STATIC SECURITY ASSESSMENT ON POWER SYSTEM USING ARTIFICIAL NEURAL NETWORK

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To my beloved parents, fiancée, brothers, sister and friend

for their encouragement

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ABSTRACT

In modern industrialized society, a supply of electric energy is expected to be reliable and continuous since a high availability of secure power system is essential for its' progress. A secure power system is expected to be free from risk or danger and to have the ability to withstand without exception to any one of the pre-selected list of credible contingencies. The objective of this research is to investigate the reliability of the Static Security Assessment (SSA) in determining the security level of power system from serious interference during operation. Therefore, back propagation Artificial Neural Network (ANN) is implemented to classify the security status in the test power system. Offline Newton-Raphson load flow is employed to gather the input data for the ANN. The large dimensionality of input data is scaled down by screening process to reduce the computational time during ANN training process. This method has been tested with 4 bus test system and IEEE 24 bus test system. Bus voltage and thermal line variables are set as a limit to the developed method. It has been discovered that error of trained ANN are within the acceptable range if compared to similar results from published works. The ANN has been found to be faster than the conventional method in predicting the security level of the tested system. It is concluded that the ANN works well in providing status of the current operating point for specific contingency of power system.

ABSTRAK

Dalam masyarakat perindustrian yang moden ini, bekalan tenaga elektrik di harap mempunyai keboleharapan dan keselamatan yang tinggi di mana ianya penting untuk perkembangan sesebuah masyarakat. Sistem kuasa yang selamat seharusnya bebas dari sebarang bahaya atau risiko dan juga mempunyai keupayaan untuk bertahan terhadap mana-mana kontingensi yang boleh dipercayai. Objektif penyelidikan ini adalah untuk mengkaji kebolehpercayaan "Penilaian Keselamatan Statik" (SSA) dalam menentukan keselamatan sistem kuasa dari sebarang gangguan ketika beroperasi. Oleh itu, "back propogation" ANN diguna untuk menentukan status keselamatan sebuah sistem kuasa ujian. Aliran beban Newton-Raphson digunakan untuk mengumpul data masukan ANN. Saiz data masukan telah diperkecilkan skalanya melalui proses "screening" untuk memendekkan tempoh masa semasa proses melatih ANN. Kaedah ini telah diuji terhadap sistem ujian 4 bus dan sistem ujian IEEE 24 bus. Voltan bus dan pembolehubah terma talian ditetapkan sebagai had penyelidikan. Didapati bahawa ANN yang dilatih mempunyai kadar kesilapan yang boleh diterima merujuk kepada sesetengah kerja. ANN didapati lebih pantas bekerja berbanding kaedah konvensional dalam menilai tahap keselamatan sistem ujian. Kesimpulannya ANN berfungsi dengan baik dalam memberi status keselamatan semasa ketika beroperasi untuk kontingensi spesifik bagi sesebuah sistem kuasa.

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LIST OF SYMBOLS

ANN	-	Artificial Neural Network
SA	-	Security Assessment
AI	-	Artificial Intelligent
IEEE	-	The Institute of Electrical and Electronics Engineers
P_i	-	Bus real power injection at bus *i*
V_i	-	Bus reactive power injection at bus *i*
δ_i	-	Angle of the voltage at bus *i*
G_i	-	Real part of the element of the bus admittance
B_i	-	Imaginary part of the element of the bus admittance
J	-	Jacobian matrix
P	-	Probability
F_K	-	Expected frequency of failure
SOM	-	Self organizing map
BP	-	Back propagation
RBF	-	Radial Basic Function
PLN	-	Progressive learning network
KSOM	-	Kohonen Self Organizing Map
MVA	-	Mega Volt-Ampere
MW	-	Mega Watt
y_i	-	Activation value of the *j*th neuron
u_i	-	Net input to the *j*th neuron
w_{ij}	-	Weight between the *j*th neuron of the *I*th layer and the *i*th neuron
Φ	-	Sigmoid activation function
Y	-	Network parameter
C	-	Contingency
E	-	Energy function of neuron

E4DT	-	Secure and insecure data for 4 bus test system
E4DT0	-	Secure data for 4 bus test system
E4DT1	-	Insecure data for 4 bus test system
E4DV	-	Validation data for 4 bus test system
E4P0	-	Target secure data for 4 bus test system
E4P1	-	Target insecure data for 4 bus test system
EDT	-	Secure and insecure un-screening data for 24 bus test system
EDT0	-	Secure un-screening data for 24 bus test system
EDT1	-	Insecure un-screening data for 24 bus test system
EDV	-	Validation un-screening data for 24 bus test system
EP0	-	Target secure un-screening data for 24 bus test system
EP1	-	Target insecure un-screening data for 24 bus test system
EDT_{sc}	-	Secure and insecure screening data for 24 bus test system
$EDT0_{sc}$	-	Insecure screening data for 24 bus test system
EDV_{sc}	-	Validation screening data for 24 bus test system
$EP0_{sc}$	-	Target secure screening data for 24 bus test system
$EP1_{sc}$	-	Target insecure screening data for 24 bus test system
V	-	Voltage
X	-	Reactive impedance
Y	-	Admittance
Z	-	Impedance

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CHAPTER I

INTRODUCTION

1.1 Background

A reliable, continuous supply of electric energy is an essential part of today's complex societies. Due to a combination of increasing energy consumption and impediment of various kinds to extension of existing electric transmission network, these power systems are operated closer to their limit. This situation requires a significantly less conservative power operation and control regime which, in turn, is possible only by monitoring the system state in much more detail than was necessary previously.

Secure power system means freedom from danger or risk. However, power system can never be secure in absolute sense. Accordingly, in power system context, security can only be a qualified absence of risk, specifically or risk of disruption of continued system operation. Thus security has come to means the ability of the system to withstand without consequences any one of a preselected list of "credible contingencies. From a control perspective, the objective of power system operation is to keep the electric power flows and bus voltage magnitudes and angles within acceptable limit, despite changes in load or available resources. In August 2003 [1], power plants separated by hundreds miles in north-east of the US and in Canada were suddenly disconnected by their own safety system from the vast power network that cover those countries. In few minutes the power failed in Cleveland and the light went out in New York and across nine states in the US. It has been found that the blackout happened because of oscillation in the power network could be the echoes from a lightning strike with poorly tuned generator.

A crucial part of power system operation is on-line power system security analysis which, involving monitoring, assessment and control to decide whether the system is currently operating safely, critically or unsafe. The security of the system is evaluated for the actual state as well as for a number of simulated states which are derived from the actual state by assuming one or several line, transformer or generator outages. It is common practice to require that the system remain operational and safe for at least all single component failures or N-1 contingency.

Security Assessment (SA) is analysis performed to determine whether, and what to extend, a power system is reasonably safe from serious interference to its operation. Thus security assessment involves the evaluation of available data to estimate the relative security level of the system in its present state or some near-term future state. The form of such assessment takes will be function of what types of data are available and of what underlying formulation of the security problem has been adopted.

1.2 Significance of Study

Conventional methods in determining level of power system security involve load flow analysis method which is iterative method. At each iteration, usually a power flow solution is required, which is an iterative method itself. Therefore, the computational time is long. For security assessment, it is vital to reduce computation time, since the security level of power system need to be determined as quick as possible. Artificial Intelligent (AI) is a suitable alternative method. The use of AI especially Artificial Neural Network (ANN) will enhance the speed in calculating the security level since no calculation based on the mathematical model of the power system is required. The ANN will read the value of parameters in the power system and outputs security level. Successful implementation of ANN in determining security will provides another promising means of security assessment of power system.

1.3 Objectives

The objectives of this study are:

1. To investigate suitable neural network architecture for static security assessment.
2. To develop steady state security assessment of power system using ANN technique.
3. To verify the performance of the technique in terms of accuracy and efficiency against conventional technique, .i.e. load flow analysis.

1.4 Scope of Study

The scope and limitation of the study are as follow:

1. The steady state security assessment is limited by the thermal of transmission lines and bus voltage limit only, since these constraints are generally accepted as security criteria for most work in security assessment.
2. The developed ANN technique and conventional technique are developed on the MATLAB platform so as to obtain fair comparison between the methods.

1.5 Research Methodology

The methodology of the study is:

1. To determine ANN input output neuron from the load flow analysis using several test run of the conventional load flow analysis on the sample power system that representative of the general power system.
2. To develop ANN technique using established input output neuron criteria for the security assessment of the test system i.e. 4-bus system and IEEE Reliability Test System 24-Bus.

3. To verify the accuracy and to justify the efficiency of the ANN developed technique to the conventional security analysis to several test on the 4-bus system and 24-bus IEEE test system.

1.6 Result of the Study

A suitable ANN architecture has been proposed for implementing static security assessment. ANN for static security assessment has been implemented by MATLAB environment and the results justify advantages of ANN technique over conventional method. A well trained ANN based steady state assessment method capable of evaluating (N-1) contingency for a given power system has been tested for various test system.

1.7 Organization of the Thesis

This thesis is divided into six chapters. The first chapter is the significant of the study, followed by Chapter II, which discuss the literature review on the security assessment determination in power system. Chapter III covers the element in security assessment and the ANN configuration. Chapter IV describes about the test system and the ANN implementation methodology. Result and discussion has been placed in Chapter V. The last chapter provides the conclusion of the study and suggestion for the future work.

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