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On-line voltage stability assessment using radial basis function network model with reduced input features

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ABSTRACT

In recent years, voltage instability has become a major threat for the operation of many power systems. This paper presents an artificial neural network (ANN)-based approach for on-line voltage security assessment. The proposed approach uses radial basis function (RBF) networks to estimate the voltage stability level of the system under contingency state. Maximum *L*-index of the load buses in the system is taken as the indicator of voltage stability. Pre-contingency state power flows are taken as the input to the neural network. The key feature of the proposed method is the use of dimensionality reduction techniques to improve the performance of the developed network. Mutual information based technique for feature selection is proposed to enhance overall design of neural network. The effectiveness of the proposed approach is demonstrated through voltage security assessment in IEEE 30-bus system and Indian practical 76 bus system under various operating conditions considering single and double line contingencies and is found to predict voltage stability index more accurate than feedforward neural networks trained by back propagation algorithm and AC load flow. Experimental results show that the proposed method reduces the training time and improves the generalization capability of the network than the multilayer perceptron networks.

1. Introduction

The intensive loading of existing generation and transmission facilities and drawing transmission lines from remotely-located generation station has resulted in voltage related problems in many power systems. Several incidents of voltage instability have been initiated by tripping of a critical line in the system. In order to save the system from voltage collapse under contingencies, it is necessary to estimate the effect of contingencies on the voltage stability, so that corrective measures can be taken to avoid system black-out.

Several approaches have been proposed for analyzing the voltage stability problem. They can be broadly classified into static and dynamic approaches. The static approach [1–6] is based on the steady-state load flow model. In the dynamic approach [7,8] the power system is represented by a dynamic model and time domain simulations are carried out using a comprehensive set of initial and transient conditions to compute the voltage stability level. These methods require comparatively large computation time and are not suitable for on-line applications.

In recent years, research endeavors in the area of security assessment have been directed towards artificial neural network [9–13]. Two separate models are proposed to estimate the voltage security of the system, a unified network to provide the voltage stability level under all the selected contingency state and a set of trained networks one each for every selected contingencies. Most of the authors have used feedforward neural networks with sigmoidal nonlinearities for model development. Also, the networks were developed based on the complete input variables, which significantly reduce their performance. With feedforward neural networks any continuous function can be approximated to within an arbitrary accuracy by carefully choosing the parameters in the network provided the network structure is sufficiently large. But the shortcoming of this network is that it takes long time for training. Also, feedforward network with sigmoidal activation function in the hidden nodes has no inherent ability to detect the outliers. Even though training is done in off-line, short training time is preferred as one may have to retrain the networks on a regular basis as the topology or the system condition changes. Outliers can occur in practice, because it is difficult to produce a complete training set representing all possible operating conditions of a power system.

In [14], a radial basis function neural network with a fast hybrid learning method is proposed in which a function approximation problem is used. An adaptive RBF network is proposed in [15] for

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