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Application of Expert System to Enhance Learning Program

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Abstract

Many expert system applications in the field of education are integrated into the Intelligent Tutoring System (ITS) using adaptive hypertext and hypermedia techniques. Most of the time, the system will help students learn by applying adaption strategies to tailor it to the surroundings, the students' prior knowledge, and their learning capacity. Expert systems in education have steadily advanced in terms of technology, moving from microcomputers to web-based and agent-based systems. Along with the technologies utilized, expert systems significantly altered how procedures and strategies were used. Starting with a straightforward rule-based system, expert system techniques have now embraced fuzzy logic and a hybrid approach. The use of expert systems in teaching basic data structures will be covered in this paper. Applications in engineering, technology, and earth science will follow.

Keywords: *Expert System, Artificial Intelligence, Knowledge Engineering, Decision Support System.*

I. Introduction

Expert systems are computer programmes derived from the field of artificial intelligence research in computer science. (AI). AI is concerned with the ideas and procedures for symbolic inference, or reasoning, by a computer, as well as how the information the computer will use to draw those conclusions will be represented internally. In contrast to knowledge gleaned from textbooks or non-experts, expert systems are programmes whose knowledge base contains the knowledge used by human experts. Knowledge engineering is the process of creating an expert system, and knowledge engineers are those who carry out this work. The computer must have all the knowledge required to solve an issue, according to the knowledge engineer. The knowledge engineer must select one or more representations—a knowledge representation—in order to store the necessary knowledge as symbol patterns in the computer's memory. He must also ensure that the machine can utilise the knowledge efficiently by selecting from a number of reasoning processes.

Vol.1 Issue 2 June 2023 EISSN: 2583-7575

II. What Reasons do People Use?

Here, we may name a number of particular human thinking techniques that can be easily transferred to the world of expert systems and artificially intelligent computers:

1. **Categorization -** When we decide that a fact is significant enough to recall, we classify it using one or more categories or criteria. These categories are kept in our minds as a loose hierarchy where lower-level bits of data can "inherit" qualities from a higher-level category. The relationships between the categories can be used to derive rules through categorization.
2. **Particular Rules** - If a certain rule, or collection of rules, are known to exist and be true, we can utilise that knowledge to navigate a problem situation where the rules are involved. In order to achieve trustworthy conclusions, humans use rules by cascading them into their reasoning process.
3. **Heuristics** - Heuristics are general principles that can be used or stored for later use. We know that searches and judgements utilising well-formed heuristics can frequently reduce the time required to arrive at a solution, despite the lack of formality associated with a heuristic.
4. **Past Experience -** This strategy, which can be regarded of as a meta-categorization, involves humans attempting to compare a scenario to ones they have previously encountered. The necessary actions can be justified based on what was done in the past if enough traits or event sequences can be matched. This kind of reasoning is based on certain pretty broad assumptions, such as the idea that history will repeat itself and that the current condition is largely comparable to the past circumstances.
5. **Expectations** - After repeatedly encountering a similar circumstance or phenomena, we start to anticipate that it will manifest itself in a specific way or under a specific set of circumstances. If things happen as we anticipate, we can infer that everything is in order or that nothing is wrong. However, if something happened to alter the anticipated set of circumstances, we can infer that the event did not turn out as we had anticipated. Simply said, reasoning based on expectations is a type of pattern recognition.

III. What is Computer Reasoning?

The techniques utilised by AI system designers to build a computer-based reasoning system are based on the same principles and processes that people use.

Vol.1 Issue 2 June 2023 EISSN: 2583-7575

1. Reasoning by rules -

The rule composition is represented by the following IF-THEN statement:

IF statement, THEN operator

A rule is said to have fired or instantiated if a condition is determined to be logically true, at which point the operator turns into an action that is permitted to be executed. The operator is disregarded and the next rule is accessed if the condition is logically false.

This process continues until the knowledge base's rules are exhausted or the problem space reaches the desired condition. Several different types of knowledge can be codified using a formal set of rules:

(a) Inferential knowledge: This sort of knowledge involves drawing conclusions from premises (facts) that have already been established.

For instance, IF... THEN conclusion

(b) Procedural Knowledge: In this case, the operator is an action to be taken when the stated circumstance is logically true, and the conditions take the form of a stated scenario. Example: IF circumstances then do.

(**c) Declarative Knowledge:** If it is determined that the antecedent is logically true, and then the consequent must also be true. For example, IF antecedent THEN subsequent

2. Framing

A semantic net, formalism for encoding knowledge, is logically extended by a frame. Concepts or things are represented as nodes in a semantic network, and the arcs that connect those nodes show their relationships. It is possible to compare the discrete structures known as slots to database fields. Each slot has one or more aspects inside of it. These attributes describe any information or particular methods connected to the slot. The daemon facet type is yet another crucial one. When a slot is created, changed, or merely accessed, a daemon, a brief function, may be launched. Two different kinds of items can be represented using the frame concept: instances and classes. Slot values that can be sent down the frame hierarchy are contained in the objects that frames represent. Subclass links (IS-A) and membership links are two constructions used to organise the frame hierarchy (INSTANCE-OF). The subclass links function as a taxonomy mechanism, and the membership links as a categorization mechanism.

3. Case-Based Reasoning

The goal is to apply solutions to issues that are comparable to the one at hand. Case-based reasoning incorporates two main steps: (a) locating examples in storage that have resolved issues comparable to the current issue, and (b) tailoring the prior solution(s) to the circumstances of the current issue.

Using a set of criteria that gauges the degree of resemblance between the chosen case and the current issue, each potential instance is contrasted with it. Following this procedure, the enclosed solutions are examined and modified to fit the new circumstance. A number of adjustments are made to the existing solutions' parameters during the adaptation process in order to make them match the new problem environment. The new solution is then tested, and if it works, it is added to the case collection. But if the test is unsuccessful, then the adaption procedure needs to be changed, or a fresh collection of cases needs to be retrieved.

4. Pattern Recognition

Visual and aural patterns are both included in pattern recognition. Similar to humans, a computer's capacity to understand its environment and surroundings determines how intelligently it will behave when using a pattern recognition system. The computer's perceptive abilities are constrained if it can only be operated using keystrokes, mouse, and trackball movements. However, completely new opportunities for imitating intelligent behaviour open up if extra hardware and software enable the computer to hear noises and recognise patterns or objects. A distinctive human voice, a fingerprint, or even a person's image captured on camera or in a video can all be recognised by sophisticated pattern recognition systems.

5. Rete Algorithm

The Rete algorithm takes use of the fact that the working memory's contents don't change significantly following the application of each rule, but rather show only slight modifications from the previous pass. The Rete algorithm specifically determines which rules from the previous cycle did not fire, which rules from the previous cycle will not fire in the following cycle, and which rules from the prior cycle that did not fire will probably fire in the following. By employing this technique, the algorithm can avoid starting each rule-cycling cycle of pattern recognition from scratch. It uses that internal representation as the foundation for repeating the cycle on each succeeding pass until the pattern is matched by keeping an internal representation of the state of each rule in working memory.

Vol.1 Issue 2 June 2023 EISSN: 2583-7575

IV. Expert Systems: Concepts and Structure

An ES's fundamental structure is as follows:

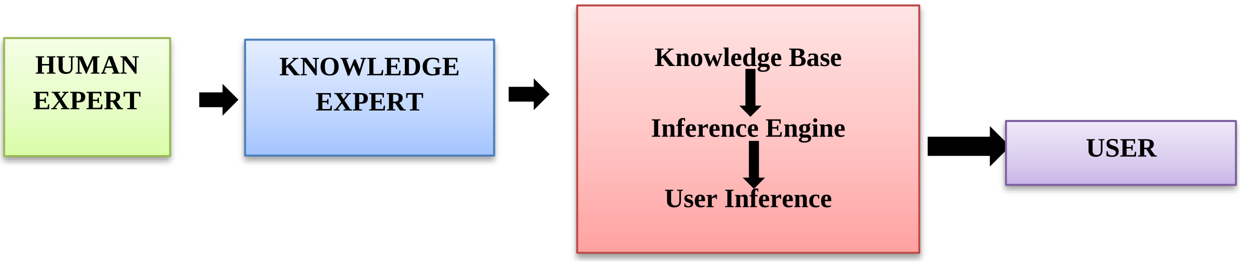

Fig. 1. Expert System Architecture

The following are the components that make up an expert system:

1. The User Interface - The following problems could be resolved with improved ES interface design:

(a) Users ought to be partners on an equal footing or in charge of the UI design.

(b) ES dialogues ought to be adaptable enough to permit user-provided information and easy changes of initiative.

(c) The explanation facilities must be very good and comprehensive.

(d) A natural language interface for an expert system might not be acceptable.

(f) Whenever possible, ES dialogues should prioritise images over words.

2. Knowledge Base - During the design phase, a sample of domain experts were used to compile the domain-specific knowledge that is contained in an ES's knowledge base.

This knowledge includes all sorts of information that the domain expert uses to solve problems connected to that domain, such as descriptions and relationships of objects, approaches to problem-solving, restrictions, heuristics, and uncertainties. The correctness and comprehensiveness of an ES's knowledge base are crucial to its success.

3. The Inference Engine

Here, the ES's processing takes place, and the knowledge is put to use to generate answers. Deductions or inferences are carried out by the inference engine (IE) using facts or rules. A control cycle is the name given to the fundamental IE procedure. An inference control cycle is categorised into three steps:

(a) Matching rules to facts

(b) Before choosing the rule to apply.

(c) Put the rule into action by introducing the omitted fact.

Chaining and resolution are the two fundamental methods that an ES employs to apply the modus ponens and modus tollens rules of deductive reasoning in order to reach the proper conclusions.

4. Chaining - This approach arranges the set of rules in a recursive fashion, using the conclusion of one rule as the basis for the next. In an ES, there are two possible chaining kinds dependent on the search direction: forward and backward. Forward chaining involves starting with the workspace's initial content and working through a succession of inference control cycles to get a resolution.

Because the process entails moving from data to goals, this line of thinking is also known as being data driven. By using a backward chaining technique, the IE can verify a goal by working backward from the required data in the workspace. Backward chaining can be compared to a type of hypothesis testing where the conclusion is put forth and then the data are gathered to see if the hypothesis is supported.

5. The Workspace at Blackboard

When addressing a problem, calculations are done on the blackboard and intermediate hypotheses and conclusions are recorded in an electronic scratchpad or notebook. The system finishes its work, cleans the blackboard space, and makes it available for the subsequent session of problem-solving.

V. Constructing and Designing of an Expert System

a. Information (Knowledge)Engineering

Expert system design and construction are the arts of knowledge engineering, and knowledge engineers are its practitioners. A knowledge engineer learns what the experts know and how they use their knowledge by interviewing and observing a human expert or a group of experts. The engineer then converts the knowledge into a language understandable by computers and creates an inference engine, or reasoning structure, that makes the best use of the knowledge. The inference engine, tools for representing information, and explanations are then programmed, and domain knowledge is gradually incorporated into the programme.

b. Skeletons, instruments, and shells

Only a few AI techniques are known to be helpful in expert systems, compared to the huge variety of domain knowledge. That is to say, there are currently just a few ways to express knowledge, draw conclusions, or come up with explanations. Thus, systems containing these practical methods can be created without a thorough understanding of the relevant subject. These systems are also referred to as shells, skeletal systems, or just AI tools.

Development of an Expert System

Prior to formal design, a number of actions specific to expert system development must be carried out:

Finding the right experts-The time commitment required to complete the ES development effort must be made apparent to the expert. He or she must be prepared to dedicate a large amount of time and effort in the project's early phases and to work on it from beginning to conclusion. In terms of productivity, performance, and quality, it is crucial that the expert thoroughly comprehends the proposed system's worth to the company.

The development group - Early in the process, the team is frequently split up into smaller groups that concentrate on particular system components. The creation of the rule set will be the responsibility of some members of the development team, while the user interface will be the responsibility of others. Knowledge engineers will play a special role in the ES design process. (KEs).

The Application Development Tool - Because prototyping, reviewing, and refining the ES occur iteratively during development, choosing the development tool is a crucial predesign choice. The tool must have the right capability for the issue domain being modelled and must enhance the abilities of the development team. The perfect development tool increases team efficiency while being adaptable and adaptive.

Hardware Selection - The chosen ES hardware platform should preferably support both the chosen ES development tool and the final ES product as well as the latter's expansion. This ensures that the prototypes created throughout the development process will function exactly the same way in the finished product and that a change in the hardware platform after development won't result in any modifications to the product's functionality or performance.

VI. An Expert System's Development Process

If success is desired, expert system design and development must be carefully programmed. Following are some of the key actions to take:

1. Outline Statement The concepts, boundaries, linkages, and control mechanisms that will be incorporated into the system are worked out by the expert and the knowledge engineer. Both user expectations and development strategies and limitations are investigated. An outline specification should contain the findings of this stage of evaluation of the system's prospective performance and advantages. This standard is valid for developing the initial prototype.

2. Knowledge Acquisition - The expert and the knowledge engineer engage often during this stage. According to the restrictions placed, the expert is precise in articulating his knowledge and tries to draw attention to the crucial elements that distinguish the material as knowledge. On the other side, the knowledge engineer strives to understand the knowledge's core, its boundaries, and its intricacies.

3. Knowledge Representation - A successful system will satisfy user needs only if the expert's knowledge is communicated in a way that is clear to users and in a manner comparable to how a human expert typically approaches a problem.

The distinguishing factor between a good and a terrible knowledge engineer is the capacity to adapt the acquired knowledge to fit both the expert's and the potential users' frames of reference.

4. Development of prototypes - Building a prototype system first has the advantage of allowing the expert and knowledge engineer to determine whether the system is practical. Additionally, users get the chance to test the system out and determine whether it will likely fit their needs. Additionally, it gives the expert and knowledge engineer the chance to assess the value and functionality of the selected system.

5. Testing - Testing entails analysing the utility and performance of the prototype programme and making any necessary changes. Problems like missing concepts and relations in the representational scheme, knowledge represented at the incorrect level of detail, or cumbersome control mechanisms may be discovered as a result of this examination. These issues could cause the developers to go back and forth between the different phases of development, reformulating the concepts, improving the inference guidelines, and re-testing the control flow.

6. Main Knowledge Acquisition - The first step in creating the real system is to determine how much knowledge is necessary to satisfy user needs. It can be decided to include multiple specialists in the acquisition process at this point. The specialists determine if the system should or can be connected with other systems already in place inside the company.

7. Specification with Detailed Information - During this stage, the expert and the knowledge produce a detailed system specification. The extended system's goals, the resources needed, the anticipated time needed for implementation, the anticipated expenses, system testing, and implementation planning are all covered in the detailed specification.

8. System Development - It is crucial that users understand exactly how the system is developing, as well as any issues that may have arisen and any indications of new constraints or opportunities. The expert and the knowledge engineer both benefit greatly from their assistance during this period.

This phase necessitates close supervision because it demands increased financial and time commitments.

9. Implementation - The user should carry out implementation operations, with professional support as needed. The "specification with detailed information" stage is when the implementation plan should have been written down.

10. Maintenance - To keep the knowledge it holds current and in line with the shifting environment in which organisations function, it necessitates ongoing modification and update. The obligation to carry out maintenance operations should be assigned in advance and should be formally documented.

VII. Expert Systems in Education

Many expert system applications in the field of education are integrated into the Intelligent Tutoring System (ITS) using adaptive hypertext and hypermedia techniques. Most of the time, the system will help students learn by applying adaption strategies to tailor it to the surroundings, the students' prior knowledge, and their learning capacity. Expert systems in education have steadily advanced in terms of technology, moving from microcomputers to web-based and agent-based systems. The use of web-based expert systems can offer a great substitute for private tuition at any time and from any location where Internet access is available. Additionally, an agent-based expert system would undoubtedly assist customers by finding content on the web based on their profiles.

Expert systems are advantageous as teaching tools because they are outfitted with special capabilities that enable users to ask questions in the how, why, and what format? It will undoubtedly assist pupils much when utilised in a classroom setting because it prepares the response without consulting the teacher. Additionally, an expert system is able to support a response with arguments. This feature is particularly fantastic since it can increase pupils' understanding and level of confidence in their response.

Another element of expert systems that makes them harder for students is their capacity to adaptively modify the training for each individual student based on his or her unique rate of learning. It must to be able to assess students' development and choose the subsequent training step.

Expert System Application in Education

Expert systems are software packages or computer program packages intended to provide advice and aids in solving problems in specific areas of specialization such as science, engineering, mathematics, medicine, education and so on. The expert system is a subset of Artificial Intelligence that seeks to adopt human knowledge into computers, combining knowledge and tracing data to solve problems that normally require human skills [1]. In the field of education, the application of expert systems not only help students in the learning process but also help teachers and also policy makers in supporting the achievement of educational goals implemented.

This paper demonstrates that, depending on the researcher's aptitude and interest, the application of expert systems in education differs significantly. Expert systems can be applied in education generally for the following domains: input, process, output, and outcome. Expert systems (ES) are used in the following areas of education as part of literature reviews: student characteristics [2], student performance analysis [3], evaluation of e-learning [4], technical education requirements [5], character- [6], digital libraries [7], remedial systems [8], learning enhancements [9], lesson plans [10], basic evaluation of student competence [11], academic advice [12], and evaluation of academic programmes [13], the effectiveness of teaching and learning [14], projections of student performance [15], and criterion master level [16]. In addition to expert system literature review, educational and career advisory services for students [17] as well as professional skills counselling and guiding services [18] are also used in vocational education.

Conclusion

From simple expert systems to large multipurpose systems, the expert system in education has through enormous phases. Researchers recently employed a novel technique that combines hybrid expert systems with fuzzy expert systems. Techniques and approaches from adaptive hypertext and hypermedia have a significant influence on the implementation of expert systems in these disciplines. Personalization capabilities, user modeling, and environmental adaptability will be extremely difficult to overcome. It can serve as a guide to help an expert system in a variety of tasks. ESs has been employed in conjunction with artificial neural networks, fuzzy logic, genetic algorithms, and other AI techniques in recent years.

Expert systems are computer algorithms that replicate the judgement skills of a human expert in a particular field. Here is how they may be used to improve educational programmes:

Personalised Learning Paths: Expert systems are able to evaluate a learner's present knowledge and abilities before designing a personalised learning route. As the student advances, these pathways might change, offering specialised resources and information to meet their individual requirements and rate of learning [19].

Adaptive Assessment: Expert systems are capable of delivering adaptive assessments to measure a learner's abilities. Depending on the outcomes, the system may recommend further reading material or exercises to improve weak areas [20].

Content Recommendation: By analysing a learner's preferences and performance, these systems may suggest pertinent educational content, such as articles, videos, or courses, ensuring that students are engaged with resources that match their interests and learning preferences [21].

Responding to inquiries and Giving response – Expert systems are able to respond to inquiries from students in real-time, giving prompt response and justifications. This can be especially useful in courses like programming or mathematics where immediate feedback is crucial [22].

Problem-Solving and Tutoring: Some expert systems may serve as virtual tutors, taking students through problem-solving exercises and providing step-by-step answers or ideas to assist them get over obstacles [23].

Skill Development: Expert systems are able to make plans for learners' skill development that include milestones and goals. To guarantee continual improvement, the system may modify these programmes as learners advance [24].

Language Learning: To make learning a new language more dynamic and immersive, expert systems can give grammar and pronunciation checks, language drills, and conversation practise.

Analytics and Progress Tracking: Professional systems can monitor and evaluate student progress, assisting both students and teachers in identifying problem areas and modifying their approaches [25].

Expert systems can be used by instructors to help with curriculum preparation and decision support. Based on data and best practises, these systems can provide instructional methodologies, assessment techniques, and learning resources [26].

Accessibility and Inclusivity: By supporting students with impairments, expert systems may assist make learning programmes more accessible. For learners who are blind or visually handicapped, they could translate text into voice or offer other material forms.

Continuous Improvement: Expert systems can gather information on interactions and results with learners to enhance the learning plan over time. Educators may increase the efficacy of the programme by making data-driven decisions by assessing this data.

Expert system integration into learning programmes involves rigorous design, development, and integration. It's crucial to make sure that the technology supports the educational objectives and that students and teachers are properly trained to use these tools. When gathering and assessing student data, it is also important to take privacy and data security concerns into account.

These techniques enable the designed system to take into consideration their advantages, making designed systems more potent tools for facilitating a variety of tasks that call for immediate, precise, and trustworthy outputs.

The use of expert systems in education shows that these systems are particularly beneficial in resolving issues connected to input domain, process, output, and outcome in education. Since expert systems are a multi-science study area, it is advisable to combine educational techniques with other fields for further growth. It is anticipated that it will provide additional opportunity for scientists to create better expert systems to address future issues and educational obstacles.

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