Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 6 (15): 2963-2977, 2006
ISSN 1812-5654

Knowledge-Based Power System Protection Design Courseware

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Abstract: This research discusses the development of a knowledge-based expert system, using an interactive multimedia approach and its usage to serve as a multimedia courseware in power system protection design. The system is characterized by its three prong capabilities: multimedia interactive, knowledge based and numerical analysis ready. It integrates 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. Being an interactive computer-assisted learning tool, the system blends power system protection knowledge domain and interactivity knowledge. Survey results concerning the acceptability of this courseware prove that it is very useful to the users in so far as its performance and effectiveness as a teaching and training tool in the power system protection knowledge is concerned.

Key words: Courseware, expert system, knowledge base, multimedia, power, system protection

INTRODUCTION

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 theories. 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.

SCATTEREDNESS AND PLAIN FACTS OF POWER SYSTEM PROTECTION INFORMATION

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, however, obviously scattered (Othman *et al*., 2004). 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 students majoring in power engineering 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 packages and intelligent tutoring systems 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 (Hippisley and Houghton, 1991).

The available expert systems such as that in instructional multimedia softwares in narrow domain of subject knowledge are given more emphasis on technology rather than on pedagogy (enlightening and educational) because of the deliverance of only plain facts and information (Cheng and Rowe, 1993). The problem is that the existing courseware authoring systems are used

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mainly to produce a presentation level application and Will (2001) advocates the use of knowledge-based approaches for developing effective courseware.

RECENT KNOWLEDGE BASED EXPERT SYSTEMS IN ELECTRICAL ENGINEERING

Expert systems currently find success in areas such as science and engineering. Rasdorf and Linda (1999) remark that of all the contributions of artificial intelligence, expert systems show some of the most significant promise for engineering applications. In electrical engineering discipline, prototype expert systems have been developed to assist with interpretation, design, planning, diagnosis, control (Rasdorf and Linda, 1999), training, teaching and other electrical engineering functions. The following are among the many expert systems/interactive multimedia coursewares that can be found in electrical engineering:

- Multimedia application in power machine education', an interactive multimedia courseware developed by Faizul (1999) targeted for electrical engineering students who are learning power machine knowledge domain. It can also be used by lecturers as a computer-based training to augment their teaching environment effectively.
- Electronic Engineering Dictionary, a knowledge-base expert system developed by Subramaniam (2000) aimed to be used by electronic engineering students.
- A Fuzzy Expert System for the Integrated Fault Diagnosis', an expert system developed using fuzzy reasoning method by Lee *et al.* (2000) to diagnose various faults that may occur in transmission network and substations. The system is designed to improve efficiency, generality and reliability of solutions and to assist SCADA operators in local control centers.
- An Intelligent Tutoring System for Turbine Startup Training of Electrical Power Plant Operators', an intelligent training system (ITS) developed by Lopez, Flores and Garcia (2002) to provide training to operators of electrical power plants on how to supervise and control turbine startup.
- Application of Artificial Intelligence to Power Electronic Circuit Design and Fault Diagnosis developed by Aris (1995) as a software application for power electronic circuit design adopting SPICE approach. The product is named PECT2 and designed using a programming language called Small Talk 80. This software is an improved version of a normal SPICE-like programme allowing the user to design and simulate complex circuit diagrams.

The main advantage of the proposed power system protection knowledge-based expert system work is that it contributes to the users the three distinct hallmarks: multimedia interactive, knowledge-based and numerical analysis ready. This sets it apart from the above-mentioned expert systems, which are absent in one of the three capabilities as summarized in Table 1.

With the three prong capabilities, the proposed expert system is thus developed not only to impart the fundamental knowledge of power system protection but also to simulate and analyze it. Essentially, the concepts, ideas, principles and theories of power system protection can be fully comprehended and experienced.

ARCHITECTURE OF KNOWLEDGE-BASED EXPERT SYSTEM BASED ON MULTIMEDIA APPROACH

Notwithstanding the scattered availability of information and hardly complete conveyance of power system protection knowledge in the traditional manner of lecture-based teaching, it is therefore necessary to develop a useful courseware referred to as an interactive knowledge-based expert system for tutoring, training and professional reference for power system protection needs. This interactive computer-assisted learning tool is in many ways can be used to promote experiential learning by providing facilities for user-paced participative interaction with the system in order to gain and augment fundamental knowledge about the various subject areas of the power system protection. The knowledge content of the proposed system shall be formatted to both academic and industrial settings so the users have the comprehensive information on integration of both fundamental knowledge and industrial applications.

Table 1: Comparison of capabilities between the proposed power system protection knowledge-based expert system and the other systems

Description of system	Interactive multimedia	Knowledge-based	Numerical Analysis ready
Interactive Multimedia Courseware for Power System Protection by the author.	✓	✓	✓
Multimedia Application in Power Machine Education, by Faizul (1999).	✓	✓	
Electronic Engineering Dictionary, by Subramaniam (2000).	✓	✓	
A Fuzzy Expert System for the Integrated Fault Diagnosis', by Lee *et al.* (2000).		✓	✓
An Intelligent Tutoring System for Turbine Startup Training of Electrical Power Plant Operators, an intelligent training system (ITS) developed by Lopez *et al.* (2002).		✓	✓
Application of Artificial Intelligence to Power Electronic Circuit Design and Fault Diagnosis by Aris (1995).		✓	✓

Note: ✓ denotes presence of the mentioned capabilities

The proposed system should be able to assist learning of the power system protection as apparent in six different ways of looking at:

- Increased interaction, quantity and intensity;
- Better access to group knowledge and support;
- More democratic environment;
- Convenience of access;
- Increased motivation;
- More critical thinking (English and Yazdani, 1999).

In order to tap into the aforementioned desired advantages and ensure usefulness, apart from imparting only basic and essential concepts, ideas, principles and theories of power system protection, the proposed system shall be properly designed to be experiential in the sense of complete involvement and appreciation by providing simulation facility of some protection techniques.

The approach in the development of the power system protection knowledge-based expert system revolves around the architecture that combines the use of such an intelligent tutoring system shell as Macromedia Director for the inference strategy to present the knowledge domain of power system protection in a multimedia interactive manner and the launch of such a task-based expert system shell as MATLAB for that domain. In simple words, the power system protection interactive tutoring system can be experimented or simulated by linking to a problem solving strategy.

MATLAB is an excellent software for modeling, simulating and analyzing dynamic engineering systems such as that in the knowledge domain of power system protection. The use of the simulation contributes to the users confidence and enhances their motivation to stay on task.

The proposed architecture of the system is essentially tailored to the production model of multimedia interactive tutoring system. This is a modified version to the usual architecture of the modern rule-based expert system as advocated by Negnevitsky (2002). Figure 1 shows the complete architecture of the proposed multimedia adapted knowledge-based expert system for the power system protection tutoring. The modified knowledge-based expert system has six components:

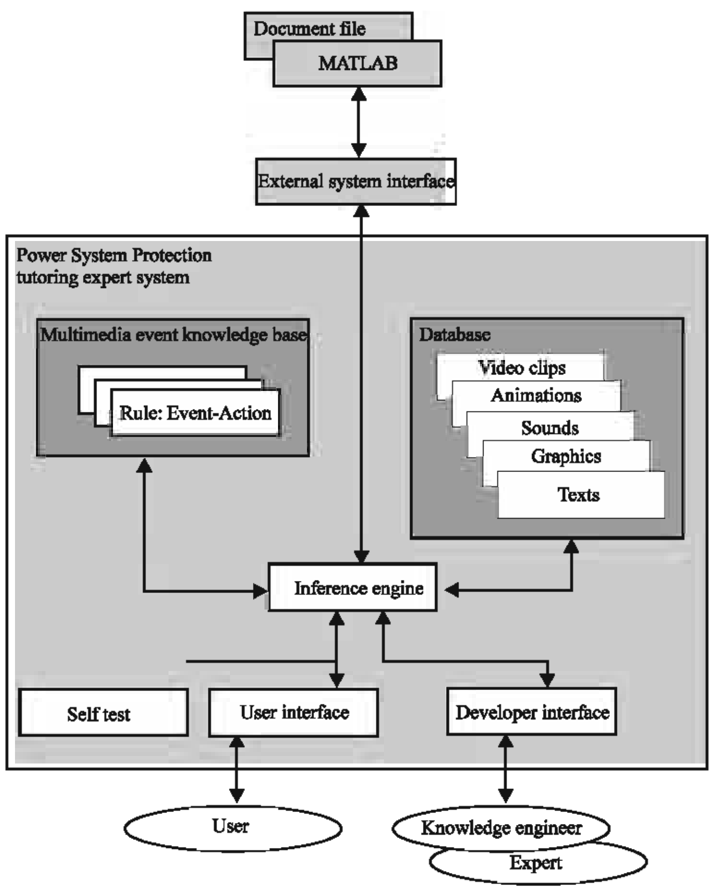

Fig. 1: Architecture of a multimedia adapted knowledge-based expert system for the power system protection tutoring

multimedia event knowledge base, database, inference engine, user interface, developer interface, external system interface and self test.

The multimedia event knowledge base as the name suggests contains a set of interactivity rules of events and actions (as compared to rules in the rule-based expert system) that handle certain actions when related interactive events such as mouse-down and cursorrollover occur. The knowledge is represented by the interactivity rules of events and actions. Each rule is composed of commands, functions, arguments and special logic to control interactive navigation of the application.

The database includes a vast amount of media elements among of which can be representations of the knowledge domain of power system protection in a variety of multimedia element forms such as texts, graphics, sounds, animations and video clips. The database is matched against the action parts of the interactivity rules of the event knowledge base.

The inference engine carries out the interactive controls whereby the expert system performs the commanded multimedia operations. It links the interactive rules given in the event knowledge base with the media elements in the knowledge domain database. Interactive controls in the event-based are akin to the selecting and firing of rules in rule- based system. This is largely an automatic process, which the user initiates to start an interactive session. The inference conducts an interaction with the user, where an event of the user's interactive action leads to the subsequent programmed action of the expert system. The solution of the interactivity is the representation of a specific topic of the domain knowledge from the database or an external task-based expert system shell (i.e., MATLAB).

The user interface is the means of communications between users seeking interactive solutions to the desired controls and operations of the expert system. The communication should be as meaningful and friendly as possible.

The developer interface is the procedure at the system design stage where all the above architectural components are linked and correlated together to form a single expert system unit. This is made possible by using the intelligent tutoring system shell called Macromedia Director. The tutoring system shell provides a text or script editor for composing the shell's scripting language called Lingo to create commands. Scripts are combinations of words that convey instructions and information to control the application system. Essentially, Lingo scripting is writing instructions using a special language that Director uses to interpret commands. Lingo is designed to be relatively easy to use and provides the ability to add extensive functions to the expert system.

The external system interface allows the expert system to work with an external expert system shell for modeling, simulating and analyzing the knowledge domain of the power system protection tutored in the main system. The intended expert system shell to be launched, as aforementioned, is MATLAB.

The self test features quizzes that allow the user to gauge his understanding of the power system protection knowledge domain presented in the expert system. He shall navigate from one protection category to another in order to test himself according to specific protection topics. A result of his achievement shall be presented at the end of each test session.

In the modified knowledge-based expert system adaptation to the interactive multimedia approach, the knowledge that is to be represented in the intended tutoring expert system is divided into two parts that are:

- The knowledge of interactive events that are formed into event-based rules. An event-based rule consists of an event-action statement where a given set of events (e.g., mouse click, mouse up, mouse down, cursor rollover, etc.) will lead to a specified set of interactive actions, or inferences (e.g., move to another screen, jump to a particular marker in a time line, change a particular graphic member etc.,). This concept is different from the conventional rule-based system concept where knowledge is represented as a set of logical if-then rules.
- The knowledge domain of power system protection itself that is represented through the execution of the above interactive event knowledge. The representation of the power system protection knowledge takes in two kinds of form:
  - Firstly, from the databases resident in the intended expert system comprising of media elements (i.e., texts, graphics, animations, videos and sounds).
  - Secondly and complementarily, from an external engineering expert system shell (such as MATLAB) that is launched from the intended main expert system under the concept of reusability.

With this concept of modified knowledge-based expert system to produce interactive multimedia, the system to be built is said to be expert in problems specific to both the knowledge of navigational interactivity (event-action relationship) and the knowledge domain of power system protection which is represented on the screen via media elements and a standalone expert system shell. For example, in order for the system to present the fundamental concept of over current relay setting of the line protection, it must be able to execute the inference of the desired navigation in order to locate and present the intended scrollable text media or launch an external expert system shell to solve the required modeling, analysis and simulation problems.

REUSABILITY OF TASK-BASED EXPERT SYSTEM SHELL

The system architecture that incorporates interaction with a generic task-based expert system shell (MATLAB) to produce a tutoring system for the knowledge domain power system protection is called reusability.

Reusability is described as the reuse of the knowledge-rich structure of generic tasks (i.e., modeling, simulating and analyzing) for instructional purposes, allowing the tutoring of domain and problem solving knowledge embedded within an expert system (El-Sheikh, 2002). A dedicated interface software (Zlaunch) for the interfacing facility in the multimedia authoring expert system shell (Director) was implemented and utilized in the proposed system to provide the accessibility to the domain knowledge manipulation in the generic task-based expert system shell.

With the method of reusability, authoring expert system shell gives knowledge engineers or the domain experts for that matter tool to produce the following important features envisioned for an effective tutoring system:

- Visually appealing and interactive screens and
- Rich and deep representation of the domain knowledge of power system protection pedagogy.

In this way, the problem of most commercial interactive multimedia systems of having shallow representation of content can possibly be addressed. The complementary advantage in the reusability is that the task-based expert system is itself an explicit representation of knowledge and inference strategies. With the task-based expert system shell, simulation serves as a source of constructive feedback that enables users to take more responsibility on their learning.

DEVELOPMENT PROCESS OF THE PROPOSED EXPERT SYSTEM

The design model for the development of the interactive multimedia expert system provides a working framework that can help in executing the design and development in a more systematic fashion. The design model emphasizes on proper planning so that the software product is appropriate and acceptable to the targeted audience as well meet the aimed objective.

The design model employed in the structured development of the expert system is based on an instructional design model specially established for this project called ADDTOIE (pronounced add toy). Generally, the ADDTOIE model is an acronym for Analysis (identifying problem, solution, learning objective and targeted audiences), Design (pre-authoring: product and page story boarding, media acquisition, conversion and editing), Development (authoring: synchronization and interactivity), Testing (testing for fulfillment of story board specifications and formation of architecture), Optimization (optimizing the product for glitch-free operation), Implementation (post-authoring: packaging, distribution and delivery) and Evaluation (performance acceptability of the end product).

SYSTEM IMPLEMENTATION

From story board representation in the design stage to the final product authoring in the development stage, the interactivity knowledge of event-action relationship is translated into scripted event-based rules or inference so that the knowledge domain of power system protection system can be presented in an interactive manner. Furthermore, through interactivity the imparting of the power protection system knowledge domain can be further perpetuated by allowing the user to launch an external expert system shell MATLAB for simulation from the main expert system. This allows more experiential learning on the part of the user.

Figure 2 shows the actual sequential representation of the interactive knowledge in the product story board of the expert system. All the screen pages in level 0, 1 and 2 represent different topics and are formed of different files formatted as the Director movie files. Due to the complexity and extensiveness of contents constituted in each topic, it is necessary that the topics are segregated into multiple modules.

The power system protection courseware can be operated in three modes of function as established in the product story board:

- Navigation between movie modules that occur between level 0, 1 and 2 of the product story board, i.e. the communication between different movies of Power System Protection Introduction, Power System Protection main menu and Power System Protection categories (e.g., Generator Protection, Motor Protection etc.) respectively.

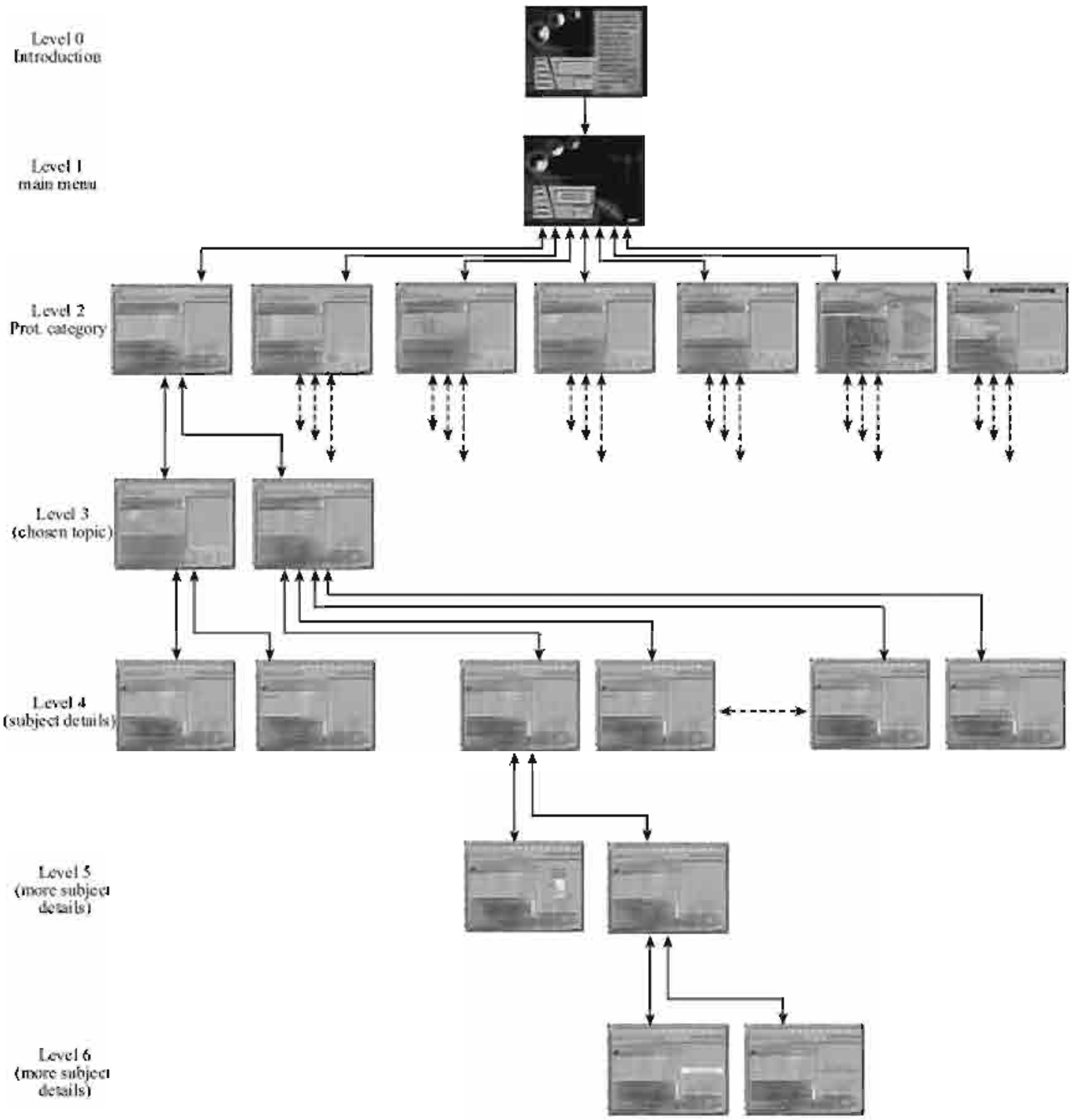

Fig. 2: Sequential representation of the interactive knowledge of the expert system

- Individual movie module navigation to verify the various interactivity functions of the page story boards within each protection category movie.
- Overall system test of the complete knowledge-based expert system in order to verify the integrated functionality of product story board and page story board planning.

As shown in Fig. 2, the example of the Generator Protection movie can be navigated from the Power System Protection Introduction movie through the Power System Protection main menu movie and finally to the Generator Protection category movie, in that order. The communication between the Power System Protection main menu movie and the Generator Protection category movie is achieved when the Generator protection button in the former is clicked on. In a likewise manner, the other Power System Protection category movies, such as the Line Protection movie, Transformer Protection movie, Motor Protection movie and the like, are opened when the corresponding buttons in the main menu movie are selected.

The user has to navigate along the branches of a tree structure that is shaped by the natural logic of the content from Power System Protection main menu movie to the various Power System Protection category movies. The

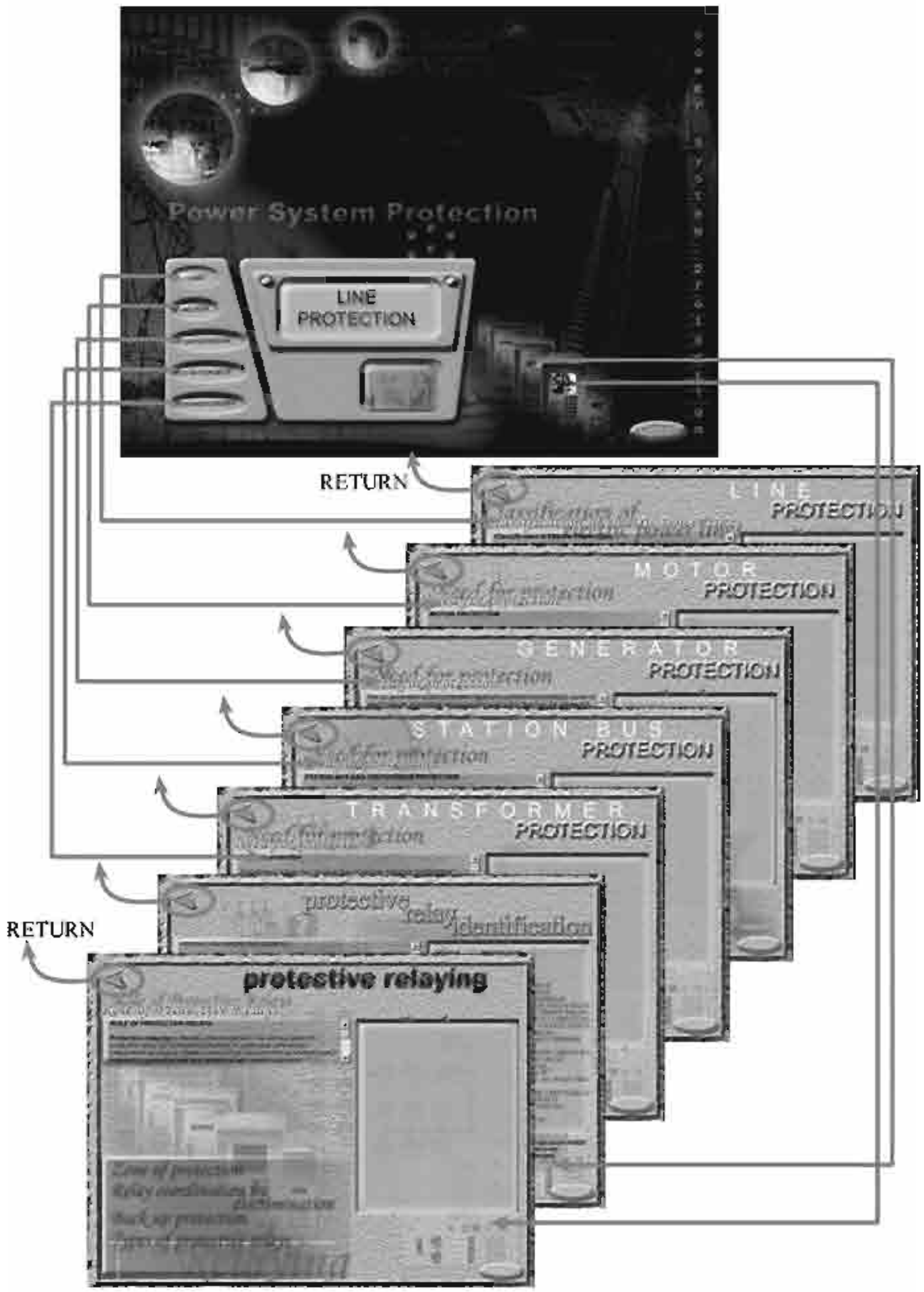

Fig. 3: Movie navigation facility of the proposed system

reverse direction from any of the Power System Protection category movies to the Power System Protection main menu movie is also made possible along the same hierarchical structure via the Power System Protection return button found in each of the movies in level 2 as in Fig. 3. This is necessary in order to allow the user to have the opportunity of opening any Power System Protection category movies as he desires when he is back in the main menu in level 1. Linear flow of navigation is invoked when the user has to follow through the sequential order of the organization from a movie at one level to the next consecutively in either downward or upward (return) direction.

Individual movie module navigation can verify the various functions of interactive elements in the page story boards within each Power System Protection category movie module so that the presentation of the corresponding protection knowledge domain is

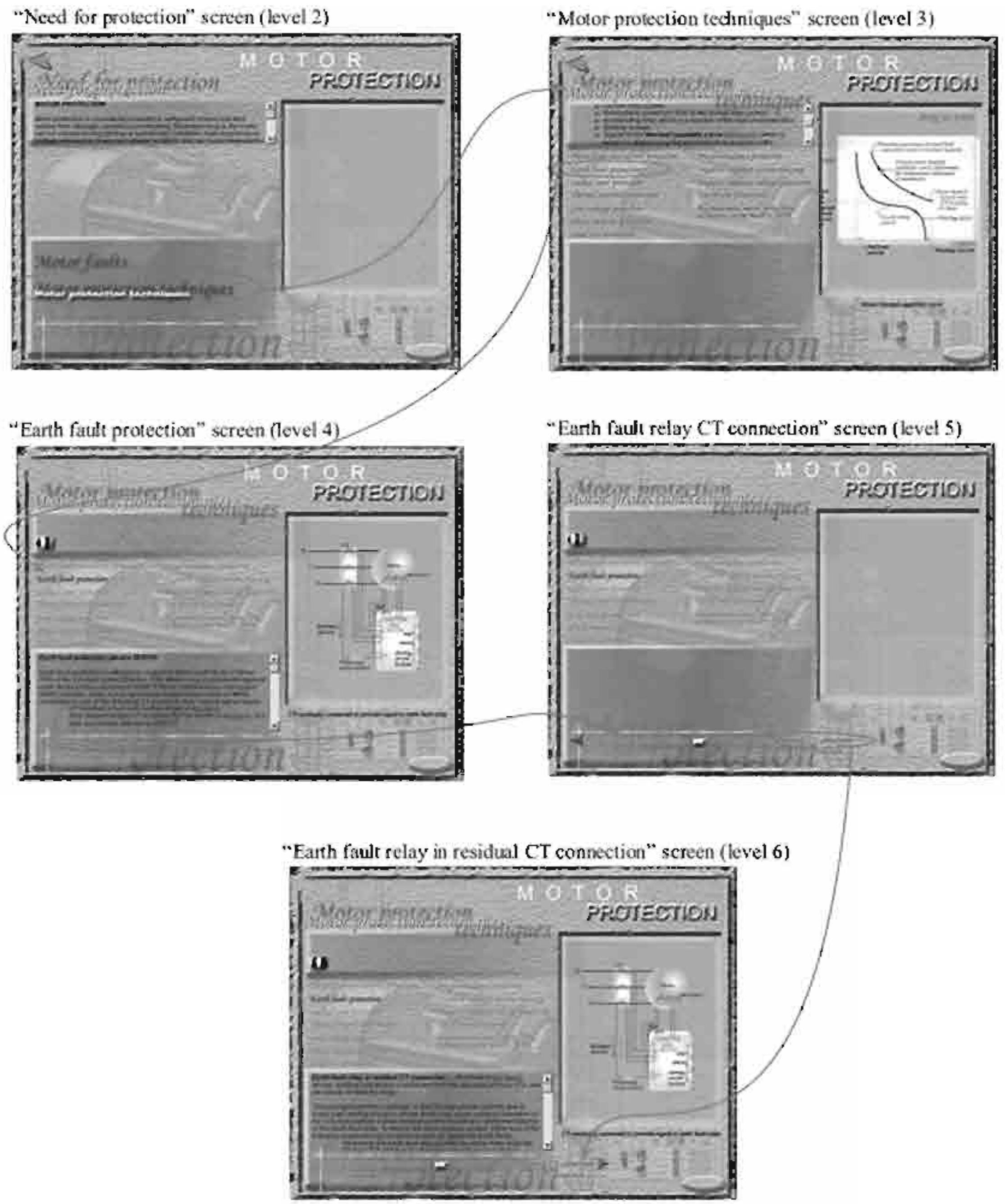

Fig. 4: Interactivity for a particular topic in the Motor Protection movie

successfully realized. As designed in the authoring stage, all the Power System Protection category movies are formed into modules as they are saved as separate Director movie files. Thus it is only proper to check the interactivity by accessing the individual Movie at level 2 and move on to the downstream at higher-level numbers for some particular topics of specific subject matters. For example, as shown in Fig. 4, the following sequence in linear fashion starting at the start of the Motor Protection movie (i.e., at level 2) has to be followed through in order to get to the Earth fault relay in residual CT connection screen of the motor earth fault protection knowledge domain: Need for protection screen (level 2), Motor protection techniques screen (level 3), Earth fault protection screen (level 4), Earth fault relay CT connection screen (level 5) and eventually Earth fault relay in residual CT connection screen (level 6), in that order. From this last point, returning to the main screen of the Motor Protection movie (i.e., at level 2) shall only be possible with linear navigation by following the same sequence in a reverse direction. In both ways, even though there seems to be numerous levels to get through, the seamless transition of screen to screen shall make one always feel at ease with the feeling and sense of direction.

The logical arrangement of the product story board from the main screen of the Motor Protection Movie (i.e., at level 2) to the levels down the line is formed around the interactive knowledge of hierarchical concept. From one level one can have a number of options of choosing the variety of screens available in the next level. The same concept of navigation knowledge is generally also adopted to all the other Power System Protection movies: Transformer Protection movie, Line Protection movie, Generator Protection movie, Station Bus Protection movie, Protective Relaying movie and Protective Relay Identification movie.

The important facility in this expert system, as has been aimed in the planning stage, is the launch of the external expert system shell MATLAB that resides independently external to the main application. This facility is needed to enhance the particular power system protection knowledge domain in review. For the example shown in Fig. 5, the click of the button IDMT over current elay setting simulation: MATLAB of the IDMT over current relay setting screen in the Line Protection movie will launch the MATLAB application and open the document file where the simulation related to the topic of interest has been created. All the user has to do once in the MATLAB environment is to run the application and observe the effect of over current on the circuit: whether the circuit breaker would trip or otherwise as shown in Fig. 6 and 7. Users that are used to the use of the MATLAB software can even manipulate the circuit by alteration of parameters, remodeling of the circuit and resimulation for different numerical analysis. In this way, experiential learning is imparted to the user for enhancing his apprehension of the knowledge of IDMT over current relay setting. When the MATLAB session is terminated the user will be able to return to the main expert system at a screen location where he left off.

The video presentation feature of some topics such as the distance protection of the line protection has been

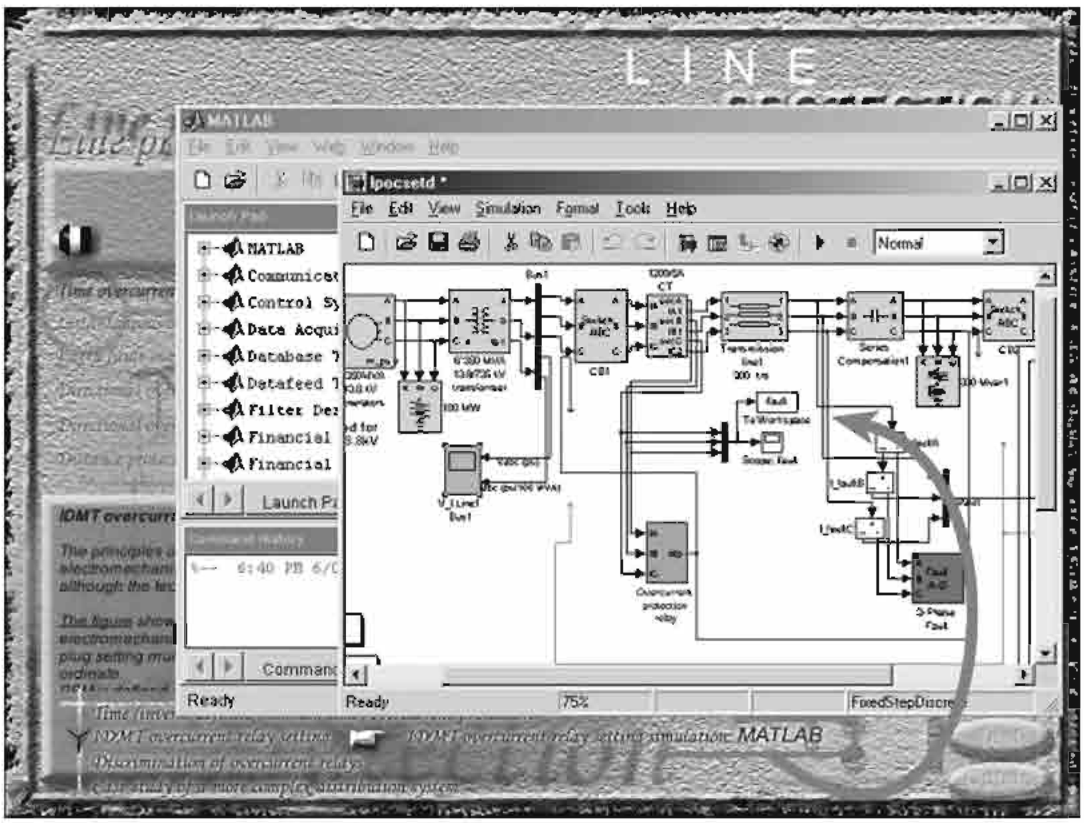

Fig. 5: Launching of an external expert system shell MATLAB that resides independently external to the main expert system

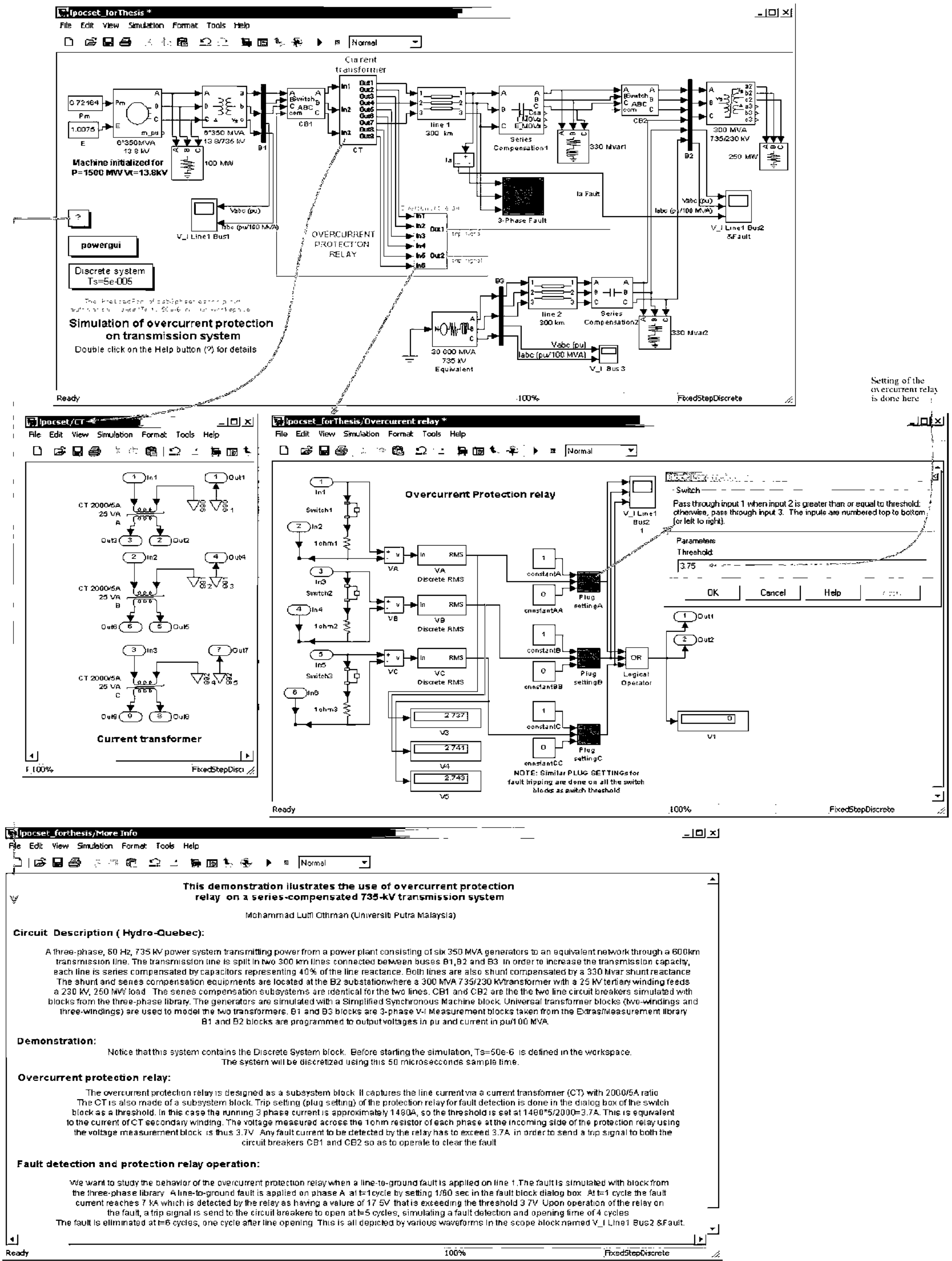

Fig. 6: Tutorial example in the launched MATLAB for over current protection setting and operation

successfully created for enhancement of understanding. In the Line Protection movie the video presentation of the distance protection is available in level 5. The Video button as shown in Figure 8, when pressed, leads to the opening of a movie-in-a-window (MIAW) movie file for the video clip presentation of the laboratory distance

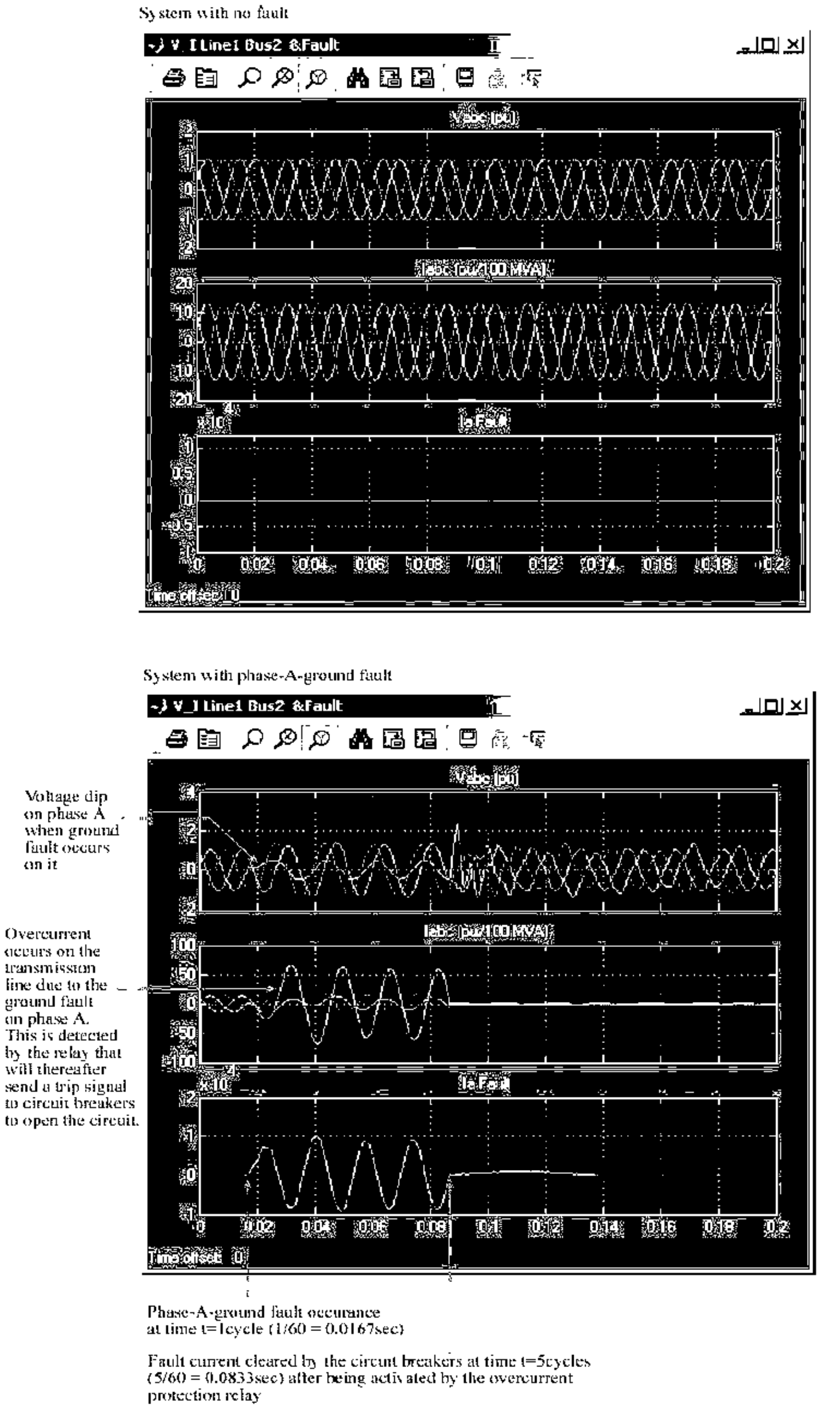

Fig. 7: The behavior of the transmission line waveforms before and after subjected to line-ground fault on phase A

protection simulation performed in the Tenaga Nasional Research and Development Center (Malaysia) within the main platform of the Line Protection movie screen of level 5. The various video control buttons are available to control the normal playback functions of the video such as play, stop, step forward, step backward, return to the start and advance to the end of the video clip.

The self test facility has been created that allows the user to gauge his understanding of the power system protection knowledge domain presented in the expert system. The user can test himself on a specific protection category. If he wants to test his understanding on line protection, then, he has to be in the Line Protection main screen and open a line protection test screen (which is an

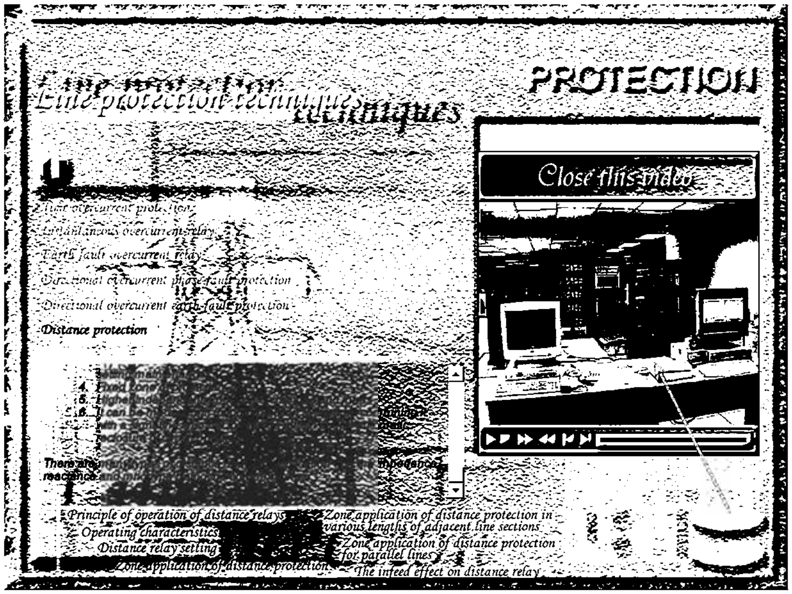

Fig. 8: Video clip presentation of the laboratory distance protection simulation

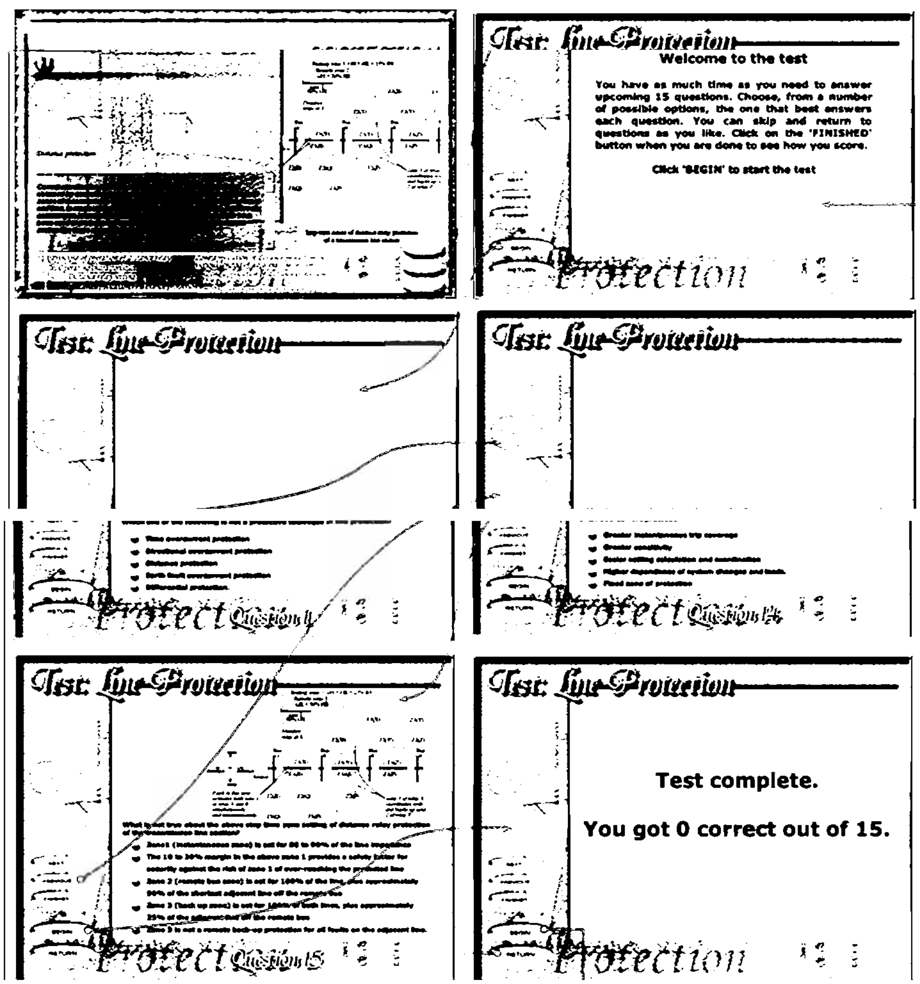

Fig. 9: Navigational flow of the Line Protection test facility

independent Director Movie file in the form of MIAW). At the end of the test session, the user's achievement on the protection category concerned is presented. Fig. 9 shows the navigational flow of the Line Protection test right from the opening of the test screen to the presentation of the test result.

EVALUATION OF THE SYSTEM'S PERFORMANCE AND EFFECTIVENESS

Evaluation of the performance and effectiveness of the interactive multimedia expert system is necessary in determining how well the objectives for interactivity and adaptive learning environments of power system protection established in the planning phase have been accomplished. An evaluation framework has been devised to evaluate the system by gauging its four main sectors through their associated factors namely:

- Content: Validity and authority, accuracy, uniqueness, appropriateness, scope and coverage.
- Presentation and organization of the content:
  - Pedagogical, concerned with learning and instructional design theories: Instructional model, structure, user's control, adaptivity (accommodation of individual differences) and cooperative learning;
  - Interface design: Interactivity, navigation, feedback and screen design.
- Technical support and update processes: Content durability over time, updating, modifying and adding procedures and technical coverage.
- Evaluation of learning:
  - learning outcome;
  - learning process that is usability of the product by measuring the user's attitude: Easy to learn, efficient to use, easy to remember, few errors and pleasant to use (Elissavet and Economides, 2003).

The evaluation framework for the system's performance and effectiveness is captured in an evaluation instrument in the form of 58 questionnaires concerning the above sectors and employing three-point suitability scale; where score 1 is assigned to disagree and score 2 to agree. The scale also includes the score 0 for those items in the questionnaire that cannot be evaluated, as they do not apply during the evaluation of the system.

In order to have an overall idea regarding the value of the courseware at the end of the evaluation process, the sum of the score in all items and its comparison with the

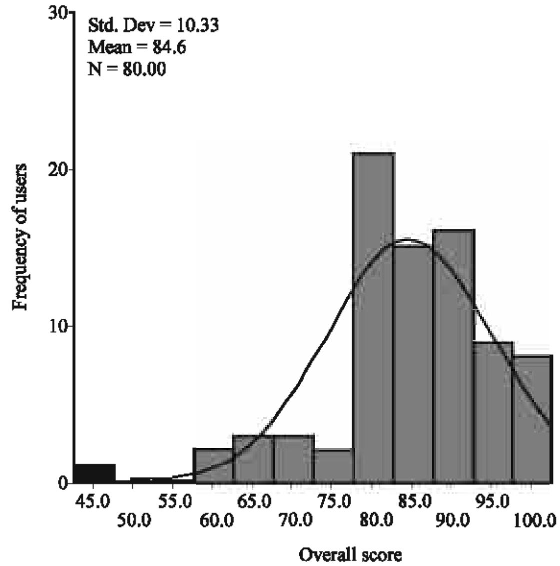

Fig. 10: Frequencies of users with respect to overall scores

total sum, that is the maximum of the marks in all items, is required. Therefore, the total sum for the overall evaluation is $58 \times 2 = 116$.

The evaluation instrument had been handed out to some eighty users ranging from electrical engineering students and lecturers of the Universiti Putra Malaysia and the University Institut Teknologi Malaysia to practicing electrical engineers and consultants, some of whom had power system protection working background or at least had seen the field application of it. Each of them had earlier been either presented with the application by the author or given a copy of the courseware in CD-ROM for trial run. The results taken from the study are summarized in Fig. 10 in terms of frequencies of users with the corresponding overall scores.

In order to interpret what the total score denotes in terms of the application's acceptability to be used for teaching and learning, it is necessary to agree on a threshold value for comparison. In university education and grading scheme of examination, it is quite a universally adopted convention that two third (67%) of a total mark is considered an average mark. In the analysis for statistics of the overall score distribution in Figure 10, we are testing whether the mean score is equal or greater than 67% (i.e., the hypothesized mean) and, thus, whether it is statistically significant to suggest that the application is of acceptable performance and effective for teaching and learning tool.

Table 2 shows the results of a one-sample t-test. In the first table, the observed sample mean is 84.55%, which

Table 2: T-test, the overall score statistics

On-sample statistics	N	Mean	Std. deviation	Std. error mean		
Score	80	84.55	10.33233	1.15519		
	Test value = 67				95% Confidence interval of the difference	
One-sample test	t	df	Sig. (2-tailed)	Mean difference	Lower	Upper
Score	15.192	79	0	17.5500	15.2507	19.8493

exceeds the tested hypothesized mean 67% with the mean difference of 17.55%. The 95% confidence interval for the difference between means goes from 15.25 to 19.85. The two-tailed p-value, which is 0.00, is definitely less than 0.05 (and 0.01), so the result with the mean difference of 17.55% is large enough to be considered statistically significant to connote that in general the expert system is relatively quite acceptable in its performance and effectiveness as a teaching and training tool in the power system protection knowledge domain.

CONCLUSIONS

This courseware has been created to address the strong call for having a computer-assisted learning package to automate the power system protection education. The traditional and non-interactive fashion of teaching in the power system protection domain causes an impasse as far as the learners participation and interaction with the subject matter is concerned. The scatteredness of the sources of complete collection of information on power system protection comprising the generator protection, station bus protection, line protection, transformer protection and motor protection, among others, is just compounding to the problem of passive absorption of vast amount of material. Thus within this traditional mode of delivery, the development of the courseware has undoubtedly propounded experiential learning by having users actively participate in and interact with the subject matter to enhance their understanding. The knowledge content of the courseware has been formatted to both academic and industrial settings so that the users have the comprehensive information on integration of the fundamental knowledge of the various subject areas of the power system protection and the corresponding industrial applications. To ensure usefulness of complete involvement and appreciation, apart from imparting only basic and essential concepts, ideas, principles and theories of power system protection, the knowledge-based expert system has been carefully designed to launch a task-based expert system shell MATLAB for problem solving strategy of the knowledge domain. To put simply, the courseware can be experimented and simulated, unlike most ordinary interactive multimedia coursewares. The use of simulation contributes to the users confidence and enhances their motivation to stay on task.

As aspired, the system has been designed to be characterized by its three prong capabilities: multimedia interactive, knowledge based and numerical analysis ready.

Survey done on a spectrum of people ranging from university students, lecturers, electrical consultants and engineers reveals that the system is relatively quite acceptable in its performance and effectiveness as a teaching and training tool in the power system protection knowledge domain.

ACKNOWLEDGMENT

The authors wish to express special gratitude to the researchers of the Tenaga Nasional Research and Development Center, Bangi, Malaysia (a research arm of Malaysia's forefront power provider Tenaga Nasional Berhad) for their cooperation in allowing experiments to sbe performed and some video captures to be taken on laboratory protection set up.

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