UNIVERSITI PUTRA MALAYSIA

ADAPTIVE ARTIFICIAL NEURAL NETWORK FOR POWER SYSTEM SECURITY ASSESSMENT AND CONTROL ACTION

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By

AHMED NAUFAL A. AL-MASRI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of of Doctor of Philosophy

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This thesis is especially dedicated to my beloved family: my dear father, mother, my only sister and brother.

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chair: Assoc. Prof. Mohd Zainal Abidin Ab Kadir, PhD

Faculty: Engineering

The mission of the power system operator has become more difficult than before due to the increasing of load demand which cause power systems to operate closer to its security limits. In addition, the control actions depend on the operating status of the power system whether it is operating in secure or insecure condition. Once an insecure condition occurs, new actions must be considered to restore the system to secure operation.

The objective of this work is to introduce new algorithms that can enhance power system security inclusive of the remedial action (generation re-dispatch/load shedding) for any scale of power system operation as well as improving the existing ANN to solve the problem faced by power system security assessment. Furthermore, an AANN for power system security assessment was developed for steady state and dynamic security assessments. This study also investigates the reliability of ANN application in power system security assessment in terms of accuracy and computational time as well as developing a new method that can be included in

security assessment tools. This is particularly important for giving a possible control action to mitigate an insecure situation during disturbance using AANN. This technique is used to improve the performance and to develop a software tool which is integrated with PSS™E software for contingency analysis. An essential part of the work was conducted to generalise the tool with the automatic data knowledge generation system and data selection and extraction for AANN inputs. Finally, a software tool based on an adaptive neural network for power system security assessment was developed.

The idea of the AANN approach presented in this thesis is to generalise the security assessment method with the consideration of remedial action for any operating point. However, the AANN approach does not replace traditional analysis methods, while these methods are still needed at the initial step of the approach. The computation of the security assessment and control are time-consuming, hence these methods cannot achieve the target of EMS for robust management system.

The proposed algorithm has been successfully tested on IEEE 9-bus test system, IEEE 39-bus test system and Peninsular Malaysia Grid 275kV for the steady-state security assessment and control. The results show that the AANN can provide the required amount of generation re-dispatch and load shedding accurately and instantaneously. In addition, the developed AANN has been successfully implemented to dynamic security assessment for predicting the security status of the IEEE 9-bus test system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor falsafah

PENYESUAIAN RANGKAIAN NEURAL TIRUAN BAGI PENILAIAN KESELAMATAN SISTEM KUASA DAN TINDAKAN KAWALAN

Oleh

AHMED NAUFAL A. AL-MASRI

February 2012

Pengerusi: Prof. Madya Mohd Zainal Abidin Ab Kadir, PhD

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Misi pengendali sistem kuasa telah menjadi lebih sukar berbanding sebelum ini disebabkan oleh peningkatan permintaan beban yang menyebabkan sistem kuasa untuk beroperasi lebih dekat kepada had keselamatan. Di samping itu, tindakan kawalan bergantung kepada status operasi sistem kuasa sama ada yang beroperasi di keadaan selamat atau tidak selamat. Apabila berlaku keadaan tidak selamat, tindakan baru mesti dipertimbangkan untuk memulihkan sistem kepada operasi selamat.

Objektif kerja ini adalah untuk memperkenalkan algoritma baru yang boleh meningkatkan sistem kuasa keselamatan termasuk tindakan (penjanaan semula-penghantaran/pengguguran beban) bagi skala mana-mana operasi sistem kuasa serta meningkatkan ANN yang sedia ada untuk menyelesaikan masalah yang dihadapi oleh penilaian keselamatan sistem kuasa. Tambahan pula, AANN bagi penilaian keselamatan sistem kuasa termasuk tindakan pemulihan telah dibangunkan bagi penilaian keselamatan keadaan mantap dan dinamik. Kajian ini juga bertujuan untuk menyiasat kebolehpercayaan ANN dalam sistem penilaian keselamatan kuasa dari segi ketepatan dan masa pengiraan serta membangunkan kaedah baru yang boleh

dimasukkan ke dalam alat penilaian keselamatan. Ini adalah penting bagi memberi tindakan kawalan yang mungkin untuk mengurangkan keadaan yang tidak selamat semasa gangguan menggunakan teknik AANN. Teknik ini digunakan untuk memperbaiki prestasi dan untuk membangunkan alat perisian yang mana disepadukan dengan perisian PSS™E untuk analisis luar jangka. Satu bahagian penting dalam kerja yang telah dijalankan ialah untuk mengeneralisasikan alat dengan sistem penjanaan pengetahuan data dan pemilihan berautomatik dan pengekstrakan data untuk input AANN. Akhir sekali, alat perisian berdasarkan penyesuaian rangkaian neural bagi penilaian keselamatan sistem kuasa telah dibangunkan.

Idea pendekatan AANN yang dibentangkan di dalam tesis ini adalah untuk mengeneralisasikan kaedah penilaian keselamatan dengan mengambil kira tindakan pemulihan bagi mana-mana titik operasi. Walau bagaimanapun, pendekatan AANN tidak menggantikan kaedah analisis tradisional, sementara kaedah ini masih diperlukan pada langkah awal pendekatan tersebut. Pengiraan penilaian keselamatan dan kawalan memakan masa dan oleh itu kaedah ini tidak dapat mencapai sasaran EMS untuk sistem pengurusan yang mantap.

Algoritma yang dicadangkan telah berjaya diuji pada sistem ujian IEEE 9-bus, sistem ujian IEEE 39-bus dan Grid Semenanjung Malaysia 275kV bagi kawalan dan penilaian keselamatan berkeadaan stabil. Keputusan telah menunjukkan bahawa AANN boleh menyediakan jumlah yang diperlukan bagi penjanaan penghantaran-semula dan pengguguran beban dengan tepat dan serta-merta. Di samping itu, AANN yang dibangunkan juga telah berjaya dilaksanakan untuk penilaian keselamatan dinamik untuk meramalkan status keselamatan pada sistem ujian IEEE 9-bus.

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My special thanks are presented to my beloved parents, brother and sister and all my friends. They were the pillars and my inspiration to complete my studies and extend my efforts to stay on the right path.

I certify that a Thesis Examination Committee has met on February 2012 to conduct the final examination of Ahmed Naufal A. AL-Masri on his thesis entitled "A**DAPTIVE ARTIFICIAL NEURAL NETWORK FOR POWER SYSTEM SECURITY ASSESSMENT AND CONTROL ACTION**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P. U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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AHMED NAUFAL A. AL-MASRI

Date: 24 February 2012

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