

ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS: KNOWLEDGE-BASED SYSTEMS

TEACHING SUGGESTIONS

The introduction of artificial intelligence concepts can seem overwhelming to some students. This is an excellent opportunity to utilize highly-involved, hands-on teaching techniques. Carefully review the **group exercises** on page 8 at the end of this chapter. These can be an effective way to introduce topic material (show how each technique is employed to create problem-solving systems).

QUESTIONS FOR THE OPENING VIGNETTE

1. Describe the common characteristics in these two cases.

The Logitech case is not described in this vignette, which makes it difficult to answer this question. However, the remaining questions can be answered considering the KPN case only.

2. Describe the motivation for developing these intelligent systems.

The motivation for developing these systems is not only the cost savings achieved by the reduction of 30 to 50 employees, but also a consistency in service provided to the end-users.

3. Explain the role of the intelligent systems and their potential benefits.

Intelligent systems are used to support decision-making and problem-solving applications. Their benefits include:

- Enhanced problem-solving.
- Improved decision quality.
- Ability to solve complex problems.
- Consistent decisions.

4. What are the major difficulties in developing these systems?

The major difficulty in developing these systems is extracting the expertise needed to develop the knowledge base. It is difficult to extract an experts knowledge and codify it into a format that can be used in an automated application.

5. How are these systems different from traditional DSS described in previous chapters?

These systems differ from traditional DSS in that the knowledge base is more complex due to less reliance on the end-user to evaluate the results.

6. What managerial lessons can be learned from this system?

Open-ended answer. However, some managerial lessons that can be learned are:

- Technology can be used to facilitate decision-making, but managers must be part of the process and work with it.
- It is good to capture expertise in a system so that if the "expert" leaves the knowledge does not go with him or her.
- There needs to be adaptability in any system that is built.

QUESTIONS FOR REVIEW

1. *What is artificial intelligence?*

There are many definitions of AI. The basic objective of AI is to represent humans' thought processes in computers. These machines are supposed to exhibit behavior that, if performed by a human being, would be considered intelligent. An alternate definition, not covered in the text is by Astro Teller: "Artificial intelligence (AI) is the science of how to get machines to do the things they do in the movies." On the other hand Wallace Marshal states that "Artificial stupidity (AS) may be defined as the attempt by computer scientists to create computer programs capable of causing problems of a type normally associated with human thought." (Both these definitions appear in Kurzweil, R., *The Age of Spiritual Machines*, NY: Penguin Books, 1999, p. 66.)

2. *What is the Turing test?*

The Turing test is designed to determine whether a computer exhibits intelligence. A computer can be considered smart only when a human interviewer cannot identify the computer while conversing with both an unseen human and a computer.

3. *What do we mean by inferencing?*

Inferencing is the reasoning process of AI. It takes place in the brain of an AI process.

4. *List the major advantages of artificial intelligence over natural intelligence.*

AI is permanent, can be easily duplicated, can be less expensive, and can be documented.

5. *List the major disadvantages of artificial intelligence as compared to natural intelligence.*

Artificial intelligence is not creative (though lately this is open to debate), it is limited in the use of sensory devices (also subject to debate), it cannot make use of a very wide context of experiences (also subject to debate), and it does not use common sense (also subject to debate).

6. *Describe the difference between a knowledge base for an application and an organizational knowledge base.*

A knowledge base is the collection of relevant knowledge that is stored in the computer and is organized in such a manner that it can be used for inferences.

7. *List the major AI technologies.*

Expert systems, natural language processing, robotics, speech understanding, speech (voice) recognition, computer vision and scene recognition, intelligent computer-aided instruction, neural computing, intelligent agents, automatic programming, translation of languages, and summarizing news can all be considered AI technologies. The major technologies are expert systems, neural networks, intelligent agents, fuzzy logic, and genetic algorithms.

8. *Define an expert system.*

An expert system is a computer program that attempts to mimic human experts by the system's capability to render advice, to teach and execute intelligent tasks.

9. *Define natural language processing.*

Natural language processing is a program that permits (to a certain degree) a human-computer dialogue in a conversational, day-to-day language (a natural language like English, French, or Dutch).

10. Define speech recognition and understanding. Why is it useful?

Speech or voice recognition is a data input method. For example, the computer recognizes and understands one (or a few) word commands. Speech understanding on the other hand is the computer's ability to understand a spoken language. That is, the computer understands the meaning of sentences and paragraphs through syntax and semantics.

11. Define an intelligent agent. Why is it useful?

An intelligent agent is a program that runs in the background and learns your patterns, like any other agent working for you. It learns your needs to serve you better. The little paperclip guy that shows up in Microsoft Word is an example of an intelligent agent.

12. List the major benefits of intelligent computer-aided instruction.

The major benefits are:

Individualized, self-adjusted level of instruction; immediate feedback; portability; consistency; and better control of updating and variety of presentations.

13. List the types of knowledge that constitute expertise.

The list in Section 10.5 under *expertise* (theories about the problem area, etc.) contains:

- Theories about the problem domain.
- Rules and procedures regarding the general problem area.
- Rules (heuristics) of what to do in a given problem situation.
- Global strategies for solving these types of problems.
- Meta-knowledge (knowledge about knowledge).
- Facts about the problem area.

14. Define the ES development environment and contrast it with the consultation environment.

The development environment includes the activities and support that are necessary to acquire and represent the knowledge as well as to make inferences and provide explanations. The major players in this environment are the knowledge engineer and the domain expert who act as builders. Once the system is completed it is used for consultation by the nonexpert user via the consultation environment.

15. List and define the major components of an ES.

The major components are:

- * **Knowledge base**--the software that represents the knowledge.
- * **Inference engine**--the reasoning mechanism.
- * **User interface**--the hardware and software that provide the dialogue between people and the computer.
 - **Domain expert**--the individual who is considered an expert.
 - **Knowledge engineer**--the individual who acquires and represents the knowledge.
 - **Explanation facility**--the software that answers questions such as "Why" and "How."
 - **Blackboard**--a workplace for storing and working on intermediate information.
 - **Reasoning improvement**--a facility (not available commercially) for improving the reasoning capabilities of an ES.
 - **User**--the non-expert who uses the machine for consultation.
 - **Hardware**--the hardware that is needed to support the ES.

The three major components are marked by an asterisk (*). These correspond nicely to the DSS components of database management system, model base management system, and user interface.

16. *What is the role of a knowledge engineer?*

Major duties are to acquire and represent the knowledge. Some knowledge engineers do the computer programming as well.

17. *Describe how expert systems perform inference.*

The brain of an expert system is the inference engine that provides a methodology for reasoning about information in the knowledge base. Inference can be performed using semantics networks, production rules, and logic statements.

18. *What are the major activities performed in the ES blackboard (workplace)?*

The blackboard records intermediate hypotheses and decisions, devises a plan of how to attack a problem, provides an agenda of actions awaiting execution, and lists the candidate solutions to be examined.

19. *Describe generic categories of ES applications.*

Generic categories of ES applications are:

Rule-based ES. Knowledge is represented by a series of rules.

Frame-based systems. Knowledge is represented as a series of frames (an object-oriented approach).

Hybrid systems. Involve several approaches such as fuzzy logic and neural networks.

Model-based systems. Structured around a model that simulates the structure and function of the system under study.

Ready-made systems. Utilize prepackaged software.

Real-time systems. Systems designed to produce a just-in-time response.

20. *Describe some of the limitations of ES.*

- Some of the limitations are:
- Knowledge is not always readily available.
- It can be difficult to extract expertise from humans.
- There are frequently multiple correct assessments.
- Time pressures.
- Users have cognitive limits.
- ES works well only within a narrow domain of knowledge.
- Most experts do not have an independent means to validate results.
- Vocabulary is often limited and difficult to understand.
- Help from knowledge engineers is difficult to obtain and costly.
- Potential for lack of trust on the part of the end-users.
- Knowledge transfer is subject to biases.

21. *Describe the success factors of ES.*

Success factors are:

- Level of knowledge must be sufficiently high.
- Expertise must be available from at least one expert.
- The problem to be solved must be fuzzy.

- The problem must be narrow in scope.
- The shell must be of high quality and naturally store and manipulate the knowledge.
- The user interface must be friendly to novice users.
- The problem to be solved must be difficult and important enough to justify the development of a system.
- Knowledgeable developers with good people skills are needed.
- The impact of the ES must be considered.
- The impact should be favorable.
- Management support is needed.

22. *What is a ready-made (off-the-shelf) ES?*

Ready-made systems are sold in computer stores or via the Web to people who want to buy general expertise in a certain area. For example, the system WINE advises a user what wine is most appropriate for certain types of meals.

23. *What is a real-time ES?*

In real-time ES the conclusions (recommendations) are derived fast so a process can be impacted immediately. They are used in quality control and robotics (e.g., to correct a malfunction).

24. *What are the benefits of deploying an ES on the Web?*

The expertise is made available to a wider audience, use of a common interface, etc.

25. *How can an ES help a decision maker in Web use?*

An ES can advise a user on how to proceed in doing his/her work (Web searches, database access, etc.).

QUESTIONS FOR DISCUSSION

1. *Compare numeric and symbolic processing techniques.*

Numerical processing involves the execution of tasks on computers where numbers and mathematical relationships are in the core of the processing. For example, preparing a payroll involves the computation of wages and deductibles. Symbolic processing involves attributes and nonalgorithmic processing. For example, the "production system" discussed in this chapter is an ideal vehicle for symbolic processing, where information is stored as IF-THEN rules.

2. *Do you agree that using speech communication as the user interface could increase willingness to use expert systems. Why or why not?*

Open-ended answer. It depends on the student's experience with speech recognition technology thus far. As of early 2000, many individuals have dropped using it because of its unreliability and difficulty to train the software to individual speech patterns and dialects.

3. *It is said that powerful computers, inference capabilities, and problem-solving heuristics are necessary but not sufficient for solving real problems. Why?*

The specific knowledge is a must. Each problem requires a different approach and uses different knowledge rules.

4. *Explain how the Web improves the benefit/cost ratio of ES and enables systems that otherwise are not justifiable.*

The Web makes it easier to disseminate knowledge and its access throughout an organization. Most people have Web browsers (or can get it easily) and are networked either directly or through telephone lines. Thus it is relatively cheap to do so.

5. *Explain the relationship between the development environment and the consultation (run-time) environment.*

Even though the two environments seem to be separate, they are interrelated. Some ES allow changes in the knowledge base in the middle of a consultation. The consultation usually provides information that leads to changes and improvements in the knowledge base. These are performed in the development environment.

6. *Explain the difference between forward chaining and backward chaining and the situations where each one is more appropriate.*

Forward chaining looks at the IF part of a rule first. Once all of the conditions are met then the appropriate rule is chosen. Backward chaining starts with the conclusion, then identifies the IF

conditions necessary to make that conclusion true.

7. *What kind of mistakes might ES make and why? Why is it easier to correct mistakes in ES than in conventional programs?*

As ES mimics a human expert, it is capable of making mistakes as much as the expert does. For example, if the expert provides wrong rules, the system will make a wrong diagnosis. Also, ES frequently work with incomplete information. Therefore, they provide probabilistic advice, e.g., they are not sure about a certain interpretation or about a diagnosis. For example, the expert system identifies a certain malfunction with a certainty factor of .8. This means that the system could be incorrect 20% of the time.

In addition to using wrong rules and providing probabilistic answers, the system may ask, like a human expert, wrong questions from the user.

However, since we separate the knowledge base from the inference engine, and the knowledge is organized in a non-sequential manner (i.e., in independent rules), it is easy to correct mistakes once detected.

8. *We list 10 categories of ES applications in the chapter. Find 20 sample applications, two in each category, from the various functional areas in an organization (accounting, finance, production, marketing, HR).*

Open-ended answer. The best approach is to check out the literature.

9. *Review the limitations of ES discussed in this chapter. From what you know, which of these limitations are the most likely to still be limitations in the year 2100? Why?*

Open-ended answer. Some interesting guessing can be made, but this question can be best answered only if the students have had some education in computer science or after the next few chapters have been read. Furthermore, the answer to this question is changing continually because of technological advancements.

10. *A ready-made ES is selling for \$5,000. Developing one will cost you \$50,000. A ready-made suit will cost you \$100, and a tailored one will cost you \$500. Develop an analogy between the two situations and describe the markets for the ready-made and customized products. Why does a ready-made ES costs only 1 percent of the cost of developing one, while a ready-made suit costs 20 percent of the cost of a tailored one?*

A tailored suit will fit better. On the other hand it will be costlier, and it will take longer to make. People who buy the ready-made suit are those who need a suit quickly, or those for whom the perfect fit is not so important (or those that cannot afford expensive suits).

Ready-made expert systems can be put into use very quickly. However, there is not going to be a perfect (or sometimes even a good) fit between the system and the problem. Thus, the advice generated may be of a little value to the user. However, there are many situations for which "quick and dirty" advice is sufficient, and this is where ready-made ES will flourish. Furthermore, like humans who cannot afford tailored suits and, therefore, are forced to buy ready-made ones, organizations, too, (e.g., in developing countries, small businesses) may be better off to use some advice than not use expertise at all. These systems will start advising people on personal matters and then move to organizational advice of a general nature (such as taxes, regulations, and accounting).

11. *Given the current status of the Web, discuss how it is changing the availability of ES and how it is being used to embed expertise in other systems.*

The Web is allowing us to deploy ES directly on it, to provide expertise to users by running directly on the Web. For example, Exsys WREN is a Web Runtime Engine for Exsys (try it out). Help desk software, essentially ES, are running on the Web pages of many technical support groups. Ginesys Corp. has such software as a part of its K-Vision ES shell. Furthermore, anytime expertise is required for customer support (e.g., in advertising to help a customer choose a product to order or use), it can be provided over the Web by an ES.

EXERCISES

1. *Interview an information system manager. Determine the extent to which the company is using AI based technologies. Also, ask what the company plans for the next three-five years. Are there any problems? (List and discuss.) Prepare a two-page report on your visit.*

Open-ended answer.

2. *Explore the literature to identify the major problems in getting AI applications accepted. What is required on the part of management?*

Open-ended answer. Some problems would include: cost, executive support, or insuring users will use it.

3. *Find five applied expert systems in the recent literature (within one year) in one or several business functional areas in which you have a strong interest. Compare their purpose, complexity, knowledge representation, and the tools with which they were constructed (shells or programming languages).*

Open-ended answer. This will vary depending upon the chosen set of ES. However, there should be much in common among the ES (usually shell developed, narrow domain of knowledge, knowledge is at a sufficiently sophisticated level, there are experts in the area, etc.).

GROUP EXERCISES

1. *In-class knowledge exercise: **Make a peanut butter and jelly sandwich.** Describe all the details of what you do as you make it and have someone in the class write down all the steps. How long is the list? Did you leave anything out? Next, have a classmate attempt to make a sandwich by following the instructions explicitly as written (someone else should read the instructions aloud). Did it work? Add the missing steps to the original list. How much longer is the new list than the old one? **Would you follow the same sequence of steps if you were making 100 sandwiches instead of one?** Explain why or why not. If you were selling sandwiches, what would you do differently?*

Open-ended answer. This is a very interesting exercise. **It shows that activities involving tacit knowledge aren't so easy to document, explain, or transfer.**

2. *Internet games have become very popular. Designing a good computer game needs to use 3D graphics and artificial intelligence technologies. Search the literature to specify what AI techniques are able to make computer entertainment more exciting and challenging.*

Open-ended answer. This is an interesting exercise because students will usually pick different types of games (e.g., sports, role-playing) that will lead to different technologies being considered.

3. *Consider the decision-making situation defined by the following rules:*

- *If it is a nice day and it is summer, then I go to the golf course.*
- *If it is a nice day and it is winter, then I go to the ski resort.*
- *If it is not a nice day and it is summer, then I go to work.*
- *If it is not a nice day and it is winter, then I go to class.*
- *If I go to the golf course, then I play golf.*
- *If I go to the ski resort, then I go skiing.*
- *If I go skiing or I play golf, then I have fun.*
- *If I go to work, then I make money.*
- *If I go to class, then I learn something.*

- a. *Follow the rules for the following situations (what do you conclude for each one?):*

- *It is a nice day and it is summer.*
- *It is not a nice day and it is winter.*
- *It is a nice day and it is winter.*
- *It is not a nice day and it is summer.*

- b. *Are there any other combinations that are valid? Explain.*

- c. *What needs to happen for you to “learn something” in this knowledge universe? Start with the conclusion “learn something” and identify the rules used (backward) to get to the needed facts.*

- d. *Encode the knowledge into a graphical diagram (like an influence diagram). Use a circle to represent a fact such as:*

The day is nice

or

The day is not nice

and an arrow to indicate influence.

- e. *Write a L.C. (or other third-generation language) program to execute this knowledge. Use IF- THEN (ELSE) statements in your implementation. How many lines long is it? How hard would it be to modify the program to insert new facts and a rule such as:*

- *If it is cloudy and it is warm*
- *and it is not raining*
- *and it is summer*
- *then I go play golf.*

- f. *Implement the knowledge in a spreadsheet or database package on a PC.*

- g. *Advanced exercise. In an implementation similar to the one in part (d), write a new implementation but store the knowledge in variables. Let the program search the arrays to make decisions.*

This is a hands-on exercise.

INTERNET EXERCISES

1. *In 1995, there were about 2,000 Web sites related to AI (see Hengl, 1995). Today there are substantially more. Do a search and describe how many Web sites you find. Categorize the first 20 into groups, or if you used a search engine that grouped them, what groups did you find?*

Open-ended answer.

2. *Identify some news groups that have an interest in applied AI. Post a question regarding the use of AI technologies for decision support.*

Open-ended answer.

3. *Link yourself to several demonstrations on the Web site of Exsys (www.exsys.com). Go over the tutorials and the “try me” demos. Choose one example to describe its advantages and limitations, and comment on how to develop a better one if you are going to develop one.*

Open-ended answer. This can also be accomplished with the software CD, optionally available with this text.

4. *Access the Web site of the American Association for Artificial Intelligence (www.aaai.org). Examine the workshops it has offered over the last year and list the major topics related to intelligent systems.*

Open-ended answer. This is one of the best sources of research activities in AI.

DEBATES

1. *Computers are programmed to play chess, scrabble, and even crossword puzzles (American Scientist, September/October 1999). They are getting better and better; in fact, a computer beat the world’s number-one chess grand master, Garry Kasparov. Do you agree that such computer systems exhibit intelligence? Why or why not?*
2. *Prepare a table showing all the arrangements you can think of that justify the position that computers cannot think. Then prepare arguments that show the opposite.*
3. *Bourbaki (1990) describes Searle’s argument against use of the Turing test. Summarize all the important issues in this debate.*
4. *Proponents of AI claim that we will never have machines that truly think because they cannot, by definition, have a soul. Supporters claim a soul is unnecessary. They cite the fact that argue humanity originally set out to create an artificial bird for flight. Instead it eventually created a airplane which is not a bird, but functionally acts as one. Debate the issue.*

GROUP TERM PROJECT

1. *Find applications of artificial intelligence and expert systems. Identify an organization with which at least one member of your group has a good contact who has a decision-making problem that requires some expertise (but is not too complicated). Understand the nature of its business and identify problems that have been supported or can potentially be supported by intelligent systems. Some examples include selection of suppliers, selection of new employee, job assignments computer selection, market-contact method selection, and determining admission to graduate school.*

Open-ended answer. This is a neat term project to do when teaching an AI/ES course over a semester or quarter. This is an excellent way to pace students through the ES development process. We have found that typically a maximum of 50 rules tends to keep the system at a manageable level. Students need to start this by about week 2 of the semester and build upon it as the semester progresses.

CASE APPLICATION 10.1: GATE ASSIGNMENT DISPLAY SYSTEM

CASE QUESTIONS

1. *Why is the gate assignment task so complex?*

There are many unpredictable changes. Schedules are interrelated, the airport controls the traffic, flights arrive in clusters (to enable connections), the time an aircraft stays at a gate vary considerably. Theoretically it falls into the category described by very complex problems because of the many possible combinations that could occur.

2. *Why is the system considered a real-time ES?*

Decisions must be made in real time. Changes are frequent (especially in a bad weather). The decisions made are implemented immediately.

3. *What are the major benefits of the ES compared to the manual system?*

It is faster and easier to set up and reschedule. It provides more information. Information is more accurate (previously, magnetic displays used to fall apart), the graphics are superb. More text and colors provide much more information and details. The status of every aircraft taxiing the airport is known (and shown) in real time. It includes a built-in reminder system, which increases safety. Explanations of decisions recommended by the system are available (so training of new employees is faster). Finally, a wealth of historical data is available for planners. In addition, zone controllers use the system for enhancing activities such as fueling, baggage handling, catering services, cleaning, and crews assignment.