An Adaptive Expert System for an Educational Institute

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Abstract

Expert Systems are entering a critical stage as interest spreads from university research to practical applications. The proposed Expert system is expected to solve the problems faced in an educational institute for gathering information for management level from the faculty level. Depending on the level of authorization the system will respond and provide a satisfactory answer for the query posed. Both essential and desirable features of an expert system are discussed. Components of an adaptive system are identified, with an emphasis on the mechanisms that enable adaptive behavior to occur. Knowledge representation in a rule-based, object-orientated expert system is described through the establishment of appropriate relationships utilizing heuristic rules, objects, and agents. The experimental expert system displays low level learning capabilities that show sufficient promise to warrant further research.
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1. Introduction

One of the most rapidly, growing and fascinating topic in computer science, psychology, linguistics and information science is expert systems. Expert systems belong to the broader discipline of Artificial Intelligence (Al) which has been characterized by Barr and Feigenbaum as 'the part of computer science that is concerned with designing intelligent computer systems; that is, systems that exhibit the characteristics we associate with intelligence in human behavior-understanding language, learning, reasoning, solving problems, and so on'. Of all the branches of artificial intelligence, expert systems hold the greatest potential.

Even though expert systems aim to mimic human experts, they lack an extremely important capability of human intelligence: the ability to learn from experience. First of all, it takes a significant amount of time to build an expert system with many hours of testing and debugging. If a human expert comes to an incorrect conclusion, he may be able to learn from the mistake and avoid making the same or similar mistakes in the future. Once an expert system is found way to correct that error is to reprogram the expert system. In other words, most current expert systems are lacking an adaptive capability.

Computer based adaptive capabilities are essential in situations where environments change, in situations where standards of expertise are changing, and in situations where there are no historical data and learning occurs as a task that has been performed.

A goal of the research described in this paper is to explore strategies that enable an expert system to adapt to, or learn from, interactions with users. It is assumed that a relatively primitive computer-based adaptive capability can be of significant value in a problem-solving environment in which a computer is used as a collaborative decision-support tool.

Also research is being focused on the development of Expert system for academia, which can provide possibilities such as the easy integration and mapping of different competency required in academia. Moreover, research efforts have been realized in the development of in faculty domain with respect to academia. The paper also provides an essential overview of the key concepts in competency-based management, relevant research and as well as a methodology that supports the efficient deployment of such an adaptive system in an educational institution.

2. A Learning Environment

The word 'learning' is mainly reserved for human beings. Researchers have long wondered whether computers could also learn. In order to answer this question, a definition of learning is necessary. According to Lacey (1998), learning is "Any relatively permanent change in behavior brought about through experience that is, through interaction with the environment ". It could be assumed that learning may involve four factors: the *learner; the environment; their interaction; and state*. A *learner* could be defined as a relatively independent system, exhibiting a learning capability and adapting to its environment. In other words, a learner is a system with the capability to change itself as a result of *interactions* with its environment. The constantly changing *environment* provides a basic force that drives a learner to learn.

A *state* is a collection of characteristics that can be used to define the status of a learner and its environment at a certain time. An environment is partially comprised of the external circumstances of a learner, and influences the way in which a learner behaves. In other words, a learner exists in an environment, which changes over time. The internal impact of this external environment impels the learner, which results in adaptive action on the part of the learner.

An approach to learning, therefore, is through the interaction between the learner and its environment. The interaction operates in terms of three basic elements: precepts; actions; and, goals. Shen (1994) defines these elements as follows:

"An action is a physical change that occurs inside the learner, such as a muscle contraction inside a human body or an electrical signal sent to some switch in a robot.

A percept is a representation inside the learner about the state information of the environment.

A goal is defined as a set of percepts that the learner wishes to receive from the environment."

Shen (1994) also explains the learning process as: "With actions and precepts as building blocks, the learner is to construct a model of the environment so that it can predict the consequences of its actions and direct its actions towards the goal."

Accordingly, a learning process is a process in which a learner builds models of its environment.

According to Shen's definition of learning, a system should not be called a learning system if it merely contains the capability to repeat exactly what it has been designed to do. A learning system must have the capability to gain knowledge and adapt its behavior accordingly. In terms of the two world's concept, a process which gains knowledge is equivalent to a process that revises old models and builds new models based on interactions between the two worlds. In this regard, memorization and creation are two possible methods of knowledge acquisition.

3. Knowledge Representation

Knowledge representation is a method used to encode the knowledge for use by the expert system, and putting the knowledge into rules or cases or other representations.

The knowledge that is contained within an expert system consists of:

- A priori knowledge. The facts and rules that are known about a specific domain prior to any consultation session with the expert system
- Inferred knowledge: the facts and rules concerning a specific case that are derived during, and at the conclusion of. a consultation with the expert system

Our concern will be with the manner in which these types of knowledge and in particular knowledge of the first type, may be represented within the digital computer. In particular, our attention will be focused on the use of rule bases for the representation of expert knowledge.

(1) Actually rules are generated during a consultation session only if our expert system is capable of learning. In general, inferred knowledge consists simply of new facts, or conclusions.

In the brief introduction to expert systems, it was noted that knowledge is contained within both the expert system's knowledge base and its working memory. The knowledge within the knowledge base is that of the first type, that is, a priori facts and rules about the specific domain. The knowledge within the working memory is dynamic as it changes for each problem addressed and is of the second type, that is, inferred knowledge about the particular problem under consideration.

Our major concerns deal with how to represent the facts and rules within the knowledge base to:

- Provide a format compatible with the computer.
- Maintain as close as possible a correspondence between this format and the actual facts and rules (i e. the rules as they are perceived by the domain expert).
- Establish a representation that can be easily addressed, retrieved, modified, and updated.

Several modes of knowledge representation have been proposed. The primary focus will be on rule-based systems for knowledge representation.

4. Building an Adaptive Expert System

An expert system could be viewed as one heuristic rule, or if-then statement, since all rules in the system work together to define a specific condition, which is achieved by asking user relevant questions. Thereafter, the system reacts with one or more actions. It is postulated that an expert system becomes adaptive during an interaction with a human user if this system proves to be capable of the formulation of new relevant questions and the adjustment of action(s).

4.1 Knowledge Node Network

The concept of a knowledge-node-network is proposed as an approach to knowledge representation in building an adaptive rule-based, object-oriented expert system. In a knowledge- node-network, all nodes are represented as objects, and adaptivity of the system is achieved through node modification and creation. Two types of nodes exist in a knowledge-node-network: question nodes (i.e., representation of relevant questions); and, action nodes (i.e., representation of corresponding actions).

A question node may contain one or more input-connections, each weighted, whose values change based on a successful search or a failed search. Each input-connection corresponds to two output-connections, each of which connects to another question node or action node. A question node carries a relevant question and a corresponding answer-key. During a reasoning process, if a question node is activated by a message, the question will be evaluated, and the return value will lead to the next activation.

An action node may contain one or more input-connections, each weighted, whose values change based on whether user feedback is positive or negative. An action node carries one or more actions, and may be activated by messages sent from question nodes.

Also, such a knowledge-node-network contains an initial body of knowledge (i.e., a group of question nodes and action nodes with appropriate connections). Upon interaction with human users, this initial body of knowledge may prove inadequate within the context of a changing problem. The system adapts to these changes though the modification of existing knowledge nodes and the creation of new knowledge nodes.

In a knowledge-node-network, each node is associated with a value represented by either a relevant question or an action. Each node also contains connections to other nodes. The creation of new nodes and the modification of either the value or the connections of the node are defined as constituting a form of system adaptation in response to a change.

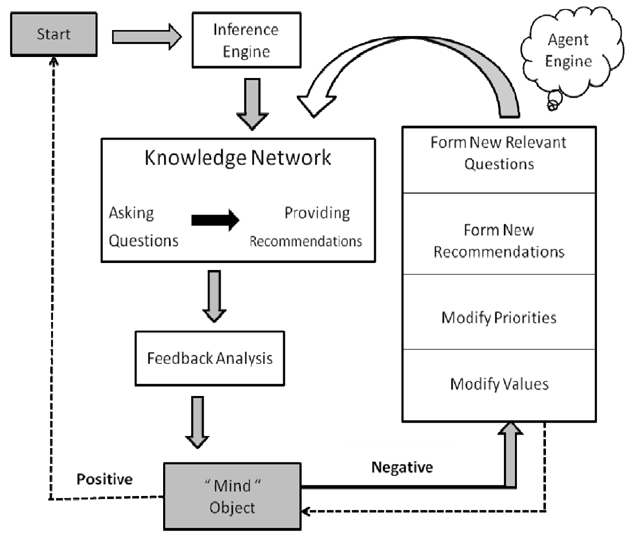


Fig-1 Proposed System Architecture

5. System Architecture

In terms of inference process, an adaptive expert system describes a generate-and-test loop that endows a system with a leaning capability (Figure 1), while a conventional expert system describes a unidirectional flow with no adaptive behavior. From a system structure perspective, an adaptive expert system differs from a conventional expert system as follows:

A) Unlike a static knowledge base in a conventional expert system, an adaptive expert system contains a dynamic knowledge base. Knowledge is represented by a knowledge network (i.e., objects and their interactions) that can be dynamically modified in real-time based on interactions with the human user.

B) In addition to containing the capabilities of a conventional inference engine, an adaptive expert system is capable of real-time adaptation to feedback and restructuring of the knowledge network.

The architecture of such an adaptive expert system consists of three major components: an inference engine; a knowledge network; and, a node-modification agent engine. The inference engine infers through condition-satisfaction action selection. In the rule-based system, it searches for the rules satisfied by facts or objects, and executes the rule with the highest priority. The knowledge base is composed of knowledge nodes and their connections. The node-modification agent engine consists of a node-maintainer, a node-builder and a node-merger. These agents analyze feedback and reconstruct the knowledge base accordingly.

The goal of the system is the development of corresponding answers to satisfy the needs of clients based on information. The mechanism provided by this system demonstrates a primitive adaptive capability of a computer-based expert system.

6. Design Methodology

Generally, the various stages of expert system development are (i) task analysis (ii) knowledge acquisition (iii) prototype development (iv) expansion and refinement and (v) verification and validation. The stages are shown in figure (2).

6.1 Task Analysis

The first stage of developing the expert system involved analysis of the tasks. During the analysis phase, the main objective was for the knowledge engineers to identify and understand the problem to be solved. The scope of domain in this research will consists of several modules belong in three levels, data level, distributed knowledge level and case based learning module. Data level will receive information from various components of ES; Distributed Knowledge level will supervise the operation of data gathering and the job identifications; finally case based learning level/module will supervise the process of the assessment of individual faculty of each teaching department.

6.2 Knowledge Acquisition

Knowledge acquisition is the knowledge engineering job of acquiring and organizing the knowledge needed to develop an expert system. The job of acquiring and representing knowledge involves organizing and representing the knowledge in a way that ensures an accurate replication of the knowledge and the decision situation under study in a form useful for transferring the knowledge to a computer system. The goal of knowledge acquisition and representation is the transfer and transformation of problem-solving and decision-making expertise from some knowledge source into a form useful for developing an expert system. There are two stages of knowledge acquisition in this research. The first stage involved a knowledge acquisition from engineer interacting with written and other knowledge sources which includes using sources such as books, journals, documents, technical manuals and databases. The second stage involved knowledge engineer interacting with domain experts who involved unstructured interview and observation of the experts. The unstructured interviews with several domain experts can be effective in exploring the background knowledge involved in a situation. Observation of the expert involves the knowledge engineer observing domain expert as they (i) perform a familiar task, solve a problem, or make a decision, (ii) deal with a simulated situation, case study, or real world problem, and (iii) describe possible decision situation scenarios that might be encountered on the job.

6.3 Prototype Development

In this stage, knowledge expertise will be transform into computer programmed. Prototype developments enable testing and refining the concept of a system. At other times, prototypes will be developed of different segments or modules of a system, as the overall system is developed in increments. In developing prototypes, an effort is made to select only the most critical factors and show only their most basic relationship, in order to test the underlying structure and concept of the system.

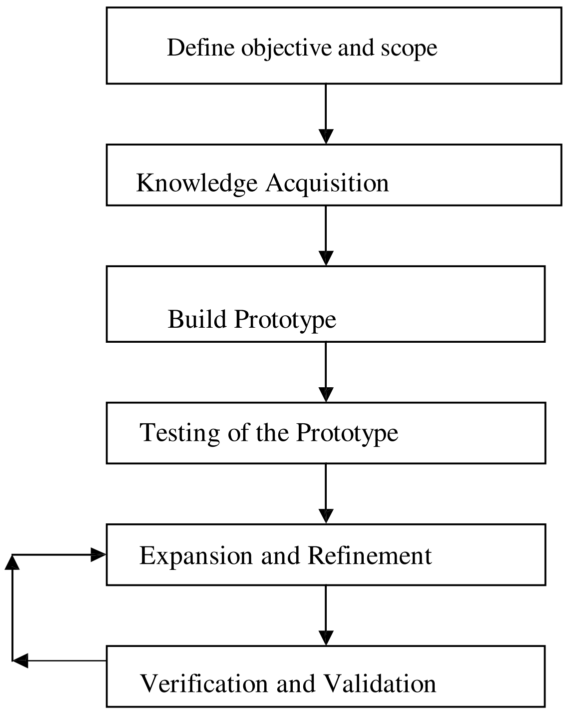
Rules are written for the knowledge base in this development process. IF-THEN rules are the common way to represent knowledge in current expert systems. The rule contain premises or conditions in the IF clauses, and conclusions in the THEN clauses. IF-THEN rules in expert systems can be modified easily to meet changing needs. Hence, it was easy to update. It also has the capability to ask users questions about information needed to deal with specific problems during consultations.

6.4 Expansion and Refinement

This stage required the expert to add more knowledge expertise from interviews, field observation and research publication such as proceeding and journals. The prototype reviewed repeatedly and rapidly until a sufficiently satisfactory prototype is achieved.

6.5 Verification and Validation

An important step of an expert system development process is the evaluation of the performance of the systems, which involves both testing and validation. It is very important that expert systems are tested and validated before their effective employment in the intended user environment. Many validation criteria such as effectiveness, accuracy, performance, ease of use, the expert's prediction of the final results to validate the system. Although validation is a prerequisite step before any expert system can be implemented, there does not seem a globally accepted method of conducting this activity.



Fig, 2 Steps in developing an expert system

7. Expert System in an Educational Institute

The proposed system will include the proactive use of the data to assist the administration, team heads, employees (teaching and non teaching) and of course students in tracking and assessing the performance. It also helps to develop the knowledge base that can provide the information required for handling the changing requirements of the enterprise to develop competencies and resources accordingly. Hence, it will provide a technique to manage the competencies strategically. We also proposed to distribute the data in layers. The layered approach provides the facility of separating the data gathering and the data manipulation. The first layer describes the data gathering process through different mediums such as employees (faculties, staff team heads), registrar, administration and other competent gathering tools. The second layer describes the knowledge base. It is developed by the discussion from domain experts and knowledge engineer. The third layer describes the inference engine used to develop the reasoning based on cases and experiences to reach to solutions as suggested by different domain experts. It helps to do evaluation and assessment and provides information required for the trainings and developments of the employees, students, resources etc.

adaptability, adequacy, reliability and credibility were considered in this case study. The system is compared to

The advantages of expert systems in the management of the institution are as follows:

- Expert systems reproduce the knowledge and skills possessed by experts-individuals who are considered to be competence management experts. The ability to reproduce an expert's knowledge allows wide distribution of this expertise available at a reasonable cost.
- As designing an Expert System involves use of heuristic programming where changes are very frequent, the fundamental concept of the separation of knowledge from the reasoning mechanism eases the process of modifying the knowledge.
- Expert Knowledge-based systems are always consistent in their problem-solving abilities, providing uniform answer at all times. There are no emotional or health considerations that can vary their performance. On the other hand, different human experts often provide dissimilar answers to the same problem. Even the same human expert may provide slightly different answers on various occasions. In some cases, these variations are minor inconsistencies with little or no consequence; in others, they are major flaws resulting from the poor health, emotional disposition, or stress of the expert.
- Expert Knowledge-based systems provide (almost) complete accessibility. They work 24 hours a day, weekends and holidays. They never tire nor take rest.
- Expert Knowledge based systems helps in preserving expertise in situations where the turnover of employees or the expert is very high.
- Knowledge based systems, by virtue of their heuristic nature, are capable of solving problems where complete or exact data do not exist. This is an important feature because complete and accurate information on a

problem is rarely available in the real world.

The objective of the study is to develop an expert knowledge based system for management of the technical educational institutions. It also expected that the developed system can overcome most of the problems encountered typically in the management of an educational institute.

Benefits to End Users

Primarily, the benefits of ESs to end users include:

- A speed-up of human professional or semi-professional work -- typically by a factor of ten and sometimes by a factor of a hundred or more.
- Within companies, major internal cost savings. For small systems, savings are sometimes in the tens or hundreds of thousands of dollars; but for large systems, often in the tens of millions of dollars and as high as hundreds of millions of dollars. These cost savings are a result of quality improvement, a major motivation for employing expert system technology.
- Improved quality of decision making. In some cases, the quality or correctness of decisions evaluated after the fact show a ten-fold improvement.
- Preservation of scarce expertise. ESs is used to preserve scarce know-how in organizations, to capture the expertise of individuals who are retiring, and to preserve corporate know-how so that it can be widely distributed to other factories, offices or plants of the company.
- Introduction of new products. A good example of a new product is a pathology advisor sold to clinical pathologists in hospitals to assist in the diagnosis of diseased tissue.

8. Typical Scenario

The following sequences exemplify some adaptive behavior capabilities of the experimental system, simulated by the interactions of the user with the system.

The 1st Interaction:

System : Hello, this is an ES for an Educational Institute! May I have your Designation, please?

User : Direct_Engg

(Identifying the user…)

System : Director Sir of Engineering welcome! For providing the best service, I need to ask you some questions, if you are ready answer 'y' to continue

User : y *(System asks the user relevant questions…)*

System : Please provide your password.

User : ******

System : Which information is required?

1. Department
2. Labs
3. Library
4. Time Table
5. University Exams
6. Others

User : 1.

System : Well sir, one moment please.

(Searching for relevant information based on the user's responses…)

System: Sir, the followings are my information for you:

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...Our Engineering College
has Four Departments:
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1). – Computer Science

2). –Electronics Engineering.

3).–Electronics and Telecommunication

4). –Mechanical Engineering.

Are you satisfied with them? y/n

User : n *(negative feedback)*

(System identifies the problem since it receives a negative feedback…)

System : That's fine, Sir, let's work this problem out together... May I know which one seems not appropriate to you? Chose the number from above

User : 6

System : What you've chosen is...

6). Others

Why it is inappropriate..?

1. You want to know what all will be included

2. It basically is fine; you just want to refine it.

3. You don't want this option to be

included

User : 2

(All three options listed above cause modifications in the knowledge-network. Option one and two trigger agents to update the value and connection weight of knowledge nodes, and option three triggers agents to modify knowledge node.)

System : Would you please explain to me what is the constraint?
User : Want to add more details to it.
System : What do you mean by it exactly?
User : Like academic calendar, Examination details etc can be added
System : So, it is inappropriate in your case because...Some more details for clarity need to be included.
User : y

(During the above interactions, the system analyses the user's response in order to achieve a certain degree of understanding.)

(A negative response here causes a modification of the existing knowledge-network, while a positive response leads to the creation of a new knowledge node.)

System : Well, Sir, the followings are recommendations from you:

. . .

1)–Option 'others' should include more details, like

2). – Departments should include academic calendar and defaulter list.

3). – Examination Schedule also to be included.. . . .

Are you satisfied with them? y/n

User : y *(positive feedback)*

System : Sir, thanks for using ES Adviser. See you!

(The end of the first interaction.)

The adaptive expert system has acquired knowledge that will be applied in the next sequence of interactions

The 2nd Interaction:

System : Hello, this is an ES for an Educational Institute! May I have your Name and Designation, please?

User : Tom, student Engineering

(Identifying the user…)

System : Tom, You are a student, welcome!

...

User : y

(System asks Tom relevant questions, and Tom's situation happens to be similar to that of any student.)

System : Which information are you interested in

1. Academic Calender
2. Time Table
3. Syllabus
4. Examinations
5. Library
6. Labs.

User : 3

(Option 1 is from a new knowledge node that was built through "The 1st Interaction".)

System : Tom, please mention your Branch and Sem
User : Electronics and 3

(Searching for relevant data.)

System : Tom, the followings are my results for you:

. . .

1) Third Semester in Electronics Engineering has 5 theory and 3 practical courses..

2) Each theory subject has 5 units covering the entire syllabus.

3) Practicals are relevant topics of some theory subjects.

4) The theory subjects include i) Digital Electronics, ii) Electronic Devices and Circuits, iii) Network Analysis iv) Maths III and v) AC Machines.

5) The Practicals are there for i) Digital Electronics, ii) Electronic Devices and Circuits, iii)Network Analysis

...

Are you satisfied with them? Y/n.*)*

User : y *(positive feedback)*

System : Ok Tom It's nice helping you.

(The end of the second interaction.)

9. Conclusion

The research conducted suggests that memorization (i.e., storing experience) is one of the fundamental capabilities of an adaptive system. The demonstrated expert system has achieved some features of memorization, during an interaction with a human user.

The system adjusts priorities of its actions based on the feedback received from the human user in real-time. In this way, useful actions can be enhanced, and inappropriate actions can be combed out.

The system automatically corrects its inappropriate actions based on evaluations received from the human user. The system can define new problems and search for new actions (i.e., creating new relevant questions and actions), according to the feedback received from the human user.

Besides the memorization capability, the system is capable of self-reorganizing its knowledge base (i.e., mergence of knowledge nodes).

A future study of an evaluation system in an adaptive system may significantly benefit the research study presented in this paper.

References

[1] Tripathi P, Ranjan J, (2007). "Decision Supporting System for the Competence Management".Procoeedings of the First International Conference on Information System Technology and Management, 2007.

[2] Tripathi,P., Ranjan J,(2008). "Measuring Competencies using Expert System: Educational Perspective" Journal of Theoretical and Applied Information Technology, 2008.

[3] E A Feigenbaum, "Thae Art of Artificial Intelligence: Themes and Case Studies of Knowledge Engineering (1977), Proceedings of the Fifth International Joint Conference on Artificial Intelligence.

[4] Gonzalez, A.J. and Dankel, D.D. 1993. The engineering of knowledge-based systems: theory and practice, Alan Apt, New Jersey.

[5] AICTE report. (2008) Retrieved 18 April 2008 from http://www.aicte.ernet.in

[6] Xiaoshan Pan "An Experimental Adaptive Expert System" Slagle R. J., Wick R. M., " A Method of Evaluating Candidate".AI Magazine Volume 9 , Number 4.

[7] Kumar Y., Jain Y., "Research Aspects of Expert System". International Journal of Computing and Business Research-2012.