Expert Systems Worldwide

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ABSTRACT

In 1993, over 4,000 expert systems in the United States and over 2,000 in Japan are operational and most of them have proven to be highly beneficial to the users. However, in Thailand and Southeast Asia, the number of operational expert systems are still much lower than those in the U.S.A. and Japan. Therefore, the International Conference on Expert System Technology and Applications is organized in order to promote understanding and applications of expert systems technology in this part of the world. To make the Conference Proceedings more useful, this paper is written to serve as a tutorial and survey or introduction to the more advanced papers by other experts such as those from Japan, Korea and Singapore. Presented in this paper are the definitions and advantages of expert systems, followed by examples of operational expert systems in the U.S.A., Japan, and the Far East. Since expert system technology and applications change rapidly, persons interested in the subject should join learned societies and study their publications. Therefore, expert-systems-related societies and their publications are also covered in this paper.

1. INTRODUCTION.

Roughly speaking, an expert system is a computer program that uses human knowledge and inference procedures stored in a computer to allow the computer to solve problems. Expert systems have been available for more than 20 years. One of the expert systems was developed in early 1970s by Digital Equipment Corporation (DEC) and Carnegie-Mellon University called “R1” or “XCON” to configure VAX-11/780 and other DEC computers. It was written in the language MAACLISP with 772 rules and used on a daily basis at that time.
In mid-1970s, Stanford University Medical Experimental Computer Facility developed the widely-known expert system called “MYCIN” to diagnose and prescribe treatment for meningitis and bacteremia infections. It was written in Interlisp with 400 rules.

In late-1970s, Stanford University developed another expert system called “Dendral” to estimate the molecular structures of unknown compounds by analyzing mass spectrographic, nuclear magnetic resonance, and other data. Some people claimed that is the first operational expert system because it was started in 1965 [9].

In addition to R1, MYCIN and Dendral, some other well-known expert systems are Crib, Prospector, Puff, Sacon, Taxadvisor and VM. Crib was written in Coral and Plan with 1,500 rules to diagnose faults in computer hardware and software. Prospector was written in the language for DEC 10 with 212 assertions and 133 inference rules to aid geologists in evaluating mineral sites for potential deposits. Puff was written in Emycin with 250 rules to analyze results of pulmonary function tests for evidence of disorder. Sacon was written in Emycin with 170 rules to advise structural engineers in using the structural analysis program MARC. Taxadvisor was written in Emycin with 275 rules to provide estate planning recommendations for clients. VM was written in Interlisp with 120 rules to provide care suggestions for patients needing breathing assistance.

With advances in computer technology, more memory and faster speed are available and so more and more expert systems are developed. By 1993, it is said [8, 11, 20, 22, 25, 26, 28, 29] that

- The numbers of operational expert systems (ES) are over 4,000 in the U.S.A. and over 2,000 in Japan.
- Financial firms on Wall Street are using ES as watchful eyes over billion of US investment dollars.
- Several ES were deployed in the Gulf War to handle radar, logistics, planning, etc.
- Help desk and service industry applications of ES continue to rise.
- Fuzzy logic applications are multiplying, especially in home consumer product market.
- ES are now operational in various industries such as steel, electromechanical, power, automobile, oil, paper, airline, construction, investment, telecommunications, etc.
- ES are widely used in the U.S. to assist people in preparing their tax returns.
- An ES is used by American Express to assist 300 credit authorizers and found to reduce bad decision by 76%.
- NASA uses ES to monitor space flights 24 hours a day.
- Whirlpool uses ES to handle nine million customers per year.
- Xerox uses ES to reduce cost by about 500 million baht per year
- Texaco ES serve 30 help desk people to answer questions on 250 products.

Even though modern computers are readily available in Thailand and Southeast Asia, the number of operational expert systems in the countries in this part of the world are still much lower than those in the U.S.A. and Japan. Therefore, the International Conference on Expert System Technology and Application is organized in order to promote understanding and applications of expert systems technology. To make the Conference Proceedings more useful, this paper is written to serve as a tutorial and survey or introduction to the more advanced papers by other experts such as those from Japan, Korea and Singapore. Presented in this paper are the definition and advantages of expert systems to be followed by examples of operational expert systems as well as other useful information such as learned societies and publications in the field of expert systems.

2. DEFINITION OF EXPERT SYSTEMS.

From Webster's New World Dictionary of Computer Terms [30]:

"Methods and techniques for constructing human-machine systems with specialized problem-solving expertise. The pursuit of this area of artificial intelligence research has emphasized the knowledge that underlies human expertise and has simultaneously decreased the apparent significance of domain-independent problem solving theory. An expert system assists or replaces an expert to solve problems."

The above definition was published in 1988 and so it may need additional explanation in 1993. While it is correct that an expert system may assist an expert to solve problems, more and more expert systems are employed to assist non-experts, especially in the popular help-desk situations.

A shorter definition which may be more general is given in the book by Hellerstein on Expert Systems in Data Processing [12] where the author modified the definition from the book on Artificial Intelligence Applications for Business [27].

"An expert system is a computer program that use explicitly represented knowledge and computational inference procedures to solve problems normally requiring significant human expertise."

From the book entitled Artificial Intelligence Enters the Marketplace [10],

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"The other AI branch, and the one that has received the most publicity, is that of expert systems. As the name implies, these systems contain the knowledge of experts in specific fields, along with the reasoning rules these people employ to manipulate their knowledge and arrive at conclusions. Given this capability, expert systems can serve as assistants to people, giving suggestions and opinions, and explaining the derivation of these if asked. The best-known expert systems include some in such fields as medical diagnosis, geological surveying, and, appropriately, computer system configuration. Natural language and expert systems are complementary, in that they can work in concert to produce a very-easy-to-use, very "smart" computer."

From the book "Expert Systems: A Decision Support Approach" by Klein and Methlie [14]:

"A computer program that employs knowledge and inferencing to solve problems is sometimes called a knowledge-based system. When knowledge and inference procedures are modeled after human experts, we call such a knowledge-based system an expert system."

Therefore, the term "expert systems" may be interchanged with "knowledge-based systems" or "rule-based system" or "knowledge-based expert systems" or "rule-based expert systems". For example, in the book entitled "Knowledge-Based Manufacturing" [13], the following definition is given

"A rule-based system consists of the following components: a database, a rule base, and inference engine (as shown in Figure 1)."

![Figure 1: Components of a Rule-Based System](image-url)
In most books on management information systems [15, 16, 23, 24], the concepts of expert systems are fairly covered. From Long [23],

"An expert system is the highest form of a knowledge-based system. An expert system is an interactive system that responds to questions, asks for clarification, makes recommendations, and generally aids in the decision-making process. The less sophisticated knowledge-based systems are called assistant systems. An assistant system helps users to make relatively straightforward decisions. Assistant systems are usually implemented to reduce the possibility that the end user will make an error in judgment rather than to resolve a particular problem."

From Laudon and Laudon [16],

"An expert system is a knowledge-intensive program (software) that solves a problem that normally requires human expertise. An expert system can merely assist decision making by asking relevant questions and explaining the reasons for adopting certain actions. Some of the common characteristics of expert systems are the following:

- They solve problems as well as or better than human experts.
- They use knowledge in the form of rules or frames.
- They interact with humans.
- They can consider multiple hypotheses simultaneously.

Expert systems are therefore different from thermostats and autopilots insofar as they attempt to base their actions on human knowledge."

Figure 1 should be modified to include the user interface as shown in Figure 2.

![Figure 2: Another View of Expert System](image-url)
To develop an expert system, a knowledge engineer has to consult the domain expert (the expert in the field or the domain) to obtain the knowledge to be stored in the knowledge base. The actual implementation may be done either by writing a new program or using a ready made program called an Expert System Shell (ESS). In writing a new program, either the AI languages like LISP or Prolog or a high level language like C could be used. An ESS is a computer program with the skeleton of the ES (such as the inference engine and the user interface) without the knowledge in the knowledge base. When an ESS is supplied with the knowledge in any field of applications, the ESS becomes an ES in that field of applications.

3. ADVANTAGES OF EXPERT SYSTEMS.

In addition to the usual benefits of computerized information systems such as accuracy, reliability, etc. the computerized expert systems offer the following benefits not usually gained in other types of computerization:

- **Preservation of knowledge.** A computerized expert system allows the knowledge of a human expert to be stored in the computer and not lost through the retirement, resignation, or even death of that human expert.

- **Expansion of decision making capabilities of many people.** A single expert system may be employed for hundreds of users to assist them in their jobs. For example, the expert system at American Express serves about 300 people.

- **Elimination of bad effects of human feelings** like love, hatred, fatigue and worry. In case of human being, even if he is the most expert in any field, his decision may be affected by his feeling. However, a computerized expert system would not be affected by any feeling.

- **Elimination of routine and unsatisfying jobs.** Some of the jobs like watching and tracking the flight of a spacecraft is very boring. The job has to be done but most people do not want to do it. So, this kind of jobs can be delegated to a computerized expert system.

- **Provision of more stability.** No matter whether the human expert is there or not, the computer expert will always be there and thus the service of the computer expert is more stable.

- **Provision of more consistency.** Every result provided by the computerized expert system is consistent with the knowledge base stored in the computer.
- **Maintenance of strategic position of a company.** With the help of expert systems, a company may gain advantages over its competitors or stay competitive.

- **Reduction of dependency of critical personnel.** The human expert is a critical personnel. Some places have only one person who is the only expert on a certain matter. If he is not available to give the service, the company may have to wait until he is available. If a computerized expert system is used, the company would not have to depend on on any human expert.

- **Training tools.** Expert systems have proven to be excellent training tools. Similar to the use of flight simulators to train pilots, an expert system in any field can be using for training in that field.

- **Improvement of productivity and performance.** With readily access to computerized expert system, decision maker can make decision faster and with more information and analysis and so his performance would be better.

4. **EXPERT SYSTEMS IN THE U.S.A.**

   More meetings, workshops, seminars and conferences on expert systems and related technology are held in the U.S.A. than any where else in the world. Some of the meetings are international in nature and include information about other countries. For example, the International Workshop on Expert Systems in Productions and Services was held in Chicago in September 1988 [1]. In addition to a good introduction on the concepts of expert systems and three closing papers on implications, impacts and prospect, actual applications are covered under the subheadings of impacts, progress reports, and training:

- **Impact**
  - Changes in tasks and functions--the services sector.
  - Expert systems in industry--changes in tasks and functions.
  - Acceptance of social aspects of the introduction of expert systems.
  - Work in the factory of the future: Is computer-integrated manufacturing a mirage?
  - Impacts of commercial applications: emerging trends.
  - Expert systems and their impact on labor--Japanese experience.
  - The social impact study of the fifth generation generation computer and AI.
Evaluation and Operational Systems’ Progress Reports.

- Evaluation criteria for expert systems.
- Evaluation of expert system applications in industrial and services environments.
- Lay-out design work in the automotive industry.
- Fault and condition monitoring on trains.
- ExpertTAXsm - Impact on work, qualifications and training.
- Summing Up: The perspective of emerging training needs.

Training and Retraining.

- Public vocational training sector and dual systems.
- The changing role of the instructor in a world of technology and expert systems.
- The training costs associated with artificial intelligence applications in manufacturing.
- Transferring expert systems technology to business—the use of learning contracts.
- The setting of today's education and training with regard to the new technologies.

A book was written specifically on operational expert systems in the U.S.A. [21]. It includes the following expert systems:

- Lending advisor expert system.
- COMPASS: Expert System for Maintaining a Telephone Company Switching System
- Two Expert Systems Applied to Clinical Trials
- MCI’S Pricing System
- Expert Systems in Data Processing California Travel Expense Claim System
- TRACKS: An Expert System at Santa Fe Railroad for Fleet Management
- The Development of the AIRAID Expert System: A Case Study
- Expert System Technology for Scheduling Satellite Communication Links

Three more recent examples of expert systems in the U.S.A. will be given in this paper.
The first example is the expert system at Carpenter Technology Corporation in Pennsylvania which is a US$500 million company specializing in the manufacturing, fabrication and marketing of specialty metals in a broad range of types, forms and sizes for all kinds of markets such as aerospace, motor vehicles, electrical and electronic equipments, metal producing and distribution, and general industrial equipment. The mill includes 13 furnaces in four different types with processing temperatures ranging from 1500-2450 degrees Fahrenheit, and 50 different heating cycles covering 350 grades of steel. In January 1991, the company purchased two expert systems from Gensym Corporation in Cambridge, MA. The first expert system is the Dynamic Scheduling Package (DSP) which is based on a finite capacity scheduling (FCS) system. The second is a real-time expert system for creating and running on-line applications. After using the expert systems for two years (1991-1993), the company is very happy with them because of:

- Fuller utilization of all resources, leading to increased return on investment;
- Improved product quality and consistency through the elimination of material variation;
- Reduced fuel consumption through more efficient use of furnaces;
- Reduced loss from scale (oxides that build up on the surface of the steel during high-temperature reactions), and subsequent savings in material costs;
- Lower inventory costs due to less work-in-process time;
- A better working environment for operators, by providing them with an easy-to-use scheduling tool that automated an overly complex manual task;
- The ability to respond quickly to changes while maintaining shop floor efficiency.

The second example for the U.S.A. is the expert system at Whirlpool which is a well-known appliance manufacturer. The company realized that customers who had a problem or question about Whirlpool products wanted to talk to a single human being who could provide the answer without having to transfer the telephone calls around and around to many people in many departments in the company. Therefore, the company decided to use an expert system and established one with the name “Consumer Appliance Diagnostic System (CADS)”. After its completion, the system has been serving three million annual phone inquiries. Each inquiry requires only one call and without putting anyone on hold. Work on the expert system began in June 1990 and completed in May 1991. In 1992, it won one of the Customer Service Application Awards from the American Association for Artificial Intelligence (AAAI). This expert system was developed by use of standard Expert System Shell (ESS) off the shelf. The shell used is Aion’s Development System for OS/2. Three experts were called upon to serve as domain experts
and they supplied 1,000 rules for 12 product lines. On the computer side, two
knowledge engineers and one programmer were employed in the project. The
expert system runs on 300 IBM PS/2 model 57 linked via eight Token Ring
networks connected to IBM 3080 mainframe. By 1999, Whirlpool expects
CADS to be able to handle nine million calls annually.

The third example is an expert system at American Express which is a
credit card company. The system has been used to provide better service to the
customers, increase productivity, and save money. The system is called the
Authorizer's Assistant expert system. It serves 300 authorizers who provide
round-the-clock service to card-holders and customers. For credit card
purchases that exceed a preset amount, retailers must contact American
Express to obtain authorization before completing the transaction. In
cooperation with a human authorizer, the expert system ultimately recom-
mends that a credit charge be approved or denied, or it recommends an
alternative line of reasoning and the need for more information. The
Authorizer's Assistant expert system was developed when the company
realized that significant losses were resulting from the bad authorization
decisions made by the less experienced authorizers. More experienced
authorizers would deny authorization to purchases that would be approved
by less experienced authorizers. To create the Authorizer's Assistant expert
system, several human expert authorizers related tried-and-true rules of
thumb to a knowledge engineer. The knowledge engineer then constructed
a knowledge base initially with 520 rules. During the testing phase, the
number of rules grew to 850. At the end of the test period, the system
demonstrated that it could reduce bad authorization decisions by 76 percent.
Thus American Express recouped its entire investment during the first year
of operation.

5. EXPERT SYSTEMS IN THE U.K.

Similar to the U.S.A. and other countries, several conferences on expert
systems have been organized in the U.K. For example, one was held in 1989
[17] and the following papers were presented:

- Expert systems in safety support.
- Knowledge-based decision support for general practitioners:
- Designing very large and versatile systems.
- Knowledge-Based support for hypertext.
- Gemini: Government expert systems methodology initiative.
- The pragmatic application of the a methodology for building commercial
  knowledge-based systems.
- Applying quality assurance to expert systems.
- Expert tutoring systems.
- Knowledge acquisition for intelligent tutoring systems.
- Hits-A hypercard-Based intelligent training system.
- Latent damage law-The expert system.
- NCR planmaster, a personal financial planning expert systems for the United Kingdom.
- An expert system to assist in filing tax returns: The case of Indian income tax.
- A corporate advice expert system.
- Knowledge-Based systems in personnel selection.
- Exmar: Automating marketing planning.
- Exspecs, a case tool for system requirements specifications using an embedded expert system.
- "Tedex" thyroid eye disease expert system—an example of an ophthalmic integrated “clinic automation” system.
- Gruyex: an expert system for assistance in improving the gruyere cheese technology.
- The intelligent way to design.
- Gogsys: an expert system for process control.
- Expert systems and process monitoring.

More details on three examples of expert systems in the U.K. will be given in this paper.

The first example of expert system in the U.K. is in safety support at British Petroleum (BP) International. Three human experts in three safety-related areas with many years of field experiences were utilized as domain experts in safety auditing, emergency response procedures, and fire and gas detection. In a period of four years, BP has developed over 60 expert system applications.

The second example of expert system in U.K. is expert tutoring systems at the University of Exeter. Traditional Computer-Based Training (CBT) teaches a subject by offering corrective feedback based on prestored set of problems, solutions, and associated remedial advice. Expert system technology can be used to produce new generation of CBT which incorporates explicit representation of subject matter and provides the trainee which an open-ended learning. With domain specific knowledge in the knowledge base, the expert system can generate new problems by itself to teach students. In addition, teaching expertise is also included in the knowledge base, allowing the expert system to know how to teach rather than just what to teach. The initial effort required by the expert system is much more than that required in the conventional CBT but it drops steadily to be much less afterward. For conventional CBT, the average number of hours for development is 300 for every hour of courseware. For expert system CBT, the number of hours of development for the very first hour of courseware is 1,000 but it drops to only ten hours compared to the fixed 300 in the conventional CBT.
The third example from the U.K. is an expert system for personnel selection at Data Logic Limited and the U.K. Ministry of Defence. The expert systems improve the state-of-the-art in personnel selection because it can readily incorporate both quantitative and qualitative criteria; it permits quick and accurate definition of a complex problem through prototyping and early feedback; and it can explain its reasoning which leads to confidence. The major benefits of expert systems in personnel selection are that it allows cost and manpower savings in selection process and allows evaluation of currently applied practice in personnel selection.

6. EXPERT SYSTEMS IN THE FAR EAST.

Expert systems in Japan, Korea, Singapore and Thailand are mention elsewhere in this Proceedings. Several expert systems in the Far East have also been covered in international conferences in the U.S.A. and U.K. A book has been written on operational expert systems in the Far East [18]. It includes 15 cases from Japan, Korea, Singapore, Hong Kong, China, and Taiwan:

- **Steel Industry**
  - Application of an expert system to blast furnace operation.
  - An expert system for large scale fault diagnosis in steel manufacturing.
  - Prediction of blast pressure in blast furnace operations.

- **Electro-mechanical Industry**
  - An expert system for elevator design.

- **Power Industry**
  - Alarm based operational guidance system
  - Diagnosis system for a Gas turbine air conditioning plant
  - Diagnosing steel structures at hydro power stations.

- **Automobile Industry**
  - DEAS2: a diagnosing system for automobiles with electronic control units.

- **Oil Industry**
  - UNIK-PCS: A crude oil delivery scheduling system.

- **Paper Industry**
  - A scheduling expert system for paper production.

- **Air Line Industry**
  - Cockpit crew scheduling and supporting system.
- Knowledge-based approach to airport staff rostering.
- Practical application of a connectionist expert system-the INSIDE story.

- **Construction Industry**
  - Development of expert systems supported construction planning for shield tunneling method.

- **Investment Industry**
  - Application of K-FOLIO at lucky securities: BRAINS.

Several experimental expert systems have been developed in Thailand such as those presented at the 1987 conference on computer applications in Bangkok [2, 3, 4] and other conferences [5, 6, 7, 19]. Operational expert systems are used in airlines, finance and banking, manufacturing, etc.

A more recent conference was held in Korea in February 1993. In addition to keynote addresses and tutorials, the following papers were presented:

- **Neural Networks**
  - Mapping fuzzy petri nets into multilayer perceptrons.
  - A connectionist Implementation of a production system on a hypercube multiprocessor.
  - Intelligent melting process control using neural network with partial inversion.

- **Knowledge Acquisition.**
  - A knowledge acquisition system and its application to man power allocation expert system.
  - Automated knowledge acquisition by reasoning failures.
  - Task analysis interview based on task ontology
  - Knowledge acquisition from multiple experts.
  - A design of knowledge acquisition methodology for eliciting deep knowledge from multiple experts.
  - Evolution of knowledge acquisition models by difference between transition time & observation one.

- **Diagnosis**
  - A framework for on-line diagnostic expert system for intelligent manufacturing.
  - An integration of heuristic and model-based reasoning in fault diagnosis.
  - A framework for hypothesis generation in model-based diagnosis.
  - Neural network application to fault diagnosis by pattern recognition of multiple alarms in nuclear power plant.
- **Finance**
  - A bond rating expert system for industrial companies.
  - Automatic knowledge generation from the stock market data.
  - Unifying rule induction and rule refinement—towards discovering anomaly from Granville’s law in a stock market technical analysis.

- **Telecommunication**
  - Applying tabular-knowledge based tool to switching system diagnosis.
  - Service order data entry: a new application of expert system technology.

- **Control**
  - Realtime hybrid control system for coke oven gas benzol recovery process.
  - Reasoning under dynamic knowledge-base with application to traffic routing.
  - A fuzzy expert system on automatic-combustion-control-system of refuse incineration plant.

- **Machine Learning**
  - Some insights into the nature of learning from machine learning studies.
  - The accuracy of decision tree induction in a noisy domain for expert system construction.
  - A conceptual model for building experts for dynamic environment in management.

- **Expert Systems Development Methodology.**
  - ES : An expert systems development planner using a constraint and rule-based approach.
  - A concurrent engineering approach for expert system development.
  - An expert system developing methodology by using TASK concepts.

- **Accounting.**
  - An artificial neural network approach for activity-based cost allocation.
  - Selection of appropriate tasks for accounting expert development in auditing.
  - The intelligent internal accounting control model using a logic programming approach.

- **Design & Planning.**
  - Adaptive expert systems for strategic design.
  - A knowledge-based prototyping system for information systems strategic planning process.
- **Validation**
  - A probability of fuzzy events approach to validating expert systems in a multiple agent environment.
  - Handling the non-technical problems in developing expert systems.

- **Water resource management.**
  - Role of expert system in decision support system for integrated management of water quantity and quality.
  - Decision making in monitoring network design for ground water remediation.

- **Medicine**
  - The development of a hybrid medical decision support system for diagnosing nasal allergy.
  - A fuzzy expert system for interpretation of Arrhythmia in ECG signal.

- **Scheduling**
  - Erection scheduling at shipbuilding using constraint-directed graph search: DAS-ERECT.
  - Object-Oriented expert system for rail vehicles scheduling in steelwork.
  - Minimizing early and tardy penalties in a job sequencing problem using genetic algorithms.

- **Knowledge Representation.**
  - REAPS: A knowledge base system for supporting REA modeling.
  - Structured representation of scientific discussion and OODB support toward scientific collaboration.

- **Constraint Logic Programming.**
  - The constraint logic programming approach for mixed logic optimization problems.
  - Constraint directed reasoning in Prolog.

- **Decision Analysis.**
  - The cost of making classificatory decisions: a binary tree classifier case.
  - An artificial neural network approach to the decision class analysis.
  - Alignment functions for measuring chainness of an extended-influence diagram.

- **Power Plant**
  - Development of a prototype expert system for failure diagnosis of primary-side systems in nuclear power plant.
  - Development of an integrated operator decision aid support system in
nuclear power plants.
- AI application to tuning system for utility boiler controller.

- Development Strategy.
  - Issues in developing commercial knowledge base systems.
  - A set-Theoretical approach to selective attention in perception level and decision-making level.
  - An Expert systems development strategy: finding problem domain from existing data processing systems.

- Intelligent CAD
  - Building a feature-based part description from CAD exchange files.
  - Image database of ultrasound B-Scan diagnosis expert system.

- Knowledge Base Management.
  - Building a common knowledge base for internal medicine.
  - Knowledge base integration and refinement using mixed inference mechanism.
  - An application of common knowledge-based and object-oriented expert system model: military aircraft maintenance.

- Natural Language Processing.
  - From natural language to shell-script: a case-based reasoning system for automatic UNIX programming.
  - Fuzzy expert system for continuous speech recognition.
  - Indexing based on formal relevancy of Bayesian document semantics.

Three examples of expert systems in the Far East will be given in this paper.

The first example is an expert system for blast furnace operation at Fukuyama Work at NKK Corporation. It started in 1980s and includes 450 production rules, 300 frame of fact-type knowledge such as operation constants, and 200 LISP function of procedural knowledge such as formula for calculating the certainty factor. NKK was satisfied with the system and planned to expand the application to other process operations.

The second example is from the automobile industry. It is and expert system for diagnosing the engine of automobiles with electric control unit at Hyundai Motor Company. It includes 12 classes of rules with a total of 240 rules. It was developed jointly by AI Laboratory of Seoul National University and the AI team of Hyundai Electronic Industries Company. After being reviewed by the trainers in Hyundai Motor Service Company, plans were drawn to expand the system to diagnose other parts of automobiles such as suspension, transmission, cruise and brake systems.
The third example is from the oil industry. It is an expert system for crude oil delivery scheduling. The purposes were to minimize purchase prices, quality loss, delivery cost, and inventory cost. The system was developed by KAIST research team. It was written in LISP and later converted to C. The knowledge in the fact base, schedule base, and the crude consumption model were represented in frames, while the rule represented in the rule base. The rules were categorized into four groups: selection of crude oil, determination of vessel, adjustment of crude oil, and combination of crudes for a vessel. The expert system could not be compared with the optimum global solution because that is not known. So it was compared with the manual system and found to be more comprehensive schedule that satisfies all the constraints.

7. LEARNED SOCIETIES AND PUBLICATIONS

Expert systems technology and applications have been changing rapidly. One way to keep up to date is to become a member of learned societies and read their publications. Each country usually has at least one computer-related society. Some of the societies are more learned or professional than the others. The most active and international are probably those with headquarters in the U.S.A.

The American Association for Artificial Intelligence (AAAI) which was founded in 1979 attracts AI specialists from all walks of life and all over the world. AAAI has a research and academic slant in most of its publications that may be difficult to read by non-AI readers. Membership is open to anybody who wishes to join. Is member a subscription to AI Magazine which is published quarterly. AI Magazine also includes announcements about upcoming conferences, seminars and workshops as well as books reviews, job announcement, editorial, letter to the editor, and product announcements. One year foreign membership is US$ 65.

The Association for Computing Machinery (ACM) which is the largest learned society in field of computer in the world has a Special Interest Group on AI (SIGART). All members of ACM receive a monthly refereed journal “Communications of the ACM (CACM)” which may include articles on expert systems. Other ACM publications such as Computing Surveys, Computing Reviews, as well as ACM Guide to the Computing Literature also cover expert systems. SIGART publishes a newsletter which is specifically on AI and expert systems. Another AI-specific publication from ACM is LISP Pointers which focuses on LISP only. Other special interest groups such as SIGPLAN (Programming LANGUages) and SIGCAS (Computer And Society) occasionally cover expert systems. the membership fee for ACM is US$ 75 plus US$ 15 for SIGART, US$ 15 for Computing Surveys, US$ 34 for Computing Review, and US$ 97 for Guide to the Computing Literature, etc.
The Institute of Electrical and Electronics Engineers (IEEE) and IEEE Computer Society (CS) publish many expert-systems-related publications such as IEEE Expert, Transactions on Knowledge and Data Engineering, Transactions on Robotics and Automation, Transactions on Systems, Man and Cybernetics, Transactions on Pattern Analysis and Machine Intelligence, and Transactions on Network. Membership fee for IEEE is US$ 95 plus US$ 22 for the Computer Society, US$ 20 for IEEE Expert, US$ 19 for Transactions and Knowledge and Data Engineering, etc.

The International Association of Knowledge Engineers (IAKE) publishes Heuristics: The Journal of Knowledge Engineering which seems to be more on practical "how-to" than theoretical. The membership fee is US$ 65 per year which includes the Knowledgebase newsletter and Heuristics journal.

8. CONCLUDING REMARKS

Intended to serve as a tutorial and survey or introduction to the more advanced papers by other experts such as those from Japan, Korea and Singapore, this paper presented the definition and advantages of expert systems, examples of operational expert systems in the U.S.A., U.K., and the Far East as well as information on learned societies and publications in the field of expert systems. It is hoped that the participants at the International Conference on Expert System Technology and Applications and/or those who read this paper will agree that expert system technology has come of age and will sooner or later adopt and adapt the technology to solve some problems for the benefits of themselves, their countries and the world in general.

REFERENCES.


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3. Chairman of the Boards of:
   - Ph.D. Programs
   - Faculty of Science and Technology
   - Graduate School of Computer Information Systems
   - Graduate School of Computer and Engineering Management
   Assumption University (AU), Bangkok 10240, Thailand

Career:
1961-1964 Lecturer, Asian Institute of Tech (AIT) and Chulalongkorn University, Thailand
1964-1966 Assistant Professor
   McMaster University, Canada
1966-1968 Associate Professor
   University of Alberta, Canada
1968-1973 Director of Graduate Studies in Computer Science
   University of Missouri, Columbia, Mo., USA
1973-1974 Professor of Computer Science
   State University of New York, USA

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1974-1977  Professor of Applied Statistics  
Chairman of the Computer Department  
President of the Staff Association  
National Institute of Development  
Administration (NIDA), Thailand

1977-1981  General Manager and Director of Computer  
Center, Bangkok Data Center Co., Ltd.

1981-1984  Advisor to the President, Bangkok Bank Ltd.

1977-1984  Vice President for Planning and Development  
Assumption University, Thailand

1984-1988  C10 Professor and President of the  
Faculty Council, King Mongkut's  
Institute of Technology Ladkrabang

1988-present  Distinguished (C11) Professor of Computer  
Engineering, King Mongkut's Institute  
of Technology Ladkrabang

Other Activities:
- Author of over 350 technical papers
- Director of research projects sponsored by
  - The National Research Council of Canada
  - The US National Science Foundation
  - The National Research Council of Thailand
  - UNESCO, UNICEF, ESCAP
  - Ford Foundation
  - USAID
  - United Nations Centre for Transnational Corporations
  - International Development Research Centre (IDRC)
  - International Federation for Information Processing  
    (IFIP)
  - International Centre for International Development (ICID)
- Commissioner, Intergovernment Bureau for Informatics (IBI)
- Lecturered in more than 15 countries
- Advisor to the Minister of Science,  
  Supreme Command, Several Agencies
- Chairman of the Board of International Technology  
  Transfer Inc., and of Computer and Professional Service  
  Company, Ltd.
- Former Advisor to several companies such as Booze, Allen  
  and Hamilton International, North Star, Sanyo, etc.
- Secretary General, Computer Association of Thailand (CAT)
- President, Thai Federation for Information Processing
- Chairman, Computer Academician Group, CAT
- Chairman of the Computer Textbook Committee, Ministry of Education
- Chairman of the Computer Textbook Committee, Sukhothai Open University
- Member of the National Research Council of Thailand
- Member of the University Service Commission chaired by the Prime Minister
- Chairman of several University Service Sub-Commissions
- Chairman of the Computer Curriculum Committee for Private Colleges and Universities, Ministry of University Affairs
- Chairman of the Computer Curriculum Committee for Government Universities, Ministry of University Affairs
- Member of the Subcommittee to Improve the Copyright Law, Ministry of Commerce; Chairman of Working Group on Software
- Member of the National Committee on Information Systems, chaired by the Deputy Prime Minister
- Chairman of the Association for Computing Machinery (ACM) Thailand Section
- Director of the Institute of Electronics and Electrical Engineers Thailand Section
- Chairman, Thailand Joint Chapter of Computer Society and Engineering Management Society of the IEEE
- President, Asian Institute of Technology Alumni Association
- Member of the Boards of Trustees of AIT, KMITL, AU etc.

**Award/Decoration:**

- Asian Computer Man of the Year 1981
- Knight Grand Commander (First Class) of the Most Noble Order of the Crown of Thailand, 1987
- Knight Grand Commander (First Class) of the Most Exalted Order of the White Elephant, 1990

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