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Dynamic voltage collapse prediction in power systems using support vector regression

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ABSTRACT

This paper presents dynamic voltage collapse prediction on an actual power system using support vector regression. Dynamic voltage collapse prediction is first determined based on the PTSI calculated from information in dynamic simulation output. Simulations were carried out on a practical 87 bus test system by considering load increase as the contingency. The data collected from the time domain simulation is then used as input to the SVR in which support vector regression is used as a predictor to determine the dynamic voltage collapse indices of the power system. To reduce training time and improve accuracy of the SVR, the Kernel function type and Kernel parameter are considered. To verify the effectiveness of the proposed SVR method, its performance is compared with the multi layer perceptron neural network (MLPNN). Studies show that the SVM gives faster and more accurate results for dynamic voltage collapse prediction compared with the MLPNN.

1. Introduction

In recent years, voltage instability which is responsible for several major network collapses have been reported in many countries (Hasani & Parniani, 2005). The phenomenon was in response to an unexpected increase in the load level, sometimes in combination with an inadequate reactive power support at critical network buses. Voltage instability phenomenon has been known to be caused by heavily loaded system where large amounts of real and reactive powers are transported over long transmission lines or lines are overloaded. It may also occur at the operating loading condition when a system is subjected to the contingency (Balamourougan, Sidhu, & Sachdev, 2004; Nizam, Mohamed, & Hussain, 2006). In this situation, it is important to assess voltage stability of power systems by developing tools that can predict the distance to the point of collapse in a given power system. Much effort is currently been put into research on the phenomenon of voltage collapse and many approaches have been explored. However, there is still a need for reducing the computational time in dynamic voltage stability assessment (Kundur, 1994). Presently, the use of artificial neural network (ANN) in dynamic voltage collapse prediction has gained a lot of interest amongst researchers due to its ability to do parallel data processing with high accuracy and fast response. Several voltage stability prediction studies have been carried out by using multi layer perceptron neural network (NN) model (Bettiol, Souza, Todesco, & Tesch, 2003; Izzri & Yahya, 2007; Pothisarn & Jiriwibhakorn, 2003). Sharkawi and Neibur (1996) and Musirin and Rahman (2004) proposed the use of radial basis function (RBF) and recurrent NN (Celli, Loddo, & Pilo, 2002) for voltage stability assessment. Another method to assess power system stability using ANN is by means of classifying the system into either stable or unstable states for several contingencies applied to the system (Krishna & Padiyar, 2000). Support Vector Machine (SVM) is another method used for solving classification problems (Moulin, daSilva, El-Sharkawi, & Marks, 2004; Ravikumar, Thukaram, & Khincha, 2008; Wang, Wu, Li, & Wang, 2005) in which the method has several advantages such as automatic determination of the number of hidden neurons, fast convergence rate and good generalization capability. Beside for classification, SVM can be applied for solving prediction problems (Pelckmans et al., 2003) named Support Vector Regression (SVR).

In this paper, a new method for dynamic voltage prediction is proposed by using SVR for fast and accurate prediction of voltage collapse. The procedures of dynamic voltage collapse prediction using SVR are explained and the performance of the SVR is compared with the multilayer perceptron neural network (MLPNN) so as to verify the effectiveness of the proposed method. The MLP NN was developed using the MATLAB Neural Network Toolbox, whereas SVM were developed using the LSSVM Matlab Toolbox (Pelckmans et al., 2003).

Initially, the work focused on the development of a new dynamic voltage collapse indicator named as the Power Transfer Stability Index (PTSI). The index is calculated by using information of total apparent power of the load, Thevenin voltage and impedance

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at a bus and the phase angle between Thevenin and load impedance. The value of PTSI will fall between 0 and 1 in which when PTSI value reaches 1, it indicates that a voltage collapse has occurred. Dynamic simulations were carried out for determining the relation between voltage, reactive power and real power at a load bus and the PTSI. Load increase at all the load buses were considered for generating the training and testing data sets. The performance of the proposed SVR technique developed for dynamic

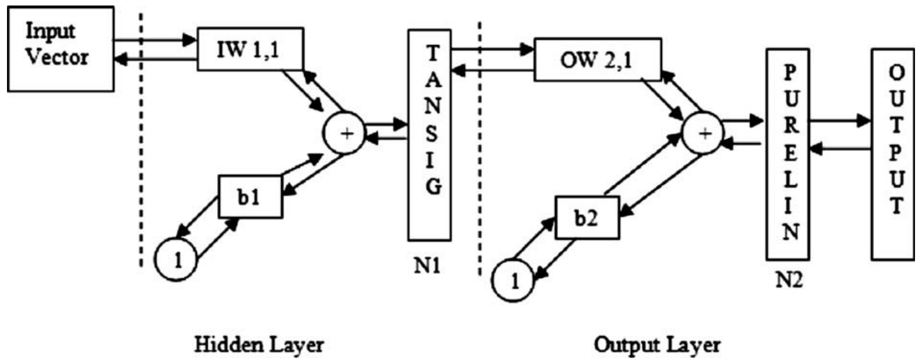

Fig. 1. MLP neural network.

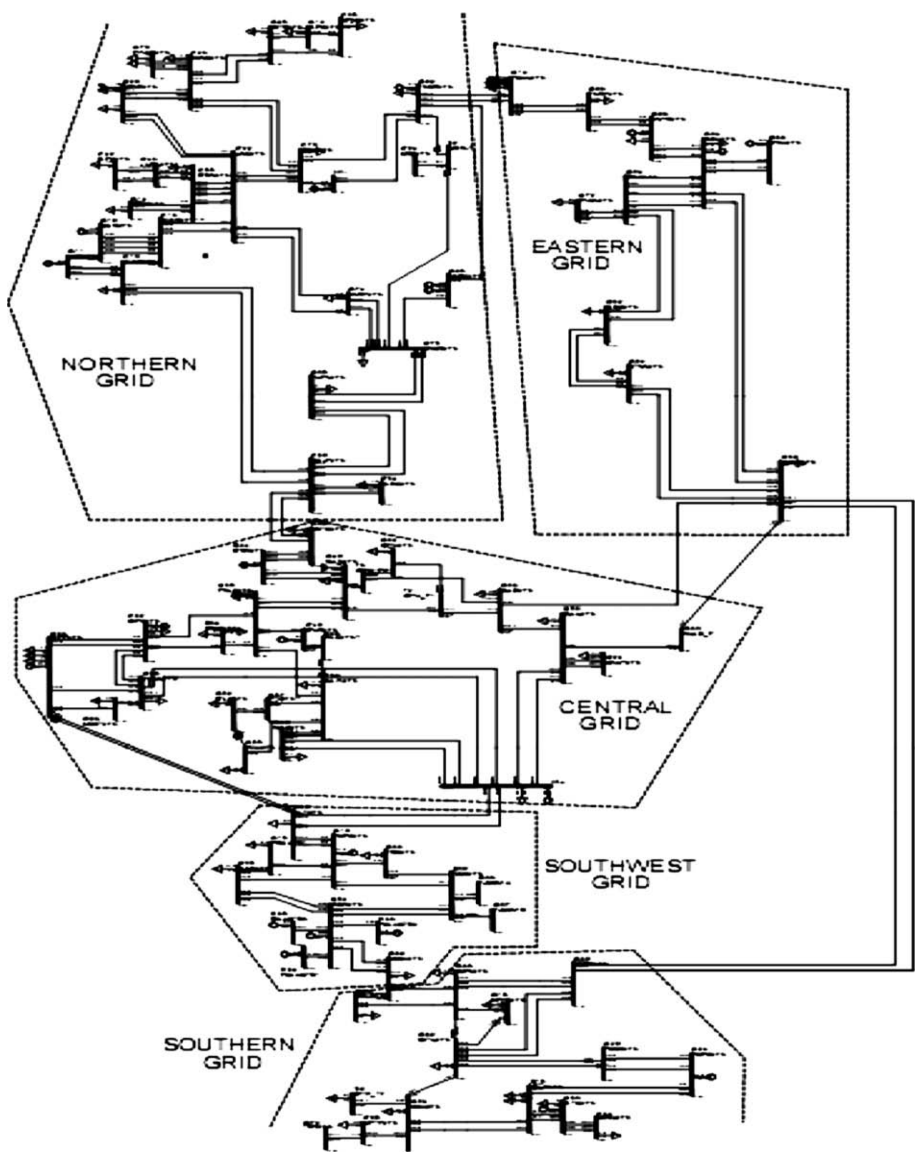

Fig. 2. The 87 bust test system.