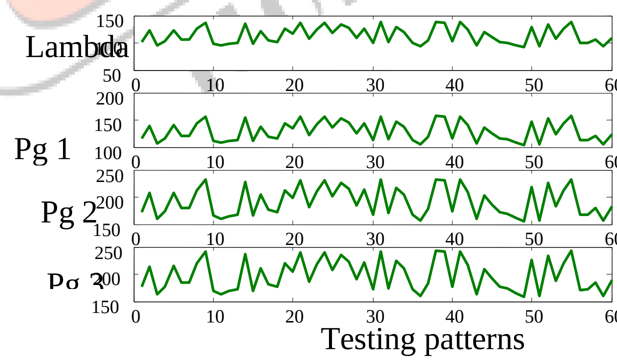

Fig.Result obtained by LMNN in testing phase for 3-Generating unit System

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