UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF KNOWLEDGE-BASED POWER SYSTEM PROTECTION DESIGN COURSEWARE

MOHAMMAD LUTFI BIN OTHMAN

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By

MOHAMMAD LUTFI BIN OTHMAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

November 2004

DEDICATION

I would like to dedicate this project to my beloved family, all my lecturers in the Department of Electrical and Electronic Engineering and friends. Their guidance and relentless support have been a great inspiration to the realization of this project. All their good deeds deserve the reward of great virtues of Allah.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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November 2004

Chairman: **Associate Professor Ishak Aris, Ph.D.**

Faculty: **Engineering**

Power system protection is a relatively specialized topic that encompasses a large variety of areas from generator protection at the source side to as far as motor protection at the load end. However, the sources for a complete collection of information on power system protections comprising the generator protection, station bus protection, line protection, transformer protection and motor protection are obviously scattered. Having been in the engineering consultancy business for years, it is realized that finding even a fundamental knowledge of a particular protection scheme in the line protection area in a convenient way is somewhat cumbersome. There isn't any interactive multimedia application software that can offer a complete compilation of topics on various power system protections comprising not only theories but also some pertinent industry application recommendations.

It is therefore the objective of the project to develop, using an expert system approach, an interactive multimedia courseware to serve as a computer-based training tool in power system protections by integrating technical theories, industrial

application recommendations and some specific simulations by which the user has a wide range of choices for obtaining technical information on power system protection. The method involved in designing the courseware revolves around the approach of using an authoring expert system shell Macromedia Director. It provides the facility of blending the power system protection knowledge domain and interactivity knowledge.

The scope of work involved in designing the software lies in the fact that the software is characterized by its three prong capabilities: multimedia interactive, knowledge based and numerical analysis ready. Being a multimedia application the final product shall be interactive and user friendly, full of attention drawing media elements such as animations, textual information, video clips, graphics, and sounds. Being a knowledge based application, it is full of information excerpt on power system protection obtained from variety of sources such as widely referred texts, industry application manuals, international standards such as IEEE's recommended practice and seminar materials. Being numerical analysis ready, the software can link itself to widely used engineering simulation softwares such as MATLAB for running simulations on some industry's power system protection configurations.

A simple survey has been carried out to ascertain its usefulness and user friendliness by having a number of people from different facets of working disciplines in the industry as well as students try out and evaluate the final product. Generally the response has been very encouraging. The application has the potential of more expansion in terms of the contemporary applications in the present power system protection advancement.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN PERISIAN REKA BENTUK PERLINDUNGAN SISTEM KUASA BERASASKAN PENGETAHUAN

Oleh

MOHAMMAD LUTFI BIN OTHMAN

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Perlindungan sistem kuasa adalah suatu topik khas yang merangkumi pelbagai bidang dari perlindungan janakuasa di bahagian sumber kuasa sehinggalah kepada perlindungan motor di hujung beban. Tetapi koleksi informasi yang lengkap tentang perlindungan sistem kuasa yang mengandungi perlindungan janakuasa, perlindungan stesyen bas, perlindungan talian, perlindungan alatubah dan perlindungan motor adalah ternyata sekali berselerak. Setelah terlibat dengan activiti perunding kejuruteraan sekian lama, adalah didapati bahawa untuk mendapatkan bahkan pengetahuan asas mengenai sesuatu skim perlindungan di dalam perlindungan talian secara mudah adalah agak sukar. Tidak tepdapat suatu perisian multimedia yang menyediakan kompilasi lengkap tentang topik-topik berkenaan pelbagai perlindungan sistem kuasa yang merangkumi bukan sahaja teori-teori tetapi juga cadangan-cadangan penting mengenai penggunaannya di dalam industri.

Oleh yang demikian adalah menjadi objectif projek ini, dengan menggunakan pendekatan sistem pakar, untuk membangunkan satu perisian pembelajaran multimedia interaktif yang bertindak sebagai alat pengajaran berasaskan komputer di

dalam bidang perlindungan sistem kuasa dengan mengintegrasikan teori-teori teknikal, applikasi-applikasi industri dan beberapa simulasi terperinci dimana pengguna diberi pilihan yang luas untuk mendapatkan informasi teknikal tentang perlindungan sistem kuasa. Kaedah yang terlibat di dalam membangunkan sistem pakar adalah berkisar kepada penggunaan perisian pengarangan sistem pakar yang dikenali sebagai Macromedia Director. Ianya menyediakan kemudahan menggabungkan pengetahuan mengenai perlindungan sistem kuasa dan pengetahuan tentang penginteraktifan.

Skop kerja yang terlibat di dalam membangunkan perisian ini berlandaskan kepada cirinya yang mempunyai tiga kemampuan: bermultimedia interaktif, berasaskan pengetahuan dan tersedia dengan analisa numerikal. Sebagai perisian yang berbentuk multimedia, peroduk akhir yang dibangunkan adalah bercirikan interaktif dan mesra pengguna, dipenuhi dengan elimen-elimen media yang menarik perhatian seperti animasi, informasi teks, klip video, grafik and suara. Sebagai perisian berasaskan pengetahuan, ianya lengkap dengan petikan informasi tentang perlindungan sistem kuasa yang deperolehi dari pelbagai sumber seperti buku-buku teks yang dirujuk dengan meluas, manual-manual aplikasi industri, amalan-amalan yang disyorkan oleh piawai antarabangsa seperti IEEE dan bahan-bahan seminar. Sebagai satu perisian yang lengkap dengan analisa pengiraan, ianya boleh dihubungkan dengan perisian simulasi kejuruteraan yang digunakan secara meluas seperti MATLAB bagi melaksanakan simulasi beberapa konfigurasi perlindungan sistem kuasa industri.

Satu kajian ringkas telah dijalankan untuk memantau keberkesanan dan kemesraan pengguna dengan melibatkan beberapa orang dari sector kerjaya yang berbeza di dalam industri begitu juga pelajar-pelajar untuk mencuba mengguna dan seterusnya menilai produk ini. Secara keseluruhannya respon yang deperolehi adalah memberangsangkan. Aplikasi ini mempunyai potensi untuk dikembangkan lagi dari segi penggunaan kontemporari di dalam kemajuan perlindungan sistem kuasa sekarang.

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Special thanks also goes to Dr. Nasrullah Khan for his valuable knowledge and field experience in power system protection imparted upon me in his Power System Protection course. May this project software be a great company as a teaching tool in his class.

Last but not least, particular thanks to my wife Azma, for working side by side in her own specialization in medicine and encouraging me to devote my time seriously in completing this great endeavor while running my consulting engineering firm. And of course my kids, Muhammad Naufal, Muhammad Naqeeb, Nuur Nuwairah and Nuur Nadhirah, their patience is my greatest motivation.

I pray for Allah's blessing for their collective sacrifice of time, effort and personal engagements.

I certify that an Examination Committee met on 14th October 2004 to conduct the final examination of Mohammad Lutfi Bin Othman on his Master of Science thesis entitled "Development of Knowledge-Based Power System Protection Design Courseware" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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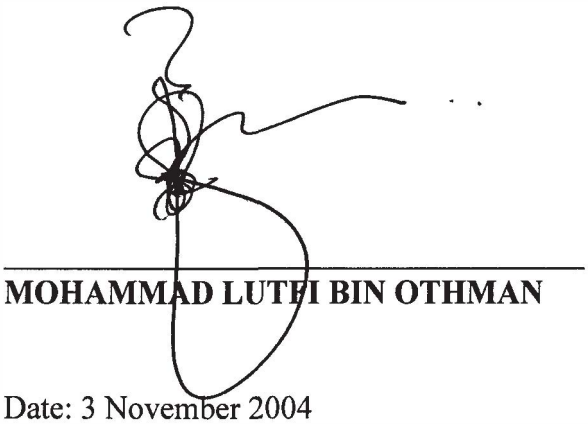
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



MOHAMMAD LUTFI BIN OTHMAN

Date: 3 November 2004

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LIST OF ABBREVIATIONS

Symbol	Description
ADDTOIE	Analysis, Design, Development, Testing, Optimization, Implementation, Evaluation
ADC	Analogue-to-digital converter
AI	Artificial intelligence
ANSI	American National Standard Institute
avi	Audio/Video Interleave file format
bmp	PC bitmap file format
CAL	Computer Assisted Learning
CBT	Computer Based Learning
CD-R	Compact disk – recordable
CD-ROM	Compact disk – read only memory
CD-RW	Compact disk – rewritable
CLIPS	C-language integrated production system
CODEC	COmpression and DECompression
DAC	Digital-to-analogue converter
dir	Director movie file format
DV	Digital video
DVD	Digital video disk
gif	Standard graphic file format for on-line services
GUI	Graphical user interface
Hz	Hertz (frequency)
IEEE	The Institute of Electrical and Electronics Engineers

IEE	The Institution of Electrical Engineers
IEM	The Institution of Engineers Malaysia
ITS	Intelligent Tutoring System
jpg	Joint Photographers Experts Group
MIAW	Movie in a window
MIDI	Musical Instrument Digital Interface
MO	Magneto-optical
MPEG	Motion Picture Experts Group
MPC	Multimedia personal computer
OCR	Optical character recognition
PC	Personal computer
png	Fireworks graphics file format
psd	Photoshop graphics file format
rtf	Rich text format
SCADA	Supervisory Control and Data Acquisition
WAVE	Windows sound file format

CHAPTER ONE

INTRODUCTION

The main objective of this research work is the development of an interactive multimedia courseware for power system protection knowledge using expert system approach. In a nutshell, it is an intelligent tutoring system (ITS) for the power system protection knowledge domain created by using authoring software based on modified expert system architecture.

The current chapter addresses an overview of this research work covering discussions on problem statement, solution framework, aims and objectives, the expert system architecture and thesis layout.

1.1 Problem Statement

Power system protection is a relatively specialized knowledge domain in power system operation that encompasses a large variety of areas from generator protection at the source side to as far as motor protection at the load end. The industrial developments with parallel technological advancements have made the power system protection to be in a tremendously great demand and wide application. As the protection revolutionizes from a mere analogue to static and currently more advanced numerical type, this leads to the emergence of new knowledge on technical concepts, ideas and theries. No matter how complex the protection system in the power industry has become, the very fundamental subject knowledge of various protection schemes are something that all industry players especially protection engineers, field technicians and learning technical students cannot

disassociate from. The term 'fundamental knowledge' in this context refers to conceptual understanding, which can be as shallow or as deep and esoteric as desired (Day and Suri, 1999). Being conversant with the fundamental conceptual knowledge of protection is in a way prerequisite to successful planning, management and operation of power system protection.

However, the sources for a complete collection of information on power system protection comprising the generator protection, station bus protection, line protection, transformer protection, and motor protection are obviously scattered. Reference books on the subject matter are plentiful but little do they really have any impact in imparting conceptual and practical protection knowledge whilst at the same time providing contemporary industry recommendations on protection solutions. In tertiary education, the protection knowledge has been taught as a not-to-be-missed course and training for some power major students and the manner it is taught has usually been of traditional and non-interactive methods (Day and Suri, 1999). This rather passive way of education is only maintaining the actual absorption of the ever-increasing amount of material in the power system protection course of limited time duration to be "hoped for rather than being ensured, leading to lessened opportunity for student participation and interaction with the subject matter" (Sener, 1991). Within this traditional mode of delivery there ought to be a scope in automating the power system protection education, as increasingly attempted by computer-assisted learning (CAL) packages and ITSs for many other expert domains, which are claimed to be able to propound experiential learning by actively participate in and interact with the subject matter to enhance their understanding.