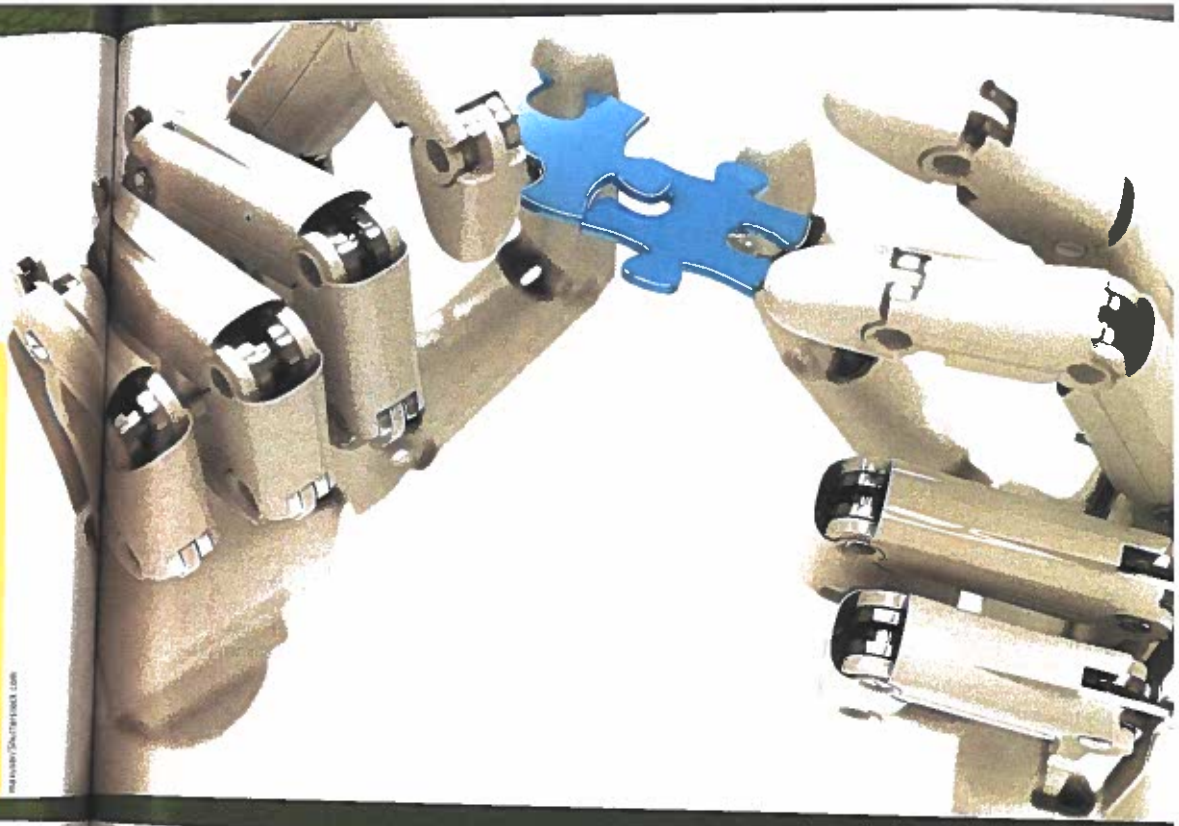
13 Intelligent Information Systems



LEARNING OUTCOMES

After studying this chapter, you should be able to:

- 13-1 Define artificial intelligence, and explain how AI technologies support decision making.
- 13-2 Describe an expert system, its applications, and its components.
- 13-3 Describe case-based reasoning.
- 13-4 Summarize the types of intelligent agents and how they are used.
- 13-5 Describe fuzzy logic and its uses.
- 13-6 Explain artificial neural networks.
- 13-7 Describe how genetic algorithms are used.
- 13-8 Explain natural-language processing and its advantages and disadvantages.
- 13-9 Summarize the advantages of integrating AI technologies into decision support systems.
- 13-10 Explain contextual computing.

After you finish this chapter, go to **PAGE 292** for the **STUDY TOOLS**

This chapter covers the use of intelligent information systems, beginning with artificial intelligence (AI). It discusses the ways AI technologies are used in decision making, with an overview of robotics as one of the earliest AI applications. Next, the chapter discusses expert systems—their components and the ways these systems are used. Case-based reasoning and intelligent agents are also discussed as applications of AI. Next, the chapter discusses fuzzy logic, artificial neural networks, genetic algorithms, and natural-language processing systems as well as the advantages of integrating AI technologies into decision support systems. Finally, it provides an overview of contextual computing.

13-1 WHAT IS ARTIFICIAL INTELLIGENCE?

Artificial intelligence (AI) consists of related technologies that try to simulate and reproduce human thought behavior, including thinking, speaking, feeling, and reasoning. AI technologies apply computers to areas that require knowledge, perception, reasoning, understanding, and cognitive abilities.[1] To achieve these capabilities, computers must be able to do the following:

- Understand common sense (see the information box on the next page).
- Understand facts and manipulate qualitative data.
- Deal with exceptions and discontinuity.
- Understand relationships between facts.
- Interact with humans in their own language.
- Deal with new situations based on previous learning.

Information systems are concerned with capturing, storing, retrieving, and working with data, but AI technologies are concerned with generating and displaying knowledge and facts. In the information systems field,

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Computers Understanding Common Sense

Humans take common sense for granted. For example, we know that fish are found in the ocean, trees and bushes are found in the woods, and people eat food. And we know that when you drop a ball, it will fall. To computers, understanding such simple things is a challenge, but this is changing.

At Carnegie Mellon University, a computer called Never Ending Image Learner runs 24 hours a day and goes through the Web finding and analyzing images in order to build a visual database that can recognize associations among these images. There are billions of images of various types on the Web; Facebook alone contains more than 200 billion images.[2]

Since it was begun in July 2013, Never Ending Image Learner has analyzed more than three million images and identified 1,500 types of objects in half a million images and 1,200 types of scenes. As a result, the computer has learned 2,500 associations by connecting the dots. For example, it knows that buildings are vertical instead of lying on their sides and that most automobiles have four wheels. As the number of analyzed images grows, the computer will learn more and will increase the number of associations. The interesting aspect of this project is that researchers are enabling a computer to teach itself common sense without any human intervention.[3]

as you have learned, programmers and systems analysts design systems that help decision makers by providing timely, relevant, accurate, and integrated information. In the AI field, knowledge engineers try to discover "rules of thumb" that enable computers to perform tasks usually handled by humans. Rules used in the AI field come from a diverse group of experts in areas such as mathematics, psychology, economics, anthropology, medicine, engineering, and physics. AI encompasses several related technologies discussed in this chapter, including robotics, expert systems, fuzzy logic systems, intelligent agents, artificial neural networks, genetic algorithms, and natural-language processing.

Although these applications and technologies may not offer true human intelligence, they are certainly more intelligent than traditional information systems. Over the years, the capabilities of these systems have improved in an attempt to close the gap between artificial intelligence and human intelligence. The following section discusses possibilities for using AI technologies in decision-making processes.

13-1a AI Technologies Supporting Decision Making

As you know, information technologies are used to support many phases of decision making. The most recent developments in AI technologies promise new areas of decision-making support. Table 13.1 lists some applications of AI-related technologies in various organizations.[4,5,6]

Decision makers use information technologies in the following types of decision-making analyses:[7]

- *What-is*—This analysis is commonly used in transaction-processing systems and management information systems. For example, if you enter a customer account number, the system displays the customer's current balance. However, these systems lack the capability to report real-time information or predict what could happen in the future. For example, reports generated by accounting information systems that show performance over the preceding fiscal quarter consist of past events, so decision makers cannot do much with this information.

Information systems are concerned with capturing, storing, retrieving, and working with data, but AI technologies are concerned with generating and displaying knowledge and facts.

TABLE 13.1 APPLICATIONS OF AI TECHNOLOGIES

Field	Organization	Applications
Energy	Arco and Tenneco Oil Company	Neural networks used to help pinpoint oil and gas deposits
Government	Internal Revenue Service	Software used to read tax returns and spot fraud
Human services	Merced County, California	Expert systems used to decide if applicants should receive welfare benefits
Marketing	Spiegel	Neural networks used to determine most likely buyers from a long list
Telecommunications	BT Group	Heuristic search used for a scheduling application that provides work schedules for more than 20,000 engineers
Transportation	American Airlines	Expert systems used to schedule the routine maintenance of airplanes
Inventory/forecasting	Hyundai Motors	Neural networks and expert systems used to reduce delivery time by 20 percent and increase inventory turnover from 3 to 3.4
Inventory/forecasting	SCI Systems	Neural networks and expert systems used to reduce on-hand inventory by 15 percent, resulting in $180 million in annual savings
Inventory/forecasting	Reynolds Aluminum	Neural networks and expert systems used to reduce forecasting errors by 2 percent, resulting in an inventory reduction of 1 million pounds
Inventory/forecasting	Unilever	Neural networks and expert systems used to reduce forecasting errors from 40 percent to 25 percent, resulting in a multimillion-dollar savings

- *What-if*—This analysis is used in decision support systems. Decision makers use it to monitor the effect of a change in one or more variables. It is available in spreadsheet programs, such as Microsoft Excel.

In addition to these types of analysis, decision makers often need to answer the following questions about information: Why? What does it mean? What should be done? When should it be done? AI technologies have the potential to help decision makers address these questions.

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13-1b Robotics

Robots are one of the most successful applications of AI. You are probably familiar with robots used in factories or ones you have seen on the news. They are far from being intelligent, but progress has been steady. They perform well at simple, repetitive tasks and can be used to free workers from tedious or hazardous jobs. Robots are currently used mainly on assembly lines in Japan and the United States as part of computer-integrated manufacturing, but they are also used in the military, aerospace, and medical industries as well as for performing such services as delivering mail to employees.

The cost of industrial robots ranges from $100,000 to $250,000 or more. Typically, their mobility is limited. For example, they might have only a fixed arm that moves objects from one point to another. Some robots have limited vision that is useful for locating and picking up objects, as long as the objects are isolated from other objects. A robot's operation is controlled by a computer program that includes commands such as when and how far to reach, which direction to go or turn, when to grasp an object, and how much pressure to apply. Programming languages for controlling robots include Variable Assembly Language (VAL), Functional Robotics (FROB), and A Manufacturing Language (AML). These languages are usually proprietary, meaning they are specific to individual robot manufacturers.

One of the most advanced and most popular robots is Honda's Advanced Step in Innovative Mobility (ASIMO) (*http://world.honda.com/ASIMO*). Honda's intelligence

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NLP IN ACTION: THE HEALTHCARE INDUSTRY

The healthcare industry could significantly benefit from various NLP applications. NLP systems could reduce administrative healthcare costs and improve the accuracy of data. Below are a few examples:

- An NLP-based clinical decision support: As an example, the system can be used to set up colonoscopy follow-up for patients. The system can extract relevant text from various files and then set a follow-up for the patient.
- Automated dictation system: A doctor can read his/her diagnostic of a patient or an X-ray, and the NLP system generates a Word document to be sent to the patient or other doctors.
- Text summarization: An NLP-based system can extract clinical information from multiple reports and generate a single document for a doctor's review.
- Clinical data and virtual administrative assistant: An NLP-based system could accommodate such requests as scheduling an office visit or paying any outstanding medical bills.
- Real-time translation services: An NLP-based system can provide real-time translation with a high degree of accuracy for patients and clinicians, similar to those services offered by companies such as Google and Microsoft.

13-9 INTEGRATING AI TECHNOLOGIES INTO DECISION SUPPORT SYSTEMS

AI-related technologies, such as expert systems, natural-language processing, and artificial neural networks, can improve the quality of decision support systems (DSSs). They can add explanation capabilities (by integrating expert systems) and learning capabilities (by integrating ANNs) and create an interface that is easier to use (by integrating an NLP system). These systems are sometimes called integrated (or intelligent) DSSs (IDSSs), and the result is a more efficient, powerful DSS.[38,39] AI technologies, particularly expert systems and natural-language processing, can be integrated into the database, model base, and user interface components of a DSS.

The benefits of integrating an expert system into the database component of a DSS are:[40]

- Adding deductive reasoning to traditional DBMS functions
- Improving access speed
- Improving the creation and maintenance of databases
- Adding the capability to handle uncertainty and fuzzy data
- Simplifying query operations with heuristic search algorithms

Similarly, you can add AI technologies to a DSS's model base component. For example, expert systems can be added to provide reasons and explanations for output from the model base, to include heuristics in the model base's analysis capabilities, to incorporate fuzzy sets in the model-building process, to reduce the time and cost of calculating data for models, and to select the best model for the problem.[41]

In addition, integrating expert system capabilities into the user interface component can improve the quality and user friendliness of a DSS. This integration can add features such as an explanation capability (explaining responses in more nontechnical terms). Integrating NLP can improve the effectiveness of an interface, too, by making it easier to use, particularly for decision makers who are not computer savvy.

13-10 CONTEXTUAL COMPUTING: MAKING MOBILE DEVICES SMARTER

We have been using GPSs on our smartphones for years. A GPS system delivers location-based services—for example, telling you which street to take when you're traveling from the eastern part of a city to the western part in order to arrive at a particular place. This is a great service for somebody who is not familiar with a city. Applications such as Apple's Siri and Google Now carry this idea a bit further. For example, Google Now uses information it has about a particular user to offer, say, weather forecasts, street directions, or sports scores for games that the user is interested in. It provides such information based on a user's previous behavior and the user's current location.

Another example of context-aware software is Microsoft's MoodScope, which is able to sense a user's mood. By analyzing phone calls, text messages, Internet access, and other smartphone activities, this "mood sensor" app is able to predict the mood of a user. Although this application is in development stages, it showed 93 percent accuracy in a small sample size of 32 users in China and the United States. These kinds of applications could have significant commercial value. For example, a user's mood could be shared with Spotify (the commercial music streaming service) to play a special song, or sent to a user's Facebook timeline in order to encourage or discourage other types of communication. It could also be shared with an online Web site that could target the user with comfort food. However, such applications must be used carefully in order not to invade a user's privacy.[43,44]

Contextual computing is expected to carry this idea much further still. For example, your smartphone may soon be able to predict with 80 percent probability that you will receive a job offer if you go to a particular job fair, based on information you have included on your various social media sites. For another example, what if you wanted to know the chances that you and your girlfriend will get married? Qualcomm, the chip maker for smartphones and other computing devices, has launched a line of Brain-Inspired Zeroth Processors to expedite contextual computing. According to the company, this line of software tools and technologies enables handheld devices to learn as they receive feedback from their environment.[45]

Humans make decisions based on what they know and how they feel about something, drawing on experiences they have accumulated throughout their lives. For example, in a dark alley, when you hear a noise, you may quickly change directions. Alternatively, if you see a friend who looks sad, you ask them if there is something wrong. These scenarios would be difficult for computers to understand and perform a role in, but it is what contextual computing is designed to achieve.

Sometimes referred to as our sixth, seventh, and eighth senses, **contextual computing** refers to a computing environment that is always present, can feel our surroundings, and—based on who we are, where we are, and whom we are with—offer recommendations.[46]

The principle behind contextual computing is that computers can both sense and react to their environments similar to how human brains understand and interpret stimuli.[47] In essence, contextual computing allows for tailoring a course of action to a user in a particular situation and environment based on what it knows about the user. To achieve this, many of the information technologies discussed in this textbook may be used, including computer networks, software, hardware, database systems, and AI technologies.

The Industry Connection highlights Alyuda Research Company, a leading developer of neural network and trading software for business and personal use.

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Industry Connection: Alyuda Research[42]

Alyuda Research is a major developer of neural networks and trading software for businesses and individuals. Its products and services include the following:

Tradecision: Provides tools to help investors and brokers make better decisions, such as advanced charting and automated trading. Includes modules for model building, strategies, alerts, simulations, and data analysis.

Scorto Credit Decision: Offers several methods for developing models for credit scoring, such as decision trees, neural networks, and fuzzy logic, and includes software for loan portfolio analysis.

NeuroIntelligence: Used to analyze and process data sets; find the best neural network architecture; train, test, and optimize a neural network; and apply the network to new data sets.

NEURAL NETWORKS IN MICROSOFT AND THE CHICAGO POLICE DEPARTMENT

Microsoft is using neural network software to maximize the returns on direct mail. Each year, Microsoft sends out approximately 40 million pieces of direct mail to 8.5 million registered customers. The goal of these mailings is to encourage customers to upgrade their software or buy other Microsoft products. The first mailing goes out to all the customers in the company's database. The second mailing goes out only to those customers who are most likely to respond, and neural network software is used to cull the latter from the former. According to Microsoft spokesman Jim Minervino, the neural network software BrainMaker has increased the rate of response from 4.9 percent to 8.2 percent. This has resulted in a significant savings for the company—the same revenue at 35 percent less cost.[32]

The Chicago Police Department has used neural network software to predict which police officers are likely to engage in misconduct. Here, BrainMaker has compared the conduct of current officers with the conduct of those who have previously been terminated for disciplinary reasons, and this has produced a list of officers that might be "at risk."[33]

Several other real-life applications of neural networks are posted at *www.calsci.com/BrainIndex.html*.

where learning takes place. If you are using an ANN for approving loans in a bank, the middle layer is trained by using past data (from old loan applications, in which the decisions are known) that includes both accepted and rejected applications. Based on the pattern of data entered in the input layer—applicant's information, loan amount, credit rating, and so on—and the results in the output layer (the accept or reject decision), nodes in the middle layer are assigned different weights. These weights determine how the nodes react to a new set of input data and mimic decisions based on what they have learned. Every ANN has to be trained, and when organizational policies change, the network needs to be retrained so it can mimic the new policies.

ANNs are used for many tasks, including the following:

- Bankruptcy prediction
- Credit rating
- Investment analysis
- Oil and gas exploration
- Target marketing

The information box above discusses real-life applications of neural networks.

Genetic algorithms (GAs) are search algorithms that mimic the process of natural evolution. They are used to generate solutions to optimization and search problems using such techniques as mutation, selection, crossover, and chromosome.

13-7 GENETIC ALGORITHMS

Although they are not as widely accepted, **genetic algorithms (GAs)** have become more recognized as a form of artificial intelligence. They are used mostly to find solutions to optimization and search problems. John Holland developed genetic algorithms in the 1940s at MIT, and the term applies to adaptive procedures in a computer system that are based on Darwin's ideas about natural selection and survival of the fittest.[34]

Genetic algorithms are used for optimization problems that deal with many input variables, such as jet engine design, portfolio development, and network design. They find the combination of inputs that generates the most desirable outputs, such as the stock portfolio with the highest return or the network configuration with the lowest cost. Genetic algorithms can examine complex problems without any assumptions of what the correct solution should be. In a GA system, the following techniques are used:

- *Selection or survival of the fittest*—Gives preference or a higher weight to better outcomes.
- *Crossover*—Combines good portions of different outcomes to achieve a better outcome.
- *Mutation*—Tries combinations of different inputs randomly and evaluates the results.
- *Chromosome*—A set of parameters that defines a proposed solution to the problem the GA is trying to solve. It is usually represented as a simple string (sequence of characters).

Genetic algorithms are already used with neural networks and fuzzy logic systems to solve scheduling, engineering design, and marketing problems, among others. For example, a docking algorithm uses a neural network and fuzzy functions with a GA to find the best and shortest route for a robot to take to a docking bay.[35] In addition, researchers at General Electric and the Rensselaer Polytechnic Institute have used a GA to design a jet engine turbine in one-fourth the time it took to develop a model manually. It improved the design by 50 percent and better kept up with the many variables involved than an expert system did.[36]

Some hybrid products that combine AI technologies use GAs—for example, GeneHunter (*www.wardsystems.com/genehunter.asp*) and NeuroDimension (*www.nd.com/genetic*). You can find more information on the uses of GAs in robotics, telecommunications, computer games, and other fields at *http://brainz.org/15-real-world-applications-genetic-algorithms*.

13-8 NATURAL-LANGUAGE PROCESSING

Despite constant efforts to make information systems user friendly, they still require a certain degree of computer literacy and skills. As mentioned in Chapter 2, **natural-language processing (NLP)** was developed so users could communicate with computers in human language. Although GUI elements, such as menus and icons, have helped with communication problems between humans and computers, GUIs still involve some training, can be cumbersome to use, and often differ depending on the OS or application. An NLP system provides a question-and-answer setting that is more natural and easier for people to use. It is particularly useful with databases. Table 13.2 lists some currently available NLP systems.

TABLE 13.2 NLP SYSTEMS

NLP System	Use
Nuance Communications Dragon Speech Recognition Software (*www.nuance.com/naturallyspeaking*)	Business data retrieval, legal document processing, medical and ER applications, professional dictation systems
AT&T Natural VoicesWizzard Speech (*www.wizzardsoftware.com/att_nv_landing.php*)	Creates speech from computer-readable text
e-Speaking (*www.e-speaking.com*)	Voice and speech recognition for Windows

At the time of this writing, these products are not capable of a dialogue that compares with conversations between humans. The size and complexity of the human language has made developing NLP systems difficult. However, progress has been steady, and NLP systems for tasks such as call routing, stock and bond trading, and banking by phone, among others, are already available.

NLP systems are generally divided into the following categories:[37]

- Interface to databases
- Machine translation, such as translating from French to English
- Text scanning and intelligent indexing programs for summarizing large amounts of text
- Generating text for automated production of standard documents
- Speech systems for voice interaction with computers

NLP systems usually perform two types of activities. The first is interfacing: accepting human language as input, carrying out the corresponding command, and generating the necessary output. The second is knowledge acquisition: using the computer to read large amounts of text and understand the information well enough to summarize important points and store information so the system can respond to inquiries about the content. The information box on the next page highlights several real life applications of NLP systems in the healthcare industry.

Natural-language processing (NLP) was developed so users could communicate with computers in human language.

degree of membership. A degree of membership shows how relevant an item or object is to a set. A higher number indicates it is more relevant, and a lower number shows it is less. For example, when heating water, as the temperature changes from 50°C to 75°C, you might say the water is warm. What about when the water's temperature reaches 85°C? You can describe it as warmer, but at what point do you describe the water as hot? Describing varying degrees of warmness and assigning them membership in certain categories of warmness involves a lot of vagueness.

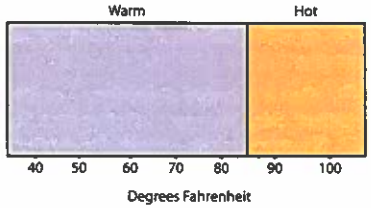
Fuzzy logic is designed to help computers simulate vagueness and uncertainty in common situations. Lotfi A. Zadeh developed the fuzzy logic theory in the mid-1960s by using a mathematical method called "fuzzy sets" for handling imprecise or subjective information.[27] Fuzzy logic allows computers to reason in a fashion similar to humans and makes it possible to use approximations and vague data yet produce clear and definable answers.

Fuzzy logic works based on the degree of membership in a set (a collection of objects). For example, 4 feet, 5 feet, and 6 feet could constitute a set of heights for a population. Fuzzy sets have values between 0 and 1, indicating the degree to which an element has membership in the set. At 0, the element has no membership; at 1, it has full membership.

In a conventional set (sometimes called a "crisp" set), membership is defined in a black-or-white fashion; there's no room for gray. For instance, if 90 percent or higher means a "Pass" grade in a course, getting 89.99 percent does not give you membership in the "Pass" area of this crisp set. Therefore, despite getting 89.99 percent, you have failed the course. In this example, there is a very small difference between the two grades (0.01), but it means the difference between passing and failing. In other words, a small difference has a huge impact. This does not happen in a fuzzy logic environment. To help you understand the membership function better, Exhibit 13.2 shows an example of a conventional set. In this example, 84.9°F is considered warm and 85.1°F is considered hot. This small change in temperature can cause a large response in the system.

Exhibit 13.3 shows the same set but with fuzzy logic conventions. For example, 80°F has a membership of 30 percent in the fuzzy set "Warm" and 40 percent in the fuzzy set "Hot." All temperatures from 40° to 100°F make up the membership set.

Exhibit 13.2
Example of a conventional set

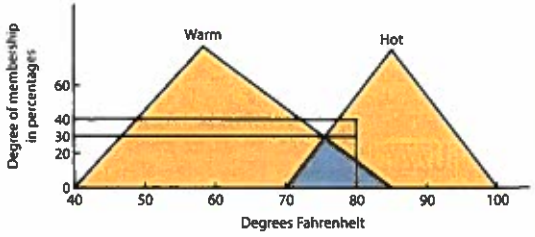


13-5a Uses of Fuzzy Logic

Fuzzy logic has been used in search engines, chip design, database management systems, software development, and other areas.[28] You might be more familiar with its uses in appliances, as shown in the following examples:

- Dryers that convert information on load size, fabric type, and flow of hot air into drying times and conditions
- Refrigerators that set defrosting and cooling times based on usage patterns
- Shower systems that suppress variations in water temperature

Exhibit 13.3
Degree of membership in a fuzzy system



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- TVs that adjust screen color and texture for each frame and stabilize the volume based on the viewer's location in the room
- Video camcorders that eliminate shakiness in images (common with handheld video cameras) and adjust focus and lighting automatically[29,30]

The information box below highlights how the Department of Defense uses fuzzy logic.

13-6 ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANNs) are networks that learn and are capable of performing tasks that are difficult with conventional computers, such as playing chess, recognizing patterns in faces and objects, and filtering spam e-mail. Like expert systems, ANNs are used for poorly structured problems—when data is fuzzy and uncertainty is involved. Unlike an expert system, an ANN cannot supply an explanation for the solution it finds because an ANN uses patterns instead of the if-then-else rules that expert systems use.

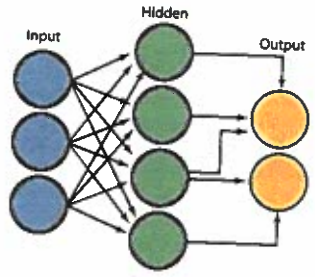
An ANN creates a model based on input and output. For example, in a loan application problem, input data consists of income, assets, number of dependents, job history, and residential status. The output data is acceptance or rejection of the loan application. After processing many loan applications, an ANN can establish a pattern that determines whether an application should be approved or rejected.

As shown in Exhibit 13.4, an ANN has an output layer, an input layer, and a middle (hidden) layer

FUZZY LOGIC IN ACTION

In addition to its increasing use in household appliances, fuzzy logic is being applied to multicriteria decision-making processes in which there is no exact data available. Today, most new cars let you know when it is time to change the oil based not on the traditional notion of doing it every 3,000 miles but on engine speed and the particular distance traveled. Likewise, the U.S. Department of Defense uses fuzzy logic to solve complex problems in such areas as assessing the cost and benefit of individual weapon systems and evaluating alternative weapons development strategies (e.g., spending more money on ground weapons than on air defense). Using qualitative as well as quantitative data, a panel of subject-matter experts combines linguistics, rule-based decision support, and maps.[31]

Exhibit 13.4
Artificial neural network configuration



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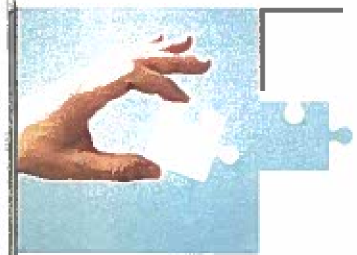


Intelligent agents can collect information about customers, such as items purchased, demographic information, and expressed and implied preferences.

information to better market their products and services to customers. Other agents, called product-brokering agents, can alert customers to new products and services. Amazon has used these agents successfully.

Intelligent agents are also used for smart or interactive catalogs, called "virtual catalogs." A virtual catalog displays product descriptions based on customers' previous experiences and preferences.

Intelligent agents that are currently available fall into these categories:

- Shopping and information agents
- Personal agents
- Data-mining agents
- Monitoring and surveillance agents

These are discussed in the following sections.

13-4a Shopping and Information Agents

Shopping and information agents help users navigate through the vast resources available on the Web and provide better results in finding information. These agents can navigate the Web much faster than humans and gather more consistent, detailed information. They can serve as search engines, site reminders, or personal surfing assistants. Pricewatch (*www.pricewatch.com*) is a commercial shopping agent that finds the lowest price for many items and displays all competitive prices. Another example is BestBookBuys (*www.bestbookbuys.com*), which asks you to identify a book by its title, author, or ISBN, then finds all the online booksellers that carry this book and organizes them into a list from least expensive to most expensive. Another comparison-shopping agent is available at *www.mysimon.com*.

Usenet and newsgroup agents have sorting and filtering features for finding information. For example, DogPile (*www.dogpile.com*) searches the Web by using several search engines, including Google, Yahoo!, and Yandex, to find information for users. DogPile can remove duplicate results and analyze the results to sort them with the most relevant results at the top.

Shopping and information agents help users navigate through the vast resources available on the Web and provide better results in finding information. These agents can navigate the Web much faster than humans and gather more consistent, detailed information. They can serve as search engines, site reminders, or personal surfing assistants.

Personal agents perform specific tasks for a user, such as remembering information for filling out Web forms or completing e-mail addresses after the first few characters are typed.

Data-mining agents work with a data warehouse, detecting trends and discovering new information and relationships among data items that were not readily apparent.

13-4b Personal Agents

Personal agents perform specific tasks for a user, such as remembering information for filling out Web forms or completing e-mail addresses after the first few characters are typed. An e-mail personal agent can usually perform the following tasks:

- Generate auto-response messages.
- Forward incoming messages.
- Create e-mail replies based on the content of incoming messages.

13-4c Data-Mining Agents

Data-mining agents work with a data warehouse, detecting trends and discovering new information and relationships among data items that were not readily apparent. Volkswagen Group uses a data-mining agent that acts as an early-warning system about market conditions. For example, the data-mining agent might detect a problem that could cause economic conditions to worsen, resulting in delayed payments from customers. Having this information early enables decision makers to come up with a solution that minimizes the negative effects of the problem.

INTELLIGENT AGENTS IN ACTION

Intelligent agents cost approximately 2 percent of what a live human assistant costs.

Here are some examples of intelligent agents in real-life practice:

- SFR, which is a division of Vodafone, a mobile communications company, uses a virtual agent to facilitate 750,000 conversations a month. The intelligent agent answers customers' questions about their accounts and about the company's services and offerings.[17]
- The French division of eBay uses an intelligent agent named Louise to assist in over 200,000 customer conversations a day throughout six countries. According to eBay, Louise performs its assigned tasks with an 88 percent problem-solving rate. Currently, it handles 30 percent of the client contact for eBay.fr.[18]
- Apple uses an intelligent agent named Siri on its iPhone, iPad, and iPod Touch devices: Siri allows the user's voice to send messages, make calls, set reminders, and much more.[19]
- IBM Watson is being marketed as an intelligent agent. For a fee, it can be used at call centers, in the medical field, in insurance companies, and much more.[20,21]
- IntelliResponse offers an intelligent agent that is used by banks, airlines, and telecommunications companies to answer customers' questions and provide other relevant information about products and services directly from the company's Web site.[22]
- Microsoft's Cortana, a voice-enabled assistant, is able to set reminders, recognize natural voices, and answer questions such as current weather and traffic conditions and sports scores.[23]
- Viv (Viv Labs) is an intelligent assistant with AI capabilities that is able to answer a number of queries for the users and becomes smarter as it is being used. It is expected to work with a diverse group of Internet-connected devices, helping to power a million different apps.[24]
- Amazon Echo is an intelligent assistant that helps you to put items in a shopping cart and eventually order a product for you. Using this software, Amazon's 1 Click becomes no click.[25]

13-4d Monitoring and Surveillance Agents

Monitoring and surveillance agents usually track and report on computer equipment and network systems to predict when a system crash or failure might occur. NASA's Jet Propulsion Laboratory has an agent that monitors inventory, planning, and the scheduling of equipment to keep costs down.[26]

The information box above highlights real-life applications of several commercial intelligent agents.

13-5 FUZZY LOGIC

Have you ever been given a questionnaire that asks ambiguous questions but expects yes or no responses? Although you might be tempted to use words such as *usually*, *sometimes*, *only if*, and the like, you know the software used to analyze responses simply cannot deal with anything but clear-cut yes and no responses. However, with the development of fuzzy logic, a wide variety of responses is possible in questionnaires and other survey tools. **Fuzzy logic** allows a smooth, gradual transition between human and computer vocabularies and deals with variations in linguistic terms by using a

Monitoring and surveillance agents usually track and report on computer equipment and network systems to predict when a system crash or failure might occur.

Fuzzy logic allows a smooth, gradual transition between human and computer vocabularies and deals with variations in linguistic terms by using a degree of membership.

EXPERT SYSTEMS IN BALTIMORE COUNTY POLICE DEPARTMENT

In Baltimore County, an expert system was developed so detectives could analyze information about burglary sites and identify possible suspects. Data entered in the system included information about known burglars, records of 300 solved burglary cases, and records of 3,000 unsolved cases. Then, 18 detectives were interviewed to gather their knowledge about local burglaries. Detectives could enter statements about burglaries, such as neighborhood characteristics, the type of property stolen, and the type of entry used; they could also get information on possible suspects. The system is now used in other police departments in the United States.[14]

Service, Department of Transportation, Department of Energy, and Department of Defense in decision-making processes.

- *Agriculture*—The National Institute of Agricultural Extension Management has designed an expert system to diagnose pests and diseases in rice crops and suggest preventive measures.[15]

The information box above highlights a real-life application of an expert system, this one in burglary and crime detection. The system reduced the time and expenses involved in police operations.

13-2c Criteria for Using Expert Systems

An expert system should be used if one or more of the following conditions exists:

- A lot of human expertise is needed but a single expert cannot tackle the problem on his or her own. (An expert system can integrate the experience and knowledge of several experts more easily.)
- The knowledge that is needed can be represented as rules or heuristics; a well-defined algorithm is not available.
- The decision or task has already been handled successfully by human experts, allowing the expert system to mimic human expertise.
- The decision or task requires consistency and standardization. (Because computers are more accurate at following standard procedures, an expert system can be preferable to humans in this situation.)
- The subject domain is limited. (Expert systems work better if the problem under investigation is narrow.)
- The decision or task involves many rules (typically between 100 and 10,000) and complex logic.
- There is a scarcity of experts in the organization, or key experts are retiring. (An expert system can be used to capture the knowledge and expertise of a long-time employee who is retiring.)

13-2d Criteria for Not Using Expert Systems

The following situations are unsuitable to expert systems:

- There are very few rules (less than 10) involved. Human experts are more effective at solving these problems.
- There are too many rules (usually more than 10,000) involved. Processing slows to unacceptable levels.
- There are well-structured numerical problems (such as payroll processing) involved, which means that standard transaction-processing methods can handle the situation more quickly and economically.
- A broad range of topics is involved, but there are not many rules. Expert systems work better when there are deep and narrow problem areas.
- There is a lot of disagreement among experts.
- The problems require human experts—for example, a combination of the five senses, such as taste and smell. Selecting a perfume is a problem better solved by human experts.

13-2e Advantages of Expert Systems

An expert system can have the following advantages over humans:

- It never becomes distracted, forgetful, or tired. Therefore, it is particularly suitable for monotonous tasks that human workers might object to.
- It duplicates and preserves the expertise of scarce experts and can incorporate the expertise of many experts.
- It preserves the expertise of employees who are retiring or leaving an organization.
- It creates consistency in decision making and improves the decision-making skills of nonexperts.

13-3 CASE-BASED REASONING

Expert systems solve a problem by going through a series of if-then-else rules, but **case-based reasoning (CBR)** is a problem-solving technique that matches a new case (problem) with a previously solved case and its solution, both stored in a database. Each case in the database is stored with a description and keywords that identify it. If there is no exact match between the new case and cases stored in the database, the system can query the user for clarification or more information. After finding a match, the CBR system offers a solution; if no match is found, even after supplying more information, the human expert must solve the problem. The new case and its solution are then added to the database.

In design and implementation of any case-based reasoning application there are 4 Rs involved: retrieve, reuse, revise, and retain.

1. To solve the current case (problem) the system compares it with the cases stored in the database and retrieves the most similar case from the library of the past cases.
2. The retrieved case is reused to solve the current problem.
3. The retrieved case is revised if necessary for further enhancement.
4. The final solution is retained as a part of the library for future use.

Hewlett-Packard uses CBR to assist users of its printers; this system performs the role of a help desk operator. Users' complaints and difficulties over the past several years have been stored in a database as cases and solutions. This information is used in dealing with new users, who likely have the same problems as users in the past. In the long term, these systems can improve customer service and save money by reducing the number of help desk employees.

As another example, some banks use a CBR system to qualify customers for loans, using parameters from past customers stored in a database. These parameters include gross income, number of dependents, total assets, net worth, and amount requested for the loan. The database also stores the final decision on each application (acceptance or rejection). When a new customer applies for a loan, the CBR system can compare the application with past applications and provide a response. The new application and its outcome then become part of the database for future use.

13-4 INTELLIGENT AGENTS

Intelligent agents, also known as bots (short for robots), are software capable of reasoning and following rule-based processes; they are becoming more popular, especially in e-commerce. They are also called virtual agents (VAs) or intelligent virtual agents (IVAs). A sophisticated intelligent agent has the following characteristics:[16]

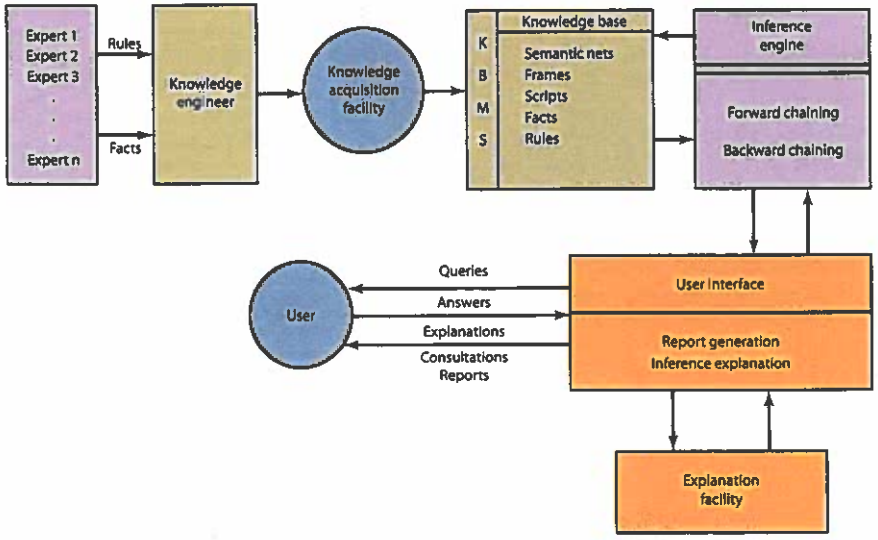
- *Adaptability*—Able to learn from previous knowledge and go beyond information given previously. In other words, the system can make adjustments.
- *Autonomy*—Able to operate with minimum input. The system can respond to environmental stimuli, make a decision without users telling it to do so, and take preemptive action, if needed.
- *Collaborative behavior*—Able to work and cooperate with other agents to achieve a common objective.
- *Humanlike interface*—Able to interact with users in a more natural language.
- *Mobility*—Able to migrate from one platform to another with a minimum of human intervention.
- *Reactivity*—Able to select problems or situations that need attention and act on them. An agent with this capability typically responds to environmental stimuli.

Most intelligent agents today fall short of these capabilities, but improvement is expected in the near future. One important application of intelligent agents that is already available is Web marketing. Intelligent agents can collect information about customers, such as items purchased, demographic information, and expressed and implied preferences. E-commerce sites then use this

Case-based reasoning (CBR) is a problem-solving technique that matches a new case (problem) with a previously solved case and its solution, both stored in a database. After searching for a match, the CBR system offers a solution; if no match is found, even after supplying more information, the human expert must solve the problem.

Intelligent agents are software capable of reasoning and following rule-based processes; they are becoming more popular, especially in e-commerce.

Exhibit 13.1
An expert system configuration



- *User interface*—This is the same as the user interface component of a decision support system. It provides user-friendly access to the expert system. Although GUIs have improved this component, one goal of AI technology is to provide a natural language (discussed later in the chapter) for the user interface.
- *Explanation facility*—An **explanation facility** performs tasks similar to what a human expert does by explaining to end users how recommendations are derived. For example, in a loan evaluation expert system, the explanation facility states why an applicant was approved or rejected. In a medical expert system, it explains why the system concluded that a patient has a kidney stone, for instance. This component is important because it helps give users confidence in the system's results.
- *Inference engine*—An **inference engine** is similar to the model base component of a decision support system (discussed in Chapter 12). By using different techniques, such as forward and backward chaining (discussed in the following paragraphs), an inference engine manipulates a series of rules. Some inference engines work from a matrix of facts that includes several rows of conditions and rules, similar to a decision table. In this case, rules are evaluated one at a time, then advice is provided. Some inference engines also learn from doing.

In **forward chaining**, a series of "if-then-else" condition pairs is performed. The "if" condition is evaluated first, then the corresponding "then-else" action is carried out. For example, "if" the temperature is less than 80°F and the grass is 3 inches long, "then" cut the grass or "else" wait. In a medical diagnostic expert system, the system could evaluate a problem as follows:

- If the patient's temperature is over 101°F and
- If the patient has a headache
- Then it's very likely (a 95 percent chance) that the patient has the flu, or else search for other diseases.

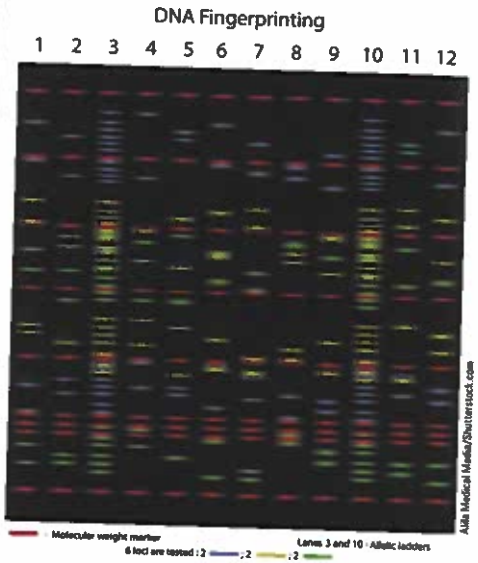
In **backward chaining**, the expert system starts with the goal—the "then" part—and backtracks to find the right solution. In other words, to achieve this goal, what conditions must be met? To understand the differences between these two techniques, consider the following example. In an expert system that provides financial investment advice for investors, the system might use forward chaining and ask 50 questions to determine which of five investment categories—oil-gas, bonds, common stocks, public utilities, and transportation—is more suitable for an investor.[12] In addition, each investor is in a specific tax bracket, and each investment solution provides a different tax shelter. In forward chaining, the system evaluates all the "if-then-else" conditions before making the final recommendation. In backward chaining, the system might start with the public utilities category, specified by the investor, and go through all the "if" conditions to see whether this investor qualifies for this investment category. The backward chaining technique can be faster in some situations because it does not have to consider irrelevant rules, but the solution the system recommends might not be the best one.

Other techniques are used for representing knowledge in the expert system's knowledge base, such as semantic (associative) networks that represent information as links and nodes, frames that store conditions or objects in hierarchical order, and scripts that describe a sequence of events. For a child's birthday party, for example, events might include buying a cake, inviting friends, lighting the candles, and serving the cake. A script for generating a purchase order might include events such as identifying the quantity to order, identifying the supplier and gathering data, generating the purchase order and sending it to the supplier, updating accounts payable, and informing the receiving department that an order has been placed.

13-2b Uses of Expert Systems

Many companies are engaged in research and development of expert systems, and these systems are now used in areas such as the following:

- *Airline industry*—American Airlines developed an expert system to manage frequent flier transactions.
- *Forensics lab work*—Expert systems are used to review DNA samples from crime scenes and generate results quickly and accurately, helping reduce the backlog in labs and get data entered in national crime databases faster.[13]



- *Banking and finance*—JPMorgan Chase developed a foreign currency trade expert system to assess historical trends, new events, and buying and selling factors.
- *Education*—Arizona State University developed an expert system to teach math and evaluate students' math skills.
- *Food industry*—Campbell's Soup Company developed an expert system to capture expertise that a highly specialized, long-time employee had about plant operations and sterilizing techniques.
- *Personnel management*—IBM developed an expert system to assist in training technicians; it has reduced training time.
- *Security*—Canada Trust Bank (now part of TD Canada Trust) developed an expert system to track credit card holders' purchasing trends and report deviations, such as unusual activity on a card.
- *U.S. government*—Expert systems have been developed to monitor nuclear power plants and assist departments such as the IRS, INS, U.S. Postal

An **explanation facility** performs tasks similar to what a human expert does by explaining to end users how recommendations are derived.

An **inference engine** is similar to the model base component of a decision support system. By using different techniques, such as forward and backward chaining, it manipulates a series of rules.

In **forward chaining**, a series of "if-then-else" condition pairs is performed.

In **backward chaining**, the expert system starts with the goal—the "then" part—and backtracks to find the right solution.

technologies enable ASIMO to coordinate with other robots. It recognizes moving objects, sound, gestures, multiple environments, faces, and postures. ASIMO is also able to choose between stepping back and yielding the right-of-way or continuing to move forward based on the predicted movement of oncoming people. It is able to automatically recharge its battery when the charge falls below a certain level.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Personal robots have attracted a lot of attention recently. These robots have limited mobility, limited vision, and some speech capabilities. Currently, they are used mostly as prototypes to test such services as helping the elderly, bringing breakfast to the table, cooking, opening doors, and carrying trays and drinks. Examples include Twendy-One, Motoman, ApriAttenda Robot, and PR2. One of the most successful and advanced personal robots on the market today, PR2 performs many ordinary tasks around the home and office.

Robots offer the following advantages over humans in the workplace:

- They do not fall in love with coworkers, get insulted, or call in sick.
- They are consistent.
- They can be used in environments that are hazardous to humans, such as working with radioactive materials.
- They do not spy for competitors, ask for a raise, or lobby for longer breaks.

MEDICAL ROBOTICS IN ACTION

Robots have been used in the medical field for two decades. They have been used to train medical personnel (doctors, dentists, and nurses), they have assisted elderly patients during rehabilitation, and they have allowed surgeons to make smaller incisions for certain types of surgery. In addition, they have been used during the training process as dummies to mimic a live patient's feelings of pain.[8]

At 5 feet, 4 inches, and 140 pounds, the RP-VITA (Remote Presence Virtual + Independent Telemedicine Assistant) by iRobot Corporation is the first robot to receive FDA clearance for use in hospitals.[9]


Source: iRobot Corporation

To make the robot resemble humans as closely as possible, it has a video screen for a head, a microphone and speaker for a mouth, and two high-definition cameras for eyes. One of its functions is to assist doctors in making hospital rounds remotely. Controllable by a tablet computer using a wired or wireless network, it is able to move around and is intelligent enough to avoid obstacles.

RP-VITA does not offer medical advice, nor does it treat patients. Instead, it is used by doctors and nurses to communicate with their patients. It can also be used with InTouch Health's cloud service to provide doctors and nurses with real-time electronic medical record information. The robot is also able to connect with diagnostic devices such as otoscopes for examining the inside of the ears; it can also perform an ultrasound.[10]

Developments in AI-related fields, such as expert systems and natural-language processing, will affect the future development of the robotics industry. For example, natural-language processing will make it easier to communicate with robots in human languages. The information box on the previous page highlights an application of robotics in the medical field.

13-2 EXPERT SYSTEMS

Expert systems have been one of the most successful AI-related technologies and have been around since the 1960s. They mimic human expertise in a particular field to solve a problem in a well-defined area. For the purposes of this book, an expert system consists of programs that mimic human thought behavior in a specific area that human experts have solved successfully. The first expert system, called DENDRAL, was developed in the mid-1960s at Stanford University to determine the chemical structure of molecules. For expert systems to be successful, they must be applied to an activity that human experts have already handled, such as tasks in medicine, geology, education, and oil exploration. PortBlue (PortBlue Corporation) is an example of an expert system that can be applied to various financial applications, including examination of complex financial structures, foreign exchange risk management, and more. COGITO (by Italian-based Expert System) is used for monitoring what consumers are saying in blogs, comment sections, message boards, and Web-based articles. It is also used in search engines to better understand users' queries.[11]

Decision support systems generate information by using data, models, and well-defined algorithms, but expert systems work with heuristic data. Heuristics consist of common sense, rules of thumb, educated guesses, and instinctive judgments, and using heuristic data encourages applying knowledge based on experience to solve or describe a problem. In other words, heuristic data is not formal knowledge, but it helps in finding a solution to a problem without following a rigorous algorithm.

13-2a Components of an Expert System

A typical expert system includes the components described in the following list, which are shown in Exhibit 13.1:

- *Knowledge acquisition facility*—A **knowledge acquisition facility** is a software package with manual or automated methods for acquiring and incorporating new rules and facts so the expert system is capable of growth. This component works with the KBMS (described later in this list) to ensure that the knowledge base is as up to date as possible.
- *Knowledge base*—A **knowledge base** is similar to a database, but in addition to storing facts and figures it keeps track of rules and explanations associated with facts. For example, a financial expert system's knowledge base might keep track of all figures constituting current assets, including cash, deposits, and accounts receivable. It might also keep track of the fact that current assets can be converted to cash within 1 year. An expert system in an academic environment might include facts about all graduate students, such as GMAT scores and GPAs, as well as a rule specifying that classified graduate students must have a GMAT of 650 or better and a GPA of 3.4 or better. To be considered part of a true expert system, the knowledge base component must include the following types of knowledge:
- *Factual knowledge*—Facts related to a specific discipline, subject, or problem. For example, facts related to kidney problems might include kidney size, blood levels of certain enzymes, and duration and location of pain.
- *Heuristic knowledge*—Rules related to a problem or discipline. For example, the general rules indicating that a patient has a kidney problem could include severe pain in the lower left or lower right of the back and high levels of creatinine and blood urea nitrogen.
- *Meta-knowledge*—Meta-knowledge is knowledge about knowledge. It enables an expert system to learn from experience and examine and extract relevant facts to determine the path to a solution. It also guides future planning or execution phases of an expert system. For example, knowing how an expert system makes decisions is considered meta-knowledge. Although this type of knowledge is not currently available in expert systems, integrating neural networks into expert systems is one possibility for acquiring meta-knowledge.
- *Knowledge base management system*—A **knowledge base management system (KBMS)**, similar to a DBMS, is used to keep the knowledge base updated, with changes to facts, figures, and rules.

Expert systems mimic human expertise in a particular field to solve a problem in a well-defined area.

A **knowledge acquisition facility** is a software package with manual or automated methods for acquiring and incorporating new rules and facts so the expert system is capable of growth.

A **knowledge base** is similar to a database, but in addition to storing facts and figures it keeps track of rules and explanations associated with facts.

A **knowledge base management system (KBMS)**, similar to a DBMS, is used to keep the knowledge base updated, with changes to facts, figures, and rules.

STUDY TOOLS 13

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REVIEWS AND DISCUSSIONS

1. What are two successful applications of artificial intelligence in business?
2. What are three advantages of a robot over a human?
3. What are two applications of case-based reasoning?
4. What are two applications that are not suitable for expert systems?
5. What are three characteristics of a sophisticated intelligent agent?
6. What is the role of the hidden layer in an artificial neural network?
7. What are two examples of commercial NLP systems?
8. How do you define contextual computing?

PROJECTS

1. After reading the information presented in this chapter and other sources, write a one-page paper that discusses the advantages and disadvantages of robotic surgery. When it comes to cost, which one is cheaper: human doctor or robot? The da Vinci Surgical System is an example of a robot used in surgery. What are two positive and two negative aspects of this system?
2. Contextual computing has generated a lot of excitement in the computing community. After reading the information presented in this chapter and other sources, write a one-page paper that discusses the advantages and disadvantages of this platform. In addition to Google Now, what other software applications currently offer this capability?
3. Nina, from Nuance.com, is being marketed as an intelligent agent. After reading the information presented in this chapter and other sources, write a one-page paper that explains the applications of this software. What types of businesses will benefit the most from it?
4. Case-based reasoning systems have been used in a variety of disciplines. In the future, they may also be used in the medical field. After reading the information presented in this chapter and other sources, write a one-page paper that explains how case-based reasoning systems will be used in this area. How might that bring healthcare costs down?
5. Intelligent agents are being used in a variety of applications. After reading the information presented in this chapter and other sources, write a one-page paper that discusses the applications of these agents in the e-commerce environment. Identify three such agents and their specific applications in e-commerce.
6. Nuance Communication's Dragon Speech Recognition Software and AT&T's Natural VoicesWizzard Speech are two of the popular commercial NLPs currently on the market. After reading the information presented in this chapter and other sources, write a two-page paper that explains key features of each NLP. What are some of the business applications of each software? What types of businesses will benefit the most from these types of software?

ARE YOU READY TO MOVE ON?

1. In an expert system environment, in forward chaining, a series of "if-then-else" condition pairs is performed. The "if" condition is evaluated first, then the corresponding "then-else" action is carried out. True or False?
2. An artificial neural network uses if-then-else in order to solve a problem. True or False?
3. Selection and crossover are two of the techniues used by a genetic algorithm. True or False?
4. Which of the following is not among the components of an expert system?
   a. Knowledge base
   b. Credit rating facility
   c. Inference engine
   d. Knowledge acquisition facility
5. Which of the following is not among the characteristics of a sophisticated intelligent agent?
   a. Adaptability
   b. Collectivity
   c. Autonomy
   d. Mobility
6. Which of the following is not a category of NLP system?
   a. Computer code generator
   b. Interface to databases
   c. Machine translation
   d. Text scanning

CASE STUDY 13-1

AI-Based Software Helps Businesses Better Understand Customers

AI-based software is getting smarter at analyzing qualitative data, words, phrases, and understanding the relationship among these words. These programs are able to analyze data generated though focus groups, surveys, online forums, call centers, help desks, and social media, and are able to generate new insights. Such new insights could help businesses offer better customer service and products and services that are more appealing to their customers.

Scotts Miracle-Gro, a major provider of lawn, garden, and outdoor-living products and services, recently noticed that a large number of customers were canceling lawn-fertilizer service. Not knowing what was causing the problem, the company conducted a survey and asked customers to rank their satisfaction with the company offerings and other feedback.

Using an AI-based software called Luminoso (*www.luminoso.com*) Scotts analyzed the data, which yielded some interesting results. The reason customers were canceling the service was because they expected better customer service from the company. Although the words "customer service" were not cited specifically in the survey, the software was able to associate words such as "listen" or "not responsive" in order to come up with the finding. According to David Erdman, a senior analyst at Scotts, the company is now examining its customer service in order to make improvements.

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Luminoso performs its analyses by accessing a large database that stores common sense knowledge and relationships (such as "if you drop a ball, it will fall") that help to understand how words and phrases relate to each other.[48]

Answer the following questions:

1. What problems were Scotts Miracle Gro facing?
2. Which software was used to analyze data collected by Scotts?
3. How does a software tool such as Luminoso analyze data?
4. What are some strategic applications of software tool such as Luminoso?

CASE STUDY 13-2

NLP: Making a Smartphone Smarter

Natural-language processing makes more sense in a mobile environment than in a desktop environment because the users of mobile devices are on the go and want to use their hands as little as possible. NLP adds a user-friendly environment and enhances data entry and data input for mobile users. And the increased memory and speed of mobile devices (as well as the increased speed of mobile and wireless networks) make them good candidates for NLP. As a result, voice-activated functions, speech-to-text dictation, and voice-activated dialing are now available for most smartphones, and voice-driven apps are getting smarter. For example, instead of saying "Call 551-535-1922" to dial a phone number, users can now say "Dial Dad" or "Phone my father."

Nuance's Dragon Dictation, available as an iPhone app, allows users to dictate everything from memos and e-mails to Twitter updates; Dragon for E-mail offers similar capabilities for the BlackBerry. Also for the iPhone, Jibbigo (*http://jibbigo.com/index.html*) translates words, phrases, and simple sentences. Voice-driven apps such as Google Voice Search, Bing Voice Search, and Microsoft Tellme are among the more popular smartphone applications. Vlingo (*www.vlingo.com*), a multiplatform app, serves as a "virtual assistant" and is being used for such services as making restaurant reservations (OpenTable, *www.opentable.com/info/aboutus.aspx*) and booking movie tickets (Fandango, *www.fandango.com*).

Oleksiy Mark/Shutterstock.com

Apple's Siri is a new entrant in the fast-growing voice-activated mobile-device market, having been added to the iPhone 4S and beyond. One of the challenges with voice-activated mobile devices is to get the device to understand what you mean, not just what you say. Other challenges include the use of foreign names, accents, and maintaining accuracy in noisy environments.[49,50]

Answer the following questions:

1. How can NLP make a smartphone smarter?
2. What are some examples of voice-based software used by iPhone?
3. What are some of the challenges that have to be overcome before achieving a full-featured voice-activated mobile device?