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Expert System in Real World Applications

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Introduction

An expert system is a computer application that solves complicated problems that would otherwise require extensive human expertise. To do so, it simulates the human reasoning process by applying specific knowledge and interfaces. Expert systems also use human knowledge to solve problems that normally would require human intelligence. These expert systems represent the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems. Books and manual guides have a tremendous amount of knowledge but a human has to read and interpret the knowledge for it to be used.

A system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise (Turban & Aronson, 2001).

A computer program designed to model the problem solving ability of a human expert (Durkin, 1994).

An intelligent computer program that uses knowledge and inference procedures to solve problems that was difficult enough to acquire significant human expertise for their solutions (Feigenbaum).

Expert systems typically have a number of several components. The *knowledge base* is the component that contains the knowledge obtained from the domain expert. Normally the way of representing knowledge is using rules. The *inference engine* is the component that manipulates the knowledge found in the knowledge base as needed to arrive at a result or solution. The *user interface* is the component that allows the user to query the system and receive the results of those queries. Many ES's also have an explanation facility which explains why a question was asked or how a result or solution was obtained.

There are several major application areas of expert system such as agriculture, education, environment, law manufacturing, medicine power systems etc. In this article we will review about agriculture, education, environment and medicine expert system. These four applications widely use among the practitioners due to the maturity of the field by revealing the acceptance of the technology by the commercial sectors.

Expert System in Agriculture

It is no different with other Expert System, the Expert System for Agriculture is same as others knowledge based system, its use the rule based which the experience and knowledge of a human expert is captured in the form of IF-THEN rules and facts which are used to solve problems by answering questions typed at a keyboard attached to a computer on such diversified topics, for example, in pest control, the need to spray, selection of a chemical to spray, mixing and application, optimal machinery management practices, weather damage recovery such as freeze, frost or drought, etc."

The Development of Expert Systems for Agriculture

The early state of developing the Expert Systems are in the 1960s and 1970s were typically written on a mainframe computer in the programming language based on list Processing (LISP). Evolving from university research laboratories, they were limited to the applications developed by these research sites. Most of these expert systems were not intended for commercial use.

They incorporated the specific knowledge of the experts. About the problem area termed "domain knowledge." Problem-solving heuristics (or "rules of thumb") and inferences capabilities, and an interface mechanism between the user and the system. Some examples of these systems include MACSYMA, developed at the Massachusetts Institute of Technology (MIT), for assisting individuals in solving complex mathematical problems: Standford University's MYCIN, which diagnosed bacterium and meningitis infections, which is the first diagnostic Expert System ever developed ever and the University of Pittsburgh's INTERNIST/CADUCEUS, which aided internal medicine diagnosis and decision making. These scientists created a general-purpose tool for developing expert systems now called a "shell".

Expert Systems Are Used To Aid

The rises of the agriculture expert system are to help the farmers to do single point decisions, which to have a well planning for before start to do anything on their land. Secondly is to design an irrigation system for their plantation use. Third is to select the most suitable Crop variety or market outlet. Fourth is Diagnosis or identification of the livestock disorder. Fifth is to interpret the set of financial accounts. Sixth is to predict the extreme events such as thunderstorms and frost. And lastly is to suggest a sequence of tactical decisions throughout a production cycle such as plant protection and nutrition decisions, livestock feeding and the like.

An Expert System for a Particular Decision Problem Can Be Used

The expert system can be used as a stand alone advisory system for the specific knowledge domain perhaps with monitoring by a human expert. It also can provide decision support for a high-level human expert. The agriculture expert system also allows a high-level expert to be replaced by a subordinate expert aided by the expert system. The main purposes the rises of the expert system are as a delivery system for extension information, to provide management education for decision makers (farmers), and for dissemination of up-to-date scientific information in a readily accessible and easily understood form, to agricultural researchers, advisers and farmers. By the help of the expert system, the farmers can produce a more high quality product to the citizen.

The Advantages of the Expert System

There are few advantages that the expert system being use in the agriculture field. First, it has the ability to imitate human thought and reasoning. Second, the expert system makes modification of knowledge very convenient. Third, it has the ability of interpretation and transparence makes interaction more user friendly. Fourth, with the machine learning technique knowledge can be acquired automatically and directly from experimental data and real time examples and helps to provide the right information which is timely and actionable. Sixth, it can provide expert level recommendations understandable to users (farmers). And lastly, it has the ability to handle uncertain information.

Some Agricultural Expert systems

Rice-Crop Doctor

National Institute of Agricultural Extension Management (MANAGE) has developed an expert system to diagnose pests and diseases for rice crop and suggest preventive/curative measures. The rice crop doctor illustrates the use of expert-systems broadly in the area of agriculture and more specifically in the area of rice production through development of a prototype, taking into consideration a few major pests and diseases and some deficiency problems limiting rice yield.

The following diseases and pests have been included in the system for identification and suggesting preventive and curative measures. The diseases included are rice blast, brown spots, sheath blight, rice tungro virus, false smut fungi, bacterial leaf blight, sheath rot and zinc deficiency disease. The pests included are stem borers, rice gall midge, brown plant hopper, rice leaf folder, green leaf hopper and Gundhi bug.

Indian Institute of Horticultural Research Institute, Bangalore

The first software for use by the grape cultivators was prepared by the Indian Institute of Horticultural Research Institute, Bangalore. This spontaneous response made them to undertake similar software for providing guidance to mushroom cultivators, which became extremely popular and a large number of growers using it regularly for getting solutions to their problems. The Institute has launched into an effort to give a comprehensive package of practices of about 148 horticulture crops for cultivation in the 4 Southern states of Kerala, Tamilnadu, Karnataka and Andhra Pradesh.

AGREX

Center for Informatics Research and Advancement, Kerala has prepared an Expert System called AGREX to help the Agricultural field personnel give timely and correct advice to the farmers. These Expert Systems find extensive use in the areas of fertilizer application, crop protection, irrigation scheduling, and diagnosis of diseases in paddy and post harvest technology of fruits and vegetables.

Farm Advisory System

Punjab Agricultural University, Ludhiana, has developed the Farm Advisory System to support agri-business management. The conversation between the system and the user is arranged in such a way that the system asks all the questions from user one by one which it needs to give recommendations on the topic of farm Management.

Computer Assisted Agriculture through Distributed Knowledge Based Expert System

There are three levels in which the basic process of agriculture is happening. 1. Low level farmers. 2. Middle level agricultural officers. 3. Higher level research institutions. Each level requires a data depending upon its requirements with interrelationships among them. The farmers interface is designed in such a way that the communication between the expert system and the farmer will be in the farmers own native language. The knowledge base acts as a bridge between farmers and research institutions. The production systems at farmers' level knowledge base which are not able to find an answer are formed as unanswered dynamic framers and tried for solution by agricultural officers. These frames are transferred to research institutions with the same additional view of points of agricultural officers. Hence research institutions can come to know about the new undiscovered problems that exist at farmers' level.

Expert Systems for Cotton Crop Management

This Expert System has been developed by the US Department of Agriculture to provide appropriate management recommendations to cotton growers.

CALEX

This is a blackboard based integrated expert decision support system for agricultural management, developed at University of California. CALEX can be used by growers, pest control advisors, consultants and other managers.

VARIEX

This expert system developed at Technical University of Brno, Czechoslovakia enables selection of the best cultivators for different agricultural situations.

Weiping Jin Expert System

There are fertilizing, irrigating, spraying insecticide process and adopting other measures in crop management, which rely on crop state analysis. CMES provides support for crop growth control system (CGCS), i.e., advises growers about optimal population and structure of crop in planting stage and when and what to adopt measures on their crop to keep at optimal state, to avoid Infestation in various stage of growth and development of crop, and finally to obtain the highest crop productivity in harvest stage

LEY Expert Systems

A RF-telemetry based computer-controlled, automated, remote, real-time weather data acquisition and reporting system in Washington State is described. Cooperation among Washington State University the National Weather Service and the U.S. Bureau of Reclamation and several private grower organizations have made this system possible. Data is collected, processed and transmitted to the NWS hourly. These hourly updates of actual conditions are broadcast on the NOAA weather band during the spring frost season to assist fruit growers with frost protection. Real-time weather data are also being used in applications such as irrigation scheduling, crop protection and pest management.

The program is divided into four main modules: frost protection strategies, operational management, forecasting, and instrumentation.. It is being designed to be an addition to other commodity management expert systems that are commercially available or are under development.

Using a unique satellite downlink facility at by R.R. Getz Auburn University, real time meteorological data are being processed on a network of advanced computer workstations. This data feeds a series of computer models that generate site specific predictions of temperature, dew point, wet bulb temperature, and other parameters used to alert Alabama fruit, vegetable, and nursery growers of freezes.

GIS Expert Systems by Naiqian Zhang

The expert system software WHEATWIZ was developed in 1987 as an effective tool to assist Kansas farmers, extension workers, and agri-business personnel in variety selection for hard red winter wheat (Shroyer et al., 1987). The software offered three modes of operation.

The concept of "prescription farming" or precision application of agronomic inputs may dramatically increase the attention a farmer gives to the spatial distribution of nutrients in the soil and methods of fertilizer application. By using a geographic information system (GIS) and a cotton model, GOSSYN, together as a spatial crop simulation, a methodology for investigating the implications of incorporating prescription farming programs for cotton production is investigated. The data contained in the GIS, the result of intensively sampling a cotton field for nitrate information, is used as the primary input to the model. Hydrologic profile information is also mapped using the GIS and used as input to the model. The model is run for each unique combination of inputs. Crop response is mapped back the GIS for spatial analysis. Information pertinent to prescription farming programs which can be extracted from the spatial simulation is discussed. Precision application of agronomic inputs may necessitate increased soil sampling and increased complexity of the technology on tractors and fertilizer applicators. However, this may also prove to increase crop yields, as well as to provide a degree of environmental protection from excessive use of chemicals.

CLIPS Expert System

A prototype alfalfa (Medicago sativa L.) management CLIPS (C Language Integrated Production System) expert system has been developed by Purdue University agricultural scientists. This form of artificial intelligence provides an extension tool, which will enable farmers to very economically use a computer program to reach conclusions concerning profitable alfalfa production that normally would require consultation with a forage expert. To date, the management considerations and the sequence in which they were built into the knowledge base are: soil drainage, soil pH, soil P test, soil K test, and use of alfalfa crop, chemical weed control, and expected longevity of stand, variety recommendation, method and rate of seeding and pure live seed. The knowledge base of these CLIPS expert system can easily be updated, as new information becomes available or can be modified for use in other states or farming regions.

DSS4Ag

The Decision Support System for Agriculture (DSS4Ag) is an expert system being developed by the *Site-Specific Technologies for Agriculture* (SST4Ag) precision farming research project at the INEEL. DSS4Ag uses state-of-the-art artificial intelligence and computer science technologies to make spatially variable, site-specific, economically optimum decisions on fertilizer use.

The DSS4Ag has an open architecture that allows for external input and addition of new requirements and integrates its results with existing agricultural systems' infrastructures. The DSS4Ag reflects a paradigm shift in the information revolution in agriculture that is precision farming. Four test plots showed that the tested fertilizer management methodologies, while applying very different fertilizer rates, produced crops of similar yield and quality. The plots also demonstrated the DSS4Ag's ability to characterize and identify management zones of common and different productive potential.

The Expert system must be developed in local languages which will help the Farmers to develop their own expertise which in turn will enhance the production and productivity of Agriculture. Expert systems must be available in village booths which act as information resource center for the farmers in the villages.

Expert Systems in Education

In education field, many of the expert system's application are embedded inside the Intelligent Tutoring System (ITS) by using techniques from adaptive hypertext and hypermedia. Most of the system usually will assist student in their learning by using adaptation techniques to personalize with the environment, prior knowledge of student and student's ability to learn.

In term of technology used, expert system in education has expanded very consistently from microcomputer to web based (Woodin D.E, 2001) and   agent-based expert system (Vivacqua A., and Lieberman H., 2000). By using web-based expert system, it can provide an excellent alterative to private tutoring at anytime from anyplace (Markham H.C, 2001) where Internet is provided. Also, agent based expert system surely will help users by finding materials from the web based on the user's profile. Supposedly, agent expert system should have capability to diagnose the users and giving the results according to the problems.

Besides technology used, expert system also had a tremendous changes in the applying of methods and techniques. Starting from a simple rule based system; currently expert system techniques had adapted a fuzzy logic (Michael Starek, Mukesh Tomer, Krishna Bhaskar, and Mario Garcia ,2002) and hybrid based technique (Jim Prentzas, Ioannis Hatzilygeroudis, C. Koutsojannis , 2001).

Needs for Expert Systems in Education

According to Markham H.C (2001), expert system are beneficial as a teaching tools because it has equipped with the unique features which allow users to ask question on how, why and what format. When it used in the class environment, surely it will gave many benefit to student as it prepare the answer without referring to the teacher. Beside that, expert system is able to a give reasons towards the given answer. This features is really great as it can make students more understand and confident with the answer.

Ability of expert system to adaptively adjust the training for each particular student on the bases of his/her own pace of learning is another feature that makes expert system more demanding for students. This feature is used in (Zorica Nedic, Vladimir Nedic and Jan Machotka, 2002) for teaching engineering students. It should be able to monitor student's progress and make a decision about the next step in training.

Application of Expert System in Education

Expert system had been used in several fields of study including computer animation (Victor Yee, 1995), computer science (Heather Christine Markham, 2001), engineering (Zorica Nedic, Vladimir Nedic and Jan Machotka, 2002), language (Expert System in Language Teaching), and business study. For Computer Animation Production, expert system been used as a guide to developer to design 2D and 3D modeling package. Other than that expert system also be used as a tool in teaching mathematic related subject (Micheal Kristopeit,). This paper would present the application of expert system in teaching introductory data structure; follow by application in engineering, technology and earth science.

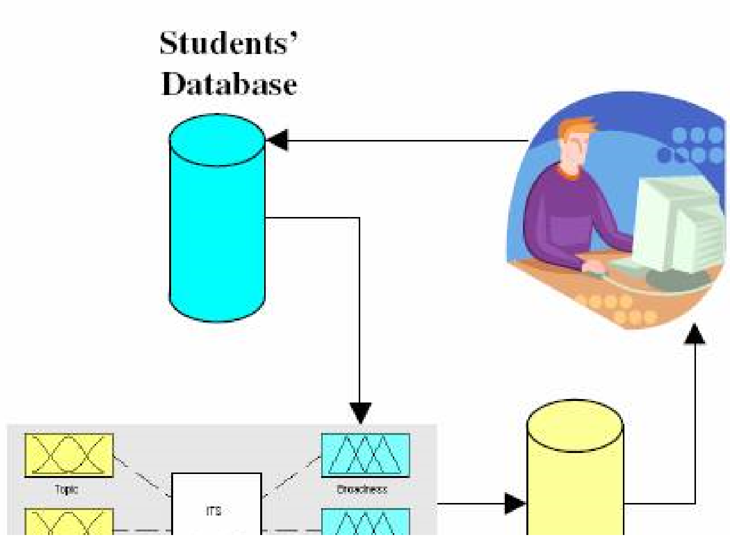
Expert System for Teaching Introductory data Structure

This expert system had used Internet technology as a medium to access the information. This expert system had been developed by using CLIP as an inference engine, and HTML program as a front page for the system. According to (Markham, 2001), this expert system had provided the excellent alternative to the private tutorial. Since this expert system is developed using Java technology, thus make this system interoperable and independent platform.

Expert System for Engineering

This expert system using fuzzy logic method as an engine to enable this system operates adaptively. This expert system was developed to help first year engineering student gain deep understanding of fundamentals to be able to follow the more advanced topics in the engineering fields. This ITS will help adaptively adjust the training for each particular student on the base on his/her pace of learning. ITS will monitor the student's progress and have the ability to make decision about the next step in training.

Figure 1 below show the architecture of ITS for teaching engineering student which was embedded expert system inside. This expert system using fuzzy rule based decision making system that would guide the ITS's behaviour. For each student, this expert system will draw the information regarding student's performance against the membership function for each topic, difficulty and importance level.



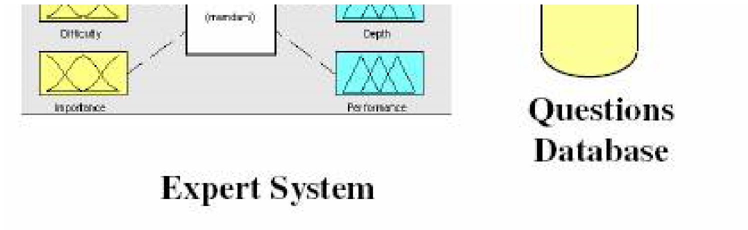


Figure 1: Structure of ITS to teach engineering student. Adapted from Zorica Nedic, Vladimir Nedic and Jan Machotka (2002)

Expert System for Learning Internet

According to (Jim Prentzas, Ioannis Hatzilygeroudis, C. Koutsojannis, 2001), hybrid expert sister lab been developed to assist teacher in learning new technologies such as Internet. They had build web based Intelligent Tutoring System (ITS) for teaching new technologies to high school teacher. Figure 2 below is example of architecture that been developed for this ITS.

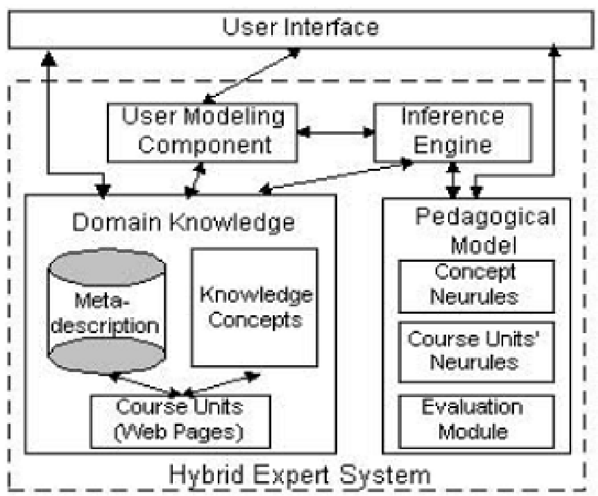


Figure 2: Architecture of ITS. Adapted from Jim Prentzas, Ioannis Hatzilygeroudis, C. Koutsojannis(2001)

This architecture had made used of expert system's knowledge representation formalism based on neurules, a type of hybrid rules integrating symbolic rules with neurocomputing. This neurules will improve the performance of symbolic rules and simultaneously retain naturalness and modularity.

Expert System for Teaching Fault Analysis

Application of expert system also been used by lecturer to teach student on subject relating fault analysis. By using this expert system, lecturer aim to make learning more productive and efficient without increasing the staff number. This ITS was developed by using Leonardo expert system shell, object oriented tool for developing expert system application.

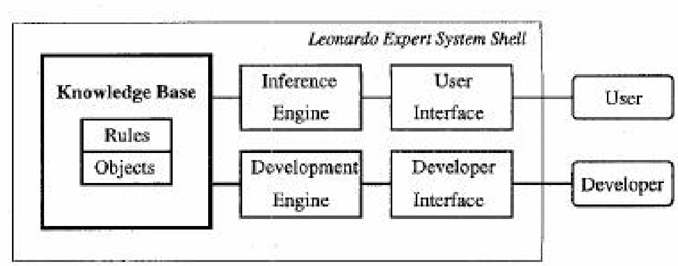


Figure 3: Basic components of Leonardo expert system shell. Adapted from Negnevitsky, M. (1998)

Figure 3 above shown the architecture of Leonardo expert system shell. This architecture was used Negnevitsky, M. (1998) to develop expert system for teaching fault analysis. According to Negnevitsky, M. (1998) this Leonardo tutoring system is a very useful tool for teaching fault analysis in power system. In October 1994, the system was installed in a computer network and it can now be accessed from any computer in the Department of Electrical and Electronic Engineering. It has been found that network delivery of computer-based tutorials is the most cost effective (Negnevitsky, M., 1998).

Expert System For Mineral Identification

This expert system developed to be used for support the teaching of mineral properties at college level and hence to promote effective and meaningful learning of scientific observation in earth science. This system used by the college students, who may or may not have n-depth computer skills. An expert system building tool which can be easily maintained by people from non-computer science background. EXSYS (EXSYS inc. 1994) was used to build this expert system. EXSYS is a commercial expert system building tool that has been in the market for several years. It is easy to use, easy to learn and easy to maintain. EXSYS can explain why and how it reaches a conclusion.

Expert Systems in Environmental Management

The most successful application of Artificial Intelligence (AI) so far is the development of Decision Support System (DSS), particularly expert system, which is a computer program that act as a ‘consultant’ or ‘advisor’ to decision makers (Wash, 1999). Expert system has been a new dimension of human’s view of life where everything seems to be easy and more useful by employing expert system. Thus, the application of expert systems technology in the domain of environmental management is particularly appropriate in order to assist human in their attempt to preserve and disseminate valuable expertise efficiently and at reasonable costs. Nowadays, there have been numbers of expert system application on environmental management domain including those which are still in the development process as well as some newly potential proposed system.

Computer-Aided System For Environmental Compliance Auditing

One of the potential expert system applications in the domain of environmental management is the computer-aided system for environmental compliance auditing which was proposed by Nazar M. Zaki and Mohd Daud from the Faculty of Engineering, University Putra Malaysia. The system was actually a cost effective integrated environmental monitoring system for Environmental Impact Assessment (EIA) project as well as environmental database management system. At that time in Malaysia, 19 different category projects require Environmental Impact Assessment (EIA) reports duly approved by Department of Environment (DOE) before their implementation.

According to the Environmental Quality Order 1987, Malaysia, every development project has some potential environmental impact, thus requires a duly approved Environmental Impact Assessment (EIA) report before implementation of that project. Environmental Impact Assessment guidelines of Department of Environment (DOE) Malaysia recommended that a matrix be used to relate the different project activities at different phases of the project such as exploration, development, operation, and rehabilitation etc. to the physio-chemical, Biological, and human or Socio-economic environment. Once the possible environmental impacts are assessed, the project initiator must identify and indicate the possible mitigation measures to be taken with a purpose of controlling the environmental pollution and keeping the environment safe and healthy. During the assessment, compliance auditing comes into picture to check whether and how far the project is complying with environmental protection and standards while it is under implementation. In fact, an environmental compliance audit is a management tool comprising the systematic, documented, periodic and objective examinations of how well environmental organization management and equipment are performing, with the aim of helping to safeguard the environment (Nazar and Daud, 2001).

From here we can see that compliance auditing plays a vital role in environmental management. Therefore, the integration of Geographic Information Systems (GIS), Expert Systems, and some other statistical packages and database software and microcomputers in the development of the computer-aided system for environmental compliance auditing might help in improving the management efficiency.

Hybrid Expert System, GIS And Simulation Modelling For Environmental And Technological Risk Management

One more examples of expert system in environment domain is the hybrid expert system, GIS and simulation modelling for environmental and technological risk management particularly called RTXPS and developed by K. Fedra and L. Winkelbauer from Environmental Software & Services GmbH. The system was actually an integration of a real-time forward chaining expert system and a backward chaining system as the Decision Support System framework using simulation models and Geographic Information Systems or GIS. RTXPS was based on the results from the international research project called HITERM which was funded under the European ESPRIT technology programme for high-performance computing and networking (HPCN) for decision support.

The HITERM project integrates high-performance computing on parallel machines and workstation clusters with a decision support approach based on a hybrid expert systems approach. To integrate the various information resources in an operational decision support system, a flexible client-server architecture is used (Figure 1), based on TCP/IP and http. The central system, which runs the RTXPS expert system as the overall framework is connected to a number of (conceptual) servers that provide high-performance computing and data acquisition tasks, as well as a number of clients that include mobile clients in the field (Fedra and Winkelbauer, 2002).

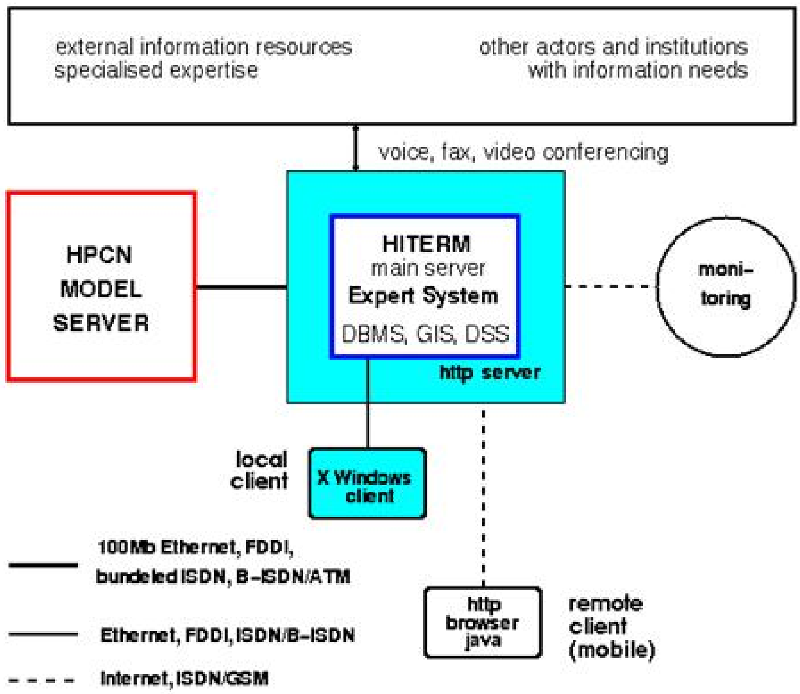


Figure 4: The HITERM systems architecture

Based on the RTXPS framework, the real-time expert system controls communication with the various actors involved in a situation where environmental and technological risk occur, provides guidance and advice based on several data bases including Material Safety Data Sheets for hazardous substances. It will then simulate the risky situation by various simulation models for the simulation of the evolution of an emergency and then predict the environmental impacts on human's life. To perform this kind of expert task, the system compiles all necessary input information for the models and performs checks for completeness, consistency, and plausibility. Based on the available information and some simple screening, the most appropriate model or set of models is then triggered, interprets the results, and translates that into guidance and advice for the operators to guide the victim of a risky situation. According to Fedra and Winkelbauer, embedded simulation models include a detailed source model for different release types including pool evaporation, atmospheric dispersion using either a multi-puff, multi-layer Eulerian, or a Lagrangian approach based on a 3D diagnostic wind field model, fire and explosion models, and a stochastic soil contamination routine. The ability of the system to perform real-time controlling and logging of data, user inputs and decisions, model results, and communication activities provide an opportunity to use the system for operational management, training purposes, as well as for planning oriented risk assessment tasks.

Application examples are drawn from the domain of technological risk assessment and management, and particular chemical emergencies in fixed installations or transportation accidents based on ongoing case studies in Italy, Switzerland and Portugal (Fedra 1998; Fedra and Weigkricht 1995). From the example given in their documented report of the system's development, the source model generates information on the total mass evaporated or directly escaping into the atmosphere and thus available for atmospheric dispersion, the mass fraction infiltrating into the soil, and the probabilities for fire and explosion. Based on these results and their respective probability distributions, the models are triggered in sequence with the most likely or dangerous impact scenario simulated first.

Geographic Information Systems (GIS) And Simulation Models For Water Resources Management

Another example of expert system development in the domain of environmental management is the Geographic Information Systems (GIS) and simulation models for Water Resources Management; a case study of the Kelantan River, Malaysia also by K. Fedra in 2002. Functioned as a water management system, it was called WaterWare, a system that manage information based on a range of linked simulation models that utilize data from an embedded GIS, monitoring data including real-time data acquisition, and an expert system. The system used a graphical interface to provide interactive decision support information for water resources planners and policy makers as it is accessible in a local area network from a central server, and alternatively through the Internet for remote clients.

The development of the system was derived from the major problem occur in Kelantan, specifically the Kelantan river which drains the province of Kelantan in north-eastern peninsular Malaysia. A catchment of about 12,000 km2 (upstream of Guillemard bridge) and an altitude difference of more than 2100 m generates an average runoff of about 500 m3/sec, with the variations of the local Monsoon climate. The variability of rainfall with extreme monthly values between 0 and 1750 mm in dry and wet months, respectively, already suggest the main problem: reliability of water resources for the rice paddies that supply about 12 % of national production. Droughts and floods that affect the efficiency of the irrigation system, continuing changes in land use, and the potential of water pollution from intensive agriculture pose a range of problems that require innovative tools for their solution (Fedra, 2002). So this system was then proposed and eventually developed in the meant of managing the water resources properly, in order to prevent those problems derived from the past situations from happening again.

The system used Geographic Information Systems or GIS to capture, analyse, and display spatial data, while the models provide the tools for complex and dynamic analysis. Input for spatially distributes models, as well as their output, can be treated as map overlays and topical maps (Fedra, 1994). Certainly the system needs to have a convenient interface to spatially referenced data, as well as a familiar format of maps to supports the understanding of model results and this particular system have it all. As an additional for complex and dynamic analysis of the system, simulation, optimisation models and of course expert system are used.

Although expert system is not the heart or particularly used in the development of the WaterWare system, but it offers a rule-based expert system for environmental impact assessment (Fedra et al., 1991). A water resources management system is subject to structural changes such as new reservoirs, or policy changes resulting in a modified water allocation pattern. Any such project or policy change will have a range of environmental impacts, positive or negative. This is where expert system is used, screening the level assessment of such projects, and new reservoirs in particular. As the expert system comes with a set of rules for the evaluation, a checklist of potential problems is used together with it, as well as the data coming from the GIS, the object data base, and model results. To produce a classification of all potential problems that may occur for a given project and environment, the inference engine uses a combination of both forward and backward chaining of the well known rule-based expert system.

So, we have reviewed some of the computer program applications which employ the technology of expert systems, the new phenomenon in the information technology world and have invaded the world of environmental management. With so many kind of data and information in various terms for different problems, the implementation of expert system in the domain of environmental management seems to be really useful and benefiting the whole creatures who live in the environment itself. But it is not denied that there are also some constraints prompting in the midst of the implementation of expert system in environmental problems, which include the issues of reliability, effectiveness and so forth. But these issues have been the issues of almost every domain where expert system was adopted in. So, there should be continuous effort and research on the method in optimising the greatness of expert system in various field and domain, where necessary.

Expert Systems in Medicine

It also seems that very early on, scientists and doctors alike were captivated by the potential such a technology might have in medicine (Ledley and Lusted, 1959). With intelligent computers able to store and process vast stores of knowledge, the hope was that they would become a perfect'doctors, assisting or surpassing clinicians with tasks like diagnosis.

In reviewing this new field in 1984, Clancey and Shortliffe provided the following definition:

'Medical artificial intelligence is primarily concerned with the construction of AI programs that perform diagnosis and make therapy recommendations. Unlike medical applications based on other programming methods, such as purely statistical and probabilistic methods, medical AI programs are based on symbolic models of disease entities and their relationship to patient factors and clinical manifestations.'

Much of the difficulty has been the poor way in which they have fitted into clinical practice, either solving problems that were not perceived to be an issue, or imposing changes in the way clinicians worked. What is now being realized is that when they fill an appropriately role, intelligent programs does indeed offer significant benefits. One of the most important tasks now facing developers of AI-based systems is to characterize accurately those aspects of medical practice that are best suited to the introduction of artificial intelligence systems.

Expert or knowledge-based systems are the commonest type of AIM (Artificial Intelligence in Medicine) system in routine clinical use. They contain medical knowledge, usually about a very specifically defined task, and are able to reason with data from individual patients to come up with reasoned conclusions. Although there are many variations, the knowledge within an expert system is typically represented in the form of a set of rules.

Expert systems can be applied in various tasks of medicine domains:

Generating alerts and reminders. In so-called real-time situations, an expert system attached to a monitor can warn of changes in a patient's condition. In less acute circumstances, it might scan laboratory test results or drug orders and send reminders or warnings through an e-mail system.

Diagnostic assistance. When a patient's case is complex, rare or the person making the diagnosis is simply inexperienced, an expert system can help come up with likely diagnoses based on patient data.

Therapy critiquing and planning. Systems can either look for inconsistencies, errors and omissions in an existing treatment plan, or can be used to formulate a treatment based upon a patient's specific condition and accepted treatment guidelines.

Agents for information retrieval. Software 'agents' can be sent to search for and retrieve information, for example on the Internet, which is considered relevant to a particular problem. The agent contains knowledge about its user's preferences and needs, and may also need to have medical knowledge to be able to assess the importance and utility of what it finds.

Image recognition and interpretation. Many medical images can now be automatically interpreted, from plane X-rays through to more complex images like angiograms, CT and MRI scans. This is of value in mass-screenings, for example, when the system can flag potentially abnormal images for detailed human attention.

Currently there are many systems that have made it into clinical use. Many of these are small, but nevertheless make positive contributions to care. In the next sections, we will examine some of the more successful examples of knowledge-based clinical systems, in an effort to understand the reasons behind their success, and the role they can play.

CaDet

CaDet is a computer-based clinical decision support system for Early Cancer Detection. Cancer risk evaluation and early detection are subject to serious limitations mainly related to human factors and to characteristics of the data involved. To help overcome these problems, a computer-based system was designed to provide the physician with a clearer clinical picture and aid in directing patients to appropriate measures.

Clinical and epidemiological data related to early cancer detection and to cancer risk factors was collected from the literature and incorporated in a database, together with heuristic rules for evaluating this data. Individual data obtained from patients through a questionnaire are input into CaDet, a computerized clinical decision support system. A report summarizing patient data and cancer hypotheses, with a scoring system that reflects degrees of alarm, is generated.

The CaDet systems, as well as some preliminary results of the clinical experience accumulated in its use, are described. These preliminary results suggest that the approach may be useful in improving cancer risk assessment and screening in primary care setups.

DXplain

DXplain is an example of one of these clinical decision support systems, developed at the Massachusetts General Hospital (Barnett et al., 1987). It is used to assist in the process of diagnosis, taking a set of clinical findings including signs, symptoms, and laboratory data and then produces a ranked list of diagnoses. It provides justification for each of differential diagnosis, and suggests further investigations. The system contains a data base of crude probabilities for over 4,500 clinical manifestations that are associated with over 2,000 different diseases.

DXplain is in routine use at a number of hospitals and medical schools, mostly for clinical education purposes, but is also available for clinical consultation. It also has a role as an electronic medical textbook. It is able to provide a description of over 2,000 different diseases, emphasizing the signs and symptoms that occur in each disease and provides recent references appropriate for each specific disease.

Decision support systems need not be 'stand alone' but can be deeply integrated into an electronic medical record system. Indeed, such integration reduces the barriers to using such a system, by crafting them more closely into clinical working processes, rather than expecting workers to create new processes to use them.

Germwatcher

Germwatcher has been developed to assist the Infection Control Departments of Barnes and Jewish Hospitals (teaching hospitals affiliated with the university) with their infection control activities. These activities include surveillance of microbiology cultures data.

Hospital-acquired (nosocomial) infections represent a significant cause of prolonged inpatient days and additional hospital charges. Using a rulebase consisting of a combination of the NNIS criteria and local hospital infection control policy, GermWatcher scans the culture data, identifying which cultures represent nosocomial infections. These infections are then reported to the CDC.

HELP

The HELP (Health Evaluation through Logical Processes) System is a complete knowledge based hospital information system. It supports not only the routine application of an HIS including ADT, order entry/charge capture, pharmacy, radiology, nursing documentation, ICU monitoring, but also supports a robust decision support function.

The HELP system is an example of this type of knowledge-based hospital information system, which began operation in 1980 (Kuperman et al., 1990; Kuperman et al., 1991). It not only supports the routine applications of a hospital information system (HIS) including management of admissions and discharges and order entry, but also provides a decision support function.

The decision support system has been actively incorporated into the functions of the routine HIS applications. Decision support provides clinicians with alerts and reminders, data interpretation and patient diagnosis facilities, patient management suggestions and clinical protocols. Activation of the decision support is provided within the applications but can also be triggered automatically as clinical data is entered into the patient's computerized medical record.

PEIRS

PEIRS (Pathology Expert Interpretative Reporting System) appends interpretative comments to chemical pathology reports (Edwards et al., 1993).

The knowledge acquisition strategy is the Ripple Down Rules method, which has allowed a pathologist to build over 2300 rules without knowledge engineering or programming support. New rules are added in minutes, and maintenance tasks are a trivial extension to the pathologist's routine duties. PEIRS commented on about 100 reports/day. Domains covered include thyroid function tests, arterial blood gases, glucose tolerance tests, hCG, catecholamines and a range of other hormones. PIERS was implemented in the St Vincent's Hospital, Sydney, but is now out of use while a new hospital information system is settling in. Once this is stable, PIERS will need to be interfaced into the system.

Puff

The Puff system diagnoses the results of pulmonary function tests. Puff went into production at Pacific Presbyterian Medical Center in San Francisco in 1977. Several implementations and many thousands of cases later, it is still in routine use. The PUFF basic knowledge base was incorporated into the commercial "Pulmonary Consult" product. Several hundred copies have been sold and are in use around the world. The PUFF system for automatic interpretation of pulmonary function tests has been sold in its commercial form to hundreds of sites world-wide (Snow et al., 1988). PUFF went into production at Pacific Presbyterian Medical Center in San Francisco in 1977, making it one of the very earliest medical expert systems in use. Many thousands of cases later, it is still in routine use.

SETH

The aim of *SETH* is to give specific advice concerning the treatment and monitoring of drug poisoning. Currently, the data base contains the 1153 most toxic or most frequently ingested French drugs from 78 different toxicological classes.

The SETH expert system simulates expert reasoning, taking into account for each toxicological class, delay, clinical symptoms and ingested dose. It generates accurate monitoring and treatment advice, addressing also drug interactions and drug exceptions.

Between April 1992 and October 1994, 2099 SETH analyzed cases inputted by residents. Since that time three phases of evaluation have been performed. It was concluded that an expert system in clinical toxicology is a valuable tool in the daily practice of a Poison Control Center.

As seen from considering of existing ES's, many of medicine ES's are for the assistance to the physicians in making diagnosing. These ES's may shorten the time to make the correct diagnosis and may reduce the number of diagnostic errors. At the same time, physicians may obtain the information on the symptoms of each of the diseases and pathologic syndromes contained therein.

These circumstances are very important for the countries with large number of population where the number of physicians respecting to 1000 person is limited. It is necessary to take into consideration designing and using of medicine ES's. Thus, researchers have to do their investigations directly on this area.

Conclusion

Expert system in agriculture, education, environmental management and medicine had been through a tremendous phases from simple expert system to the complex multipurpose systems. Hybrid expert system and together with fuzzy expert system can be seen as a new techniques that be used by researchers lately. Implementation of expert system in such fields is greatly influenced by techniques and methods from adaptive hypertext and hypermedia. Features of personalization, user modeling and ability of adaptive towards environment will become great challenges to settle. It can be used as a guideline to promote an expert system in various functions.

In recent years, ES's have been used together with artificial neural networks, fuzzy logic, genetic algorithms and other methods of Artificial Intelligence. These methods allow taking into account their advantages in the designed system and, therefore, new designed systems are more powerful instruments to facilitate various tasks that require instant, accurate and reliable results.

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