PLUG IT IN OUTLINE
PI4.1 Introduction to intelligent systems
PI4.2 Expert systems
PI4.3 Neural networks
PI4.4 Fuzzy logic
PI4.5 Genetic algorithms
PI4.6 Intelligent agents

LEARNING OBJECTIVES
1 Explain the potential value and the potential limitations of artificial intelligence.
2 Provide examples of the benefits, applications and limitations of expert systems.
3 Provide examples of the use of neural networks.
4 Provide examples of the use of fuzzy logic.
5 Describe the situations in which genetic algorithms would be most useful.
6 Describe the use case for several major types of intelligent agents.
PI4.1 Introduction to intelligent systems

This Plug IT In focuses on information systems that can make decisions by themselves. These systems are called intelligent systems. The major categories of intelligent systems are expert systems, neural networks, fuzzy logic, genetic algorithms and intelligent agents. You learn about each of these systems in the following sections.

Intelligent systems is a term that describes the various commercial applications of artificial intelligence. Artificial intelligence (AI) is a subfield of computer science that is concerned with studying the thought processes of humans and re-creating the effects of those processes via machines, such as computers and robots.

One well-publicised definition of AI is 'behaviour by a machine that, if performed by a human being, would be considered intelligent.' This definition raises the question, 'What is intelligent behaviour?' The following capabilities are considered to be signs of intelligence: learning or understanding from experience, making sense of ambiguous or contradictory messages and responding quickly and successfully to new situations.

The ultimate goal of AI is to build machines that will mimic human intelligence. A widely used test to determine whether a computer exhibits intelligent behaviour was designed by Alan Turing, a British AI pioneer. The Turing test proposes that a human and a computer both pretend to be human, and a human interviewer has to identify which is which (see figure PI4.1). Based on this standard, the intelligent systems exemplified in commercial AI products are far from exhibiting any significant intelligence.

![FIGURE PI4.1 A completely automated public Turing test to tell computers and humans apart (CAPTCHA). A CAPTCHA is a common form of Turing test and is used to verify whether or not a user is human; the words are deliberately distorted to make it difficult for spam bots to create an email address or participate in an online poll, or any number of other functions.](image)

We can better understand the potential value of AI by contrasting it with natural human intelligence. AI has several important commercial advantages over natural intelligence, but it also displays some limitations, as outlined in table PI4.1.

Intelligent systems show up in a number of places, some of them surprising, as the following examples illustrate.

- A good session player is hard to find, but UJAM ([www.ujam.com](http://www.ujam.com)) is always ready to rock. This web app doubles as a studio band and a recording studio. It analyses a melody and then produces sophisticated harmonies, bass lines, drum tracks, horn parts and more.
  - Before UJAM can produce accompaniment, the app must figure out which notes the user is singing or playing. Once UJAM recognises them, its algorithms use a mix of statistical techniques and programmed musical rules to search for chords to match the tune.
- To the human eye, an X-ray is a murky puzzle. But to a machine, an X-ray — or a computed tomography (CT) scan or a magnetic resonance imaging (MRI) scan — is a dense data field that can be assessed down to the pixel level. AI techniques are being applied very aggressively in the field of medical imaging.
  - New software gathers high-resolution image data from multiple sources — X-rays, MRI scans, ultrasounds, CT scans — and then groups together biological structures that share hard-to-detect similarities. For instance, the software can examine several images of the same breast to measure tissue density. The software then colour codes tissues with similar densities so humans can see the pattern as well.
The software finds and indexes pixels that share certain properties, even if they are far apart in one image or in a different image altogether. This process enables medical personnel to identify hidden features of diffuse structures as well as features within a region of tissue.

A human brain receives visual information from two eyes. Google's AI system receives visual information from billions of smart phone camera lenses. The company collects these images from users of Google Goggles (www.google.com/mobile/goggles), a mobile service that lets users run web searches by taking pictures. Snap a barcode and Goggles will shop for the item's best price. Scan a QR code (see figure PI 4.2), and Goggles will bring up the URL it represents. Take a picture of a book, and it will link users to, for instance, a Wikipedia page about the book's author. Photograph the Eiffel Tower and Goggles will give you historical background on the landmark.

The software behind Goggles coordinates the efforts of multiple object-specific recognition databases. There is a database for text, one for landmarks, one for corporate logos and so on. When an image arrives, Goggles transmits it to each of these databases, which in turn use a variety of visual-recognition techniques to identify potential matches and compute confidence scores. Goggles then applies its own algorithm to decide which result(s), if any, go back to the user. Goggles' next category? Identifying plants.

Building a model to run a major railroad is a complex task. One of the nation's largest freight carriers, Norfolk Southern (www.nscorp.com), uses an intelligent system, the Princeton Locomotive and Shop Management System (PLASMA), to manage its huge operation. PLASMA uses algorithms to analyse the railroad's operations by tracking thousands of variables to predict the impact of changes in fleet size, maintenance policies, transit time and other factors. The key breakthrough was refining PLASMA so that it could mimic the complex behaviour of the company's dispatch centre in Atlanta, Georgia. PLASMA examines vast amounts of historical data from the railroad's databases. It then uses this analysis to model the dispatch centre's collective human decision making and suggest improvements.

Today we have much to keep up with while we are driving, such as GPS devices, touchscreen media and climate controls, text messages (that we should not answer while driving), phone calls and of course oncoming traffic! Add a stressful day on the job, fatigue, irritability or sickness, and you have the recipe for disaster.

### TABLE PI4.1 Comparison of the capabilities of natural vs. artificial intelligence

<table>
<thead>
<tr>
<th>Capabilities</th>
<th>Natural intelligence</th>
<th>Artificial intelligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preservation of knowledge</td>
<td>Perishable from an organisational point of view</td>
<td>Permanent</td>
</tr>
<tr>
<td>Duplication and dissemination of knowledge</td>
<td>Difficult, expensive, takes time</td>
<td>Easy, fast and inexpensive once in a computer</td>
</tr>
<tr>
<td>Total cost of knowledge</td>
<td>Can be erratic and incomplete at times</td>
<td>Consistent and thorough</td>
</tr>
<tr>
<td>Ability to document process and knowledge</td>
<td>Difficult, expensive</td>
<td>Fairly easy, inexpensive</td>
</tr>
<tr>
<td>Creativity</td>
<td>Can be very high</td>
<td>Low, uninspired</td>
</tr>
<tr>
<td>Use of sensory experiences limited</td>
<td>Direct and rich in possibilities</td>
<td>Must be interpreted first, limited</td>
</tr>
<tr>
<td>Recognising patterns and relationships</td>
<td>Fast, easy to explain</td>
<td>Machine learning still not as good as people in most cases, but in some cases better</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Making use of wide context of experiences</td>
<td>Good only in narrow, focused and stable domains</td>
</tr>
</tbody>
</table>

- The software finds and indexes pixels that share certain properties, even if they are far apart in one image or in a different image altogether. This process enables medical personnel to identify hidden features of diffuse structures as well as features within a region of tissue.
- A human brain receives visual information from two eyes. Google's AI system receives visual information from billions of smart phone camera lenses. The company collects these images from users of Google Goggles (www.google.com/mobile/goggles), a mobile service that lets users run web searches by taking pictures. Snap a barcode and Goggles will shop for the item's best price. Scan a QR code (see figure PI 4.2), and Goggles will bring up the URL it represents. Take a picture of a book, and it will link users to, for instance, a Wikipedia page about the book's author. Photograph the Eiffel Tower and Goggles will give you historical background on the landmark.
- The software behind Goggles coordinates the efforts of multiple object-specific recognition databases. There is a database for text, one for landmarks, one for corporate logos and so on. When an image arrives, Goggles transmits it to each of these databases, which in turn use a variety of visual-recognition techniques to identify potential matches and compute confidence scores. Goggles then applies its own algorithm to decide which result(s), if any, go back to the user. Goggles' next category? Identifying plants.
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- Today we have much to keep up with while we are driving, such as GPS devices, touchscreen media and climate controls, text messages (that we should not answer while driving), phone calls and of course oncoming traffic! Add a stressful day on the job, fatigue, irritability or sickness, and you have the recipe for disaster.
Artificial intelligence could change all of this. Google is testing a car that drives itself and learns as it drives. Although it ultimately may not be necessary to put a vehicle on ‘autopilot’ for long periods of time, it could be helpful in either congested, bumper-to-bumper traffic or in rural areas where there is very little traffic. In these situations, it could be useful to have a computer monitoring 360 degrees of surroundings while the driver checks email, places a phone call or takes care of other business while on the road.

**Apply the Concept**

**Background**
This section introduced you to a few applications of artificial intelligence. One of those was the Google self-driving car. This is a very interesting situation where technology can greatly enhance the safety of motorists, pedestrians and passengers. However, there are also significant risks posed by turning over the keys to the computer.

**Activity**
Search the YouTube video that introduces the Google self-driving car. Although this is very exciting, it can also be very scary! While you are watching the video, imagine the advantages and disadvantages of this type of intelligent system. Would it be best as a ‘pilot’ or just a very helpful ‘co-pilot’?

**Deliverable**
Build a table that shows both the advantages and disadvantages for different scenarios as shown in the example table below.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tired driver</td>
<td></td>
</tr>
<tr>
<td>Distracted driver (texting)</td>
<td></td>
</tr>
<tr>
<td>Sick/stressed-out driver</td>
<td></td>
</tr>
<tr>
<td>Ambulance driver</td>
<td></td>
</tr>
<tr>
<td>School bus driver</td>
<td></td>
</tr>
<tr>
<td>Soccer mum, mini van driver</td>
<td></td>
</tr>
</tbody>
</table>
When an organisation has to make a complex decision or solve a problem, it often turns to experts for advice. These experts have specific knowledge and experience in the problem area. They can offer alternative solutions and predict how likely the proposed solutions are to succeed. At the same time, they can calculate the costs that the organisation may incur if it does not resolve the problem. Companies engage experts for advice on such matters as mergers and acquisitions, advertising strategy and purchasing equipment. The more unstructured the situation, the more specialised and expensive is the advice.

*Expertise* refers to the extensive, task-specific knowledge acquired from training, reading and experience. This knowledge enables experts to make better and faster decisions than nonexperts in solving complex problems. Expertise takes a long time (often many years) to acquire, and it is distributed unevenly across organisations.

**Expert systems (ESs)** are computer systems that attempt to mimic human experts by applying expertise in a specific domain. ESs can either support decision makers or completely replace them. ESs are the most widely applied and commercially successful intelligent system. A fascinating example of an ES is IBM’s Watson.

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**EXAMPLE**

In the last decade, question-answering systems have become increasingly important for companies dealing with vast amounts of information. Legal firms, for example, need to quickly sift through case law to find a useful precedent or citation. Help-desk workers often have to access enormous databases of product information to find an answer for customers on the line. In situations like these, speed is typically of the essence.

IBM scientists have recently been developing what they expected to be the world’s most advanced question answering system, known as Watson. Their goal was to program Watson so that it could understand a question posed in everyday human language, or *natural language*, and come up with a precise, factual, correct answer. That is, Watson’s capabilities must surpass those of search engines like Google and Bing, which merely point to a document where a user might find a suitable answer. Watson has to give the correct answer itself.

The IBM team input millions of documents into Watson to build up its knowledge base— including books, reference manuals, any sort of dictionary, encyclopedias, novels, plays, the Bible and many other information sources. Watson is not connected to the internet. It ‘knows’ only what has been input into its knowledge base (see figure PI 4.3).

Watson uses more than a hundred algorithms at the same time to analyse a question in different ways, generating hundreds of possible solutions. Another set of algorithms ranks these answers according to plausibility. In essence, Watson thinks in probabilities.

IBM trained Watson in medicine by inputting medical textbooks and journals. The team plans on linking Watson to the electronic health records that the federal government requires hospitals to maintain. In addition, medical students are sending sample questions to Watson to help train it.

The medical Watson offers several possible diagnoses, ranked in order of its confidence in the diagnoses. The IBM team learned that physicians want to see a list of options. Further, being presented with more than one choice might help doctors move away from ‘anchoring’, or being too attached to a particular diagnosis. The medical Watson will have a diagnosis application and a treatment application.

IBM envisions several uses for medical Watson:

- allowing a doctor to connect to Watson by speaking into a handheld device, using speech-recognition technology and cloud computing
- serving as a repository for the most advanced research in cancer and other fields
- providing an always-available second opinion.
Medical Watson does have competition. Isabel Healthcare ([www.isabelhealthcare.com](http://www.isabelhealthcare.com)) offers Isabel, a private medical database that is already being used by several multihospital health systems. Isabel is purported to perform roughly the same functions as the medical Watson system.

**FIGURE PI4.3** IBM input millions of documents into Watson, the world’s most advanced question answering system, including entire dictionaries, reference manuals and encyclopedias.


ESs are also used by human resources management to analyse applicants for available positions. These systems assign ‘scores’ to candidates, lessening the workload for HR managers in the hiring process. Human HR managers actually make the final decision, but the ES provides useful information and recommendations.

The previous examples demonstrated the usefulness of ESs in a relatively narrow domain. Overall, however, ESs may not be as helpful as users would like. Consider the Microsoft Windows troubleshooting software located in the ‘Help’ section in the taskbar menu. Microsoft has designed its ES to provide solutions, advice and suggestions to common errors users encounter in its operating systems. We have all found that, in some cases, the assistance provided by the help section is not particularly useful.

Typically, an ES is decision-making software that can reach a level of performance comparable to a human expert in certain specialised problem areas. Essentially, an ES transfers expertise from a domain expert (or other source) to the computer. This knowledge is then stored in the computer. Users can call on the computer for specific advice as needed. The computer can make inferences and arrive at conclusions. Then, like a human expert, it offers advice or recommendations. In addition, it can explain the logic behind the advice. Because ESs can integrate and manipulate so much data, they sometimes perform better than any single expert can.

An often overlooked benefit of ESs is that they can be embedded in larger systems. For example, credit card issuers use ESs to process credit card applications.

The transfer of expertise from an expert to a computer and then to the user involves the following four activities.

- **Knowledge acquisition.** Knowledge is acquired from domain experts or from documented sources.
- **Knowledge representation.** Acquired knowledge is organised as rules or frames (object oriented) and stored electronically in a knowledge base.
- **Knowledge inferring.** The computer is programmed so that it can make inferences based on the stored knowledge.
- **Knowledge transfer.** The inferred expertise is transferred to the user in the form of a recommendation.
The components of expert systems

An ES contains the following components: knowledge base, inference engine, user interface, blackboard (workplace) and explanation subsystem (justifier). In the future, ESs will include a knowledge-refining component as well. You learn about these components below. In addition, figure PI4.4 diagrams the relationships among these components.

The **knowledge base** contains knowledge necessary for understanding, formulating and solving problems. It is comprised of two basic elements: facts, such as the problem situation, and rules that direct the use of knowledge to solve specific problems in a particular domain.

The **inference engine** is essentially a computer program that provides a methodology for reasoning and formulating conclusions. It enables the system to make inferences based on the stored knowledge. The inference engine is considered the 'brain' of the ES.

The following is an example of a medical ES for lung cancer treatment:

IF lung capacity is high
AND X-ray results are positive
AND patient has fever
AND patient has coughing
THEN surgery is necessary.

IF tumour has spread OR contraindications to surgery exist
THEN surgery cannot be performed.

The **user interface** enables users to communicate with the computer. That communication can best be carried out in a natural language, usually a question-and-answer format. In some cases, it is supplemented by graphics. The dialogue between the user and the computer triggers the inference engine to match the problem symptoms with the knowledge contained in the knowledge base and then generate advice.

The **blackboard** is an area of working memory set aside for the description of a current problem, as specified by the input data. It is a kind of database.

A unique feature of an ES is its ability to **explain** its recommendations. It performs this function in a subsystem called the **explanation subsystem** or **justifier**. The explanation subsystem interactively answers questions a number of questions. Why did the ES ask a certain question? How did the ES reach a particular conclusion? What is the plan to reach the solution?

Human experts have a **knowledge-refining** system — that is, they can analyse their own performance, learn from it and improve it for future consultations. This type of evaluation is also necessary in computerised learning so that the program will be able to improve by analysing the reasons for its success or failure. Unfortunately, such a component is not available in commercial ESs at the moment. However, it is being developed in experimental systems.

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**FIGURE PI4.4** Structure and process of an expert system.
Applications, benefits and limitations of expert systems

Today, ESs are found in all types of organisations. They are especially useful in ten generic categories, which are displayed in table PI4.2.

### TABLE PI4.2 Ten generic categories of expert systems

<table>
<thead>
<tr>
<th>Category</th>
<th>Problem Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation</td>
<td>Inferring situation descriptions from observations</td>
</tr>
<tr>
<td>Prediction</td>
<td>Inferring likely consequences of given situations</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Inferring system malfunctions from observations</td>
</tr>
<tr>
<td>Design</td>
<td>Configuring objects under constraints</td>
</tr>
<tr>
<td>Planning</td>
<td>Developing plans to achieve goal(s)</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Comparing observations to plans, flagging exceptions</td>
</tr>
<tr>
<td>Debugging</td>
<td>Prescribing remedies for malfunctions</td>
</tr>
<tr>
<td>Repair</td>
<td>Executing a plan to administer a prescribed remedy</td>
</tr>
<tr>
<td>Instruction</td>
<td>Diagnosing, debugging and correcting system performance</td>
</tr>
<tr>
<td>Control</td>
<td>Interpreting, predicting, repairing and monitoring systems behaviour</td>
</tr>
</tbody>
</table>

During the past few years, thousands of organisations worldwide have successfully applied ES technology to problems ranging from AIDS research to analysing dust in mines. ESs have become so popular because they provide a large number of capabilities and benefits. Table PI4.3 lists the major benefits of ESs.

### TABLE PI4.3 Benefits of expert systems

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased output and productivity</td>
<td>ESs can configure components for each custom order, increasing production capabilities.</td>
</tr>
<tr>
<td>Increased quality</td>
<td>ESs can provide consistent advice and reduce error rates.</td>
</tr>
<tr>
<td>Capture and dissemination of scarce expertise</td>
<td>Expertise from anywhere in the world can be obtained and used.</td>
</tr>
<tr>
<td>Operation in hazardous environments</td>
<td>Sensors can collect information that an ES interprets, enabling human workers to avoid hot, humid or toxic environments.</td>
</tr>
<tr>
<td>Accessibility to knowledge and help desks</td>
<td>ESs can increase the productivity of help-desk employees or even automate this function.</td>
</tr>
<tr>
<td>Reliability</td>
<td>ESs do not become tired or bored, call in sick or go on strike. They consistently pay attention to detail.</td>
</tr>
</tbody>
</table>
TABLE PI4.3 Benefits of expert systems (continued)

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to work with incomplete or uncertain information</td>
<td>Even with an answer of ‘Don’t know’, an ES can produce an answer, although it may not be a definite one.</td>
</tr>
<tr>
<td>Provision of training</td>
<td>The explanation facility of an ES can serve as a teaching device and knowledge base for novices.</td>
</tr>
<tr>
<td>Enhancement of decision-making and problem-solving capabilities</td>
<td>ESs allow the integration of expert judgment into analysis (e.g. diagnosis of machine and problem-malfunction and even medical diagnosis).</td>
</tr>
<tr>
<td>Decreased decision-making time</td>
<td>ESs usually can make faster decisions than humans working alone.</td>
</tr>
<tr>
<td>Reduced downtime</td>
<td>ESs can quickly diagnose machine malfunctions and prescribe repairs.</td>
</tr>
</tbody>
</table>

Despite all of these benefits, ESs present some problems as well. The difficulties involved with using ESs include the following.

- Transferring domain expertise from experts to the ES can be difficult because these experts cannot always explain how they know what they know. Often they are not aware of their complete reasoning process.
- Even if the domain experts can explain their entire reasoning process, automating that process may not be possible. The process may be either too complex, requiring too many rules or too vague.
- In some contexts, there may be a potential liability from the use of ESs. Humans are known to make errors from time to time, but they are generally ‘off the hook’ if they take reasonable care and apply generally accepted methods. An organisation that chooses to use an ES, however, may lack this legal protection if problems arise later. The usual example is medical treatment, but this issue can arise if someone is harmed financially by a business decision driven by an ES.

BEFORE YOU GO ON …

1. What is an expert system?
2. Describe the benefits and limitations of using expert systems.

Apply the Concept

Background

In the ‘old days’, expertise was transferred from a master to an apprentice by years of training. Only when all the tricks of the trade were mastered was the apprentice ready to go perform on his or her own. We still use similar methods today for doctors when they participate in a residency program under the guidance of the resident doctor.

This is different in situations that are not life threatening. In some cases, being able to make an expert decision is simply a matter of having access to the experts’ knowledge and experiences. If this can be captured in a computer-based information system, then this can be distributed to others to use this information to make similar decisions.

Although this sounds great, there are many challenges to obtaining this expertise. In some cases, it is the expertise that makes the employee special and valuable! To give this up would remove the need of the organisation to keep the individual employee, right?
Activity
The knowledge base consists of facts and rules. In this activity, you will experience the difficulty of obtaining facts and turning them into rules. Consider the job of getting dressed. That may seem easy to you, but you will interview a friend and ask a series of questions to determine how to advise someone on getting dressed. Some of the questions you will ask should revolve around plans, weather, protocol (what is expected where the person is going), wardrobe, preferences and so on.

Deliverable
Develop ten facts and rules that a computer system could use to make a decision on how to get dressed. Submit your list to your tutorial group.

PI4.3 Neural networks
A neural network is a system of programs and data structures that simulates the underlying concepts of the biological brain. A neural network usually involves a large number of processors operating in parallel, each with its own small sphere of knowledge and access to data in its local memory (see figure PI4.5). Typically, a neural network is initially ‘trained’ or fed large amounts of data and rules about data relationships.

Neural networks are particularly adept at recognising subtle, hidden and newly emerging patterns within complex data, as well as interpreting incomplete inputs. Neural networks can help users solve a wide range of problems, from airline security to infectious disease control. They have become the standard for combating fraud in the credit card, health care and telecom industries, and they are playing an increasingly important role in today’s stepped-up international efforts to prevent money laundering.

Neural networks are used in a variety of ways, as illustrated by the following examples.
- Neural network software (NNS) is essential to each sector of business, from finance, marketing, information technology and health, to insurance, energy, retail and science. For each sector, NNS plays an important role, creating models and solutions to provide the best outcome for businesses and consumers.
  - For example, in the business sector, NNS assisted in the accounting and financial sectors to manage resource allocation, scheduling and data mining. An example is SPSS Neural Networks by IBM solutions.
  - NNS is available to the health sector to provide the necessary decision support tools, powered by proven artificial intelligence (AI) to prevent incorrect medical guidance and increase bottom line. Researchers in the health sector are using NNS to address problems, for example prediction and pattern recognition, and this software can be useful for the diagnosis of Alzheimer’s disease, Parkinson’s disease and autism.
• Neural networks are used to forecast the performance of stock index futures, currencies, natural gas and oil stocks, T-bond futures, gold stocks and other major investments.

• Neural networks are used to detect fraud in credit card transactions and insurance claims, to fight crime and to gauge customer satisfaction.

Figure PI4.5 on the previous page illustrates how a neural network would process a typical mortgage application. Note that the network has three levels of interconnected nodes (similar to the human brain): an input layer, a middle or hidden layer and an output layer. As you train the neural network, the strengths, or weights, of the connections change. In our example, the input nodes are age, income, occupation, marital status, employer, length of time with that employer, amount of mortgage desired and current interest rate. The neural network has already been trained with data input from many successful and unsuccessful mortgage applications. That is, the neural network has established a pattern as to which input variables are necessary for a successful mortgage application. Interestingly, the neural network can adjust as both mortgage amounts and interest rates increase or decrease.

Apply the Concept

Background
This section describes a neural network as one that operates much like a human brain. Our minds are able to analyse and sometimes predict and make decisions much quicker than computers. It resembles our learning processes. Imagine yourself as a child learning to walk. Each stand and each fall made connections in your brain that helped you eventually learn to walk.

Activity
Search for the YouTube video that demonstrates a neural network in which a car learns to drive itself around a road. Watch this demo and be amazed at how this system learns over time. It seems that the car is constantly crashing, then all of a sudden it makes it all the way around the track.

Imagine what other applications could use this type of technology where systems are built to learn how to navigate tricky scenarios like the stock market, gold futures and even predicting crime!

Deliverable
Build a list of possible applications of neural networks. Research the web if you need some help. For example, imagine the trial and error we have gone through with medical care and the treatment of various diseases. Can we learn from each other the way a computer-based neural network operates? Submit your list of possible applications to your tutorial group.

Fuzzy logic

Fuzzy logic is a branch of mathematics that deals with uncertainties by simulating the process of human reasoning. The rationale behind fuzzy logic is that decision making is not always a matter of black and white, true or false. It often involves gray areas where the term maybe is more appropriate.

A computer programmed to use fuzzy logic defines in precise terms subjective concepts that humans do not define precisely. For example, for the concept income, terms such as high and moderate are subjective and imprecise. Using fuzzy logic, however, a computer could define ‘high’ incomes as those exceeding $150 000 per year and ‘moderate’ incomes as those ranging from $100 000 to $150 000 per year. A loan officer at a bank might use these fuzzy values when considering a loan application.

Fuzzy logic has also been used in financial analysis and the manufacture of antilock brakes. In accounting and finance, fuzzy logic allows you to analyse information with imprecise values, such as intangible assets like goodwill. Google uses fuzzy logic to find answers to your search terms because your perception of a topic often influences how you phrase your query, therefore determining the relevance of the web pages that Google delivers to you.
Apply the Concept

Background
Fuzzy logic allows computers to use our vague descriptions as data points. Although we may describe a house as big or small, the computer will assign specific data ranges to ‘big’ homes and ‘small’ homes so that a house under 1000 square feet is ‘small’ and anything bigger is ‘big’. Fuzzy logic, then, can be used to let computer systems analyse and consider options where ‘fuzzy’ descriptions are the best we can come up with.

Activity
Imagine that you are going to use fuzzy logic to design a formula that will help determine if people are at risk for having an accident while texting. What variables would you use? What categories would you create for each criterion?

Come up with at least five variables that each have three categories. For example, you may use ‘comfort with texting’ as a variable and have measurements such as the following:
‘Uncomfortable’ (sends less than 100 messages a month)
‘Somewhat comfortable’ (sends 101–500 messages a month)
‘Very comfortable’ (sends more than 501 messages a month).

Deliverable
Develop your list of criteria that would predict whether a person would have an accident while texting. Submit your fuzzy logic information to your tutorial group.

PI4.5 Genetic algorithms

An algorithm is a method for solving a problem expressed as a finite sequence of steps. A genetic algorithm is an approach that mimics the evolutionary, survival-of-the-fittest process to generate increasingly better solutions to a problem. That is, a genetic algorithm is an optimising process that finds the combination of inputs that produces the best outputs. Genetic algorithms have three functional characteristics:
• Selection (survival of the fittest). The key to selection is to give preference to better and better outcomes.
• Crossover. The process of combining portions of good outcomes in the hope of creating an even better outcome.
• Mutation. The process of randomly trying combinations and evaluating the success (or failure) of an outcome.

Genetic algorithms are best suited to decision-making environments in which thousands or millions of solutions are possible. Genetic algorithms can find and evaluate solutions intelligently, and they can process many more possibilities more thoroughly and faster than a human can.

Users do have to tell the genetic algorithm what constitutes a ‘good’ solution. Good solutions could be low cost or high return, or any number of other results. Let us look at some examples.
• Boeing uses genetic algorithms in its design of aircraft parts such as the fan blades on its 777 jet. Rolls Royce and Honda also use genetic algorithms in their design processes.
• Retailers such as Marks and Spencer, a British chain that has 320 stores, use genetic algorithms to manage their inventories more effectively and also to optimise their store displays.
• Air Liquide, a producer of industrial gases, uses genetic algorithms to find optimal production schedules and distribution points in its supply chain. The company has 40 plants and 8000 client sites and must consider factors such as power prices and customer demand projections, as well as the power costs and efficiency of each plant.
Intelligent agents

An intelligent agent is a software program that assists you, or acts on your behalf, in performing repetitive computer-related tasks. Behind the scenes, intelligent agents often use ISs such as ESs and fuzzy logic to create their seemingly intelligent behaviour.

You may be familiar with an early type of intelligent agent: the paper clip (‘Clippy’) that popped up in early versions of Microsoft Word. For example, if your document appeared as though it were going to be a business letter — that is, you typed in a date, name and address — the animated paper clip would offer helpful suggestions on how to proceed. Users objected so strenuously to this primitive intelligent agent that Microsoft deleted it from subsequent versions.

There are many intelligent agents — also called bots — for a wide variety of tasks. You can view the many different types of available agents by visiting BotSpot (www.botspot.com), for example. The following sections examine three types of agents: information agents, monitoring-and-surveillance agents and user or personal agents.

Information agents

Information agents are a type of intelligent agent that searches for information of some kind and displays it to the users. The best-known information agents are buyer agents. A buyer agent (or shopping bot) is an intelligent agent on a website that helps customers find the products and services they need. There are many examples of information agents. Here are a few illustrative cases.

• The information agents for Amazon display lists of books and other products that customers might like, based on past purchases.
• Google and Ask.com use information agents to find information, and not just when you request it. Google, for example, sends Googlebots out to surf all the websites in Google's index. These bots copy individual pages to Google's repository, where Google software indexes them. This process means that when you perform a Google search, the search engine builds a list of all the pages that contain the key words you specify and presents them to you in PageRank order. Google's PageRank algorithm sorts web pages based on the number of links on the web that point to each page. That is, the more links on the web that point to a particular page, the higher the likelihood that website will be on the list.
• Agent Oriented Software Pty Ltd (AOS), with Australian offices based in Melbourne and Adelaide, offers a number of outstanding and innovative intelligent software agent solutions to the global market, most prominently JACK Intelligent Agent. JACK has been developed and marketed by AOS since 1988, and is an environment for building, running and integrating commercial-grade multi-agent systems using a component based approach. This intelligent agent can be used in aerospace and defence (i.e. intelligent air mission planning and operational analysis), and enterprise systems (i.e. oil and gas industry decision support systems).

Monitoring-and-surveillance agents

Monitoring-and-surveillance agents (or predictive agents) are intelligent agents that constantly observe and report on some item of interest. There are many examples of predictive agents. Consider the following.

• Allstate Insurance uses monitoring-and-surveillance agents to manage its large computer networks 24 hours a day, 7 days a week, 365 days a year. Every 5 seconds, the agent measures 1200 data points. It can predict a system crash 45 minutes before it happens. The agent also watches for electronic attacks to detect them early so they can be prevented.
• Monitoring-and-surveillance agents can watch your competitors and notify you of price changes and special offers.
• These agents can monitor internet sites, discussion groups and mailing lists for stock manipulations, insider trading and rumours that might affect stock prices.
• These agents can monitor websites for updated information on topics of your choice, such as price changes on desired products (e.g. airline tickets).
User agents

User agents (or personal agents) are intelligent agents that take action on your behalf. Let us look at what these agents can do (or will be able to do shortly).

- Check your email, sort it according to your priority rules and alert you when high-value emails appear in your inbox.
- Automatically fill out forms on the web for you. They will also store your information for future use.

Apply the Concept

Background

Information agents are a type of intelligent agent that searches for information or products and displays it to the users. The best-known information agents are buyer agents. A buyer agent, also called a shopping bot, is an intelligent agent on the web that helps customers find products and services.

Activity

Let us assume the big game is coming up this weekend and you have invited a group of friends over to watch it at your house. However, last evening, your TV stopped working. So you need to shop for a new TV quickly. You have heard about websites that can help you find the best deals, so you decide to try one out. You have at the most about $450 to spend and you think you want an LCD screen. Because a lot of people are coming, you would like a big screen, at least 40 inches, so everybody can see. Visit Shopzilla’s website where you can put in the criteria described above and shop many sites at one time.

Compare your results here to those you may find on Google’s shopping site (or any other shopping site you may find).

Deliverable

After you work through the activity described above, submit your top five choices to your tutorial group. Also, describe your experience with the buyer agent.

WHAT’S IN IT FOR ME?

FOR THE ACCOUNTING MAJOR

Intelligent systems are used extensively in auditing to uncover irregularities. They are also used to uncover and prevent fraud. Today’s CPAs use intelligent systems for many of their duties, ranging from risk analysis to cost control. Accounting personnel also use intelligent agents for several mundane tasks such as managing accounts and monitoring employees’ internet use.

FOR THE FINANCE MAJOR

People have been using computers for decades to solve financial problems. Innovative intelligent applications have been developed for activities such as making stock market decisions, refinancing bonds, assessing debt risks, analysing financial conditions, predicting business failures, forecasting financial trends and investing in global markets. In many cases, intelligent systems can facilitate the use of spreadsheets and other computerised systems used in finance. In addition, intelligent systems can help to reduce fraud in credit cards, shares and other financial services.

FOR THE MARKETING MAJOR

Marketing personnel utilise intelligent systems in many applications, from allocating advertising budgets to evaluating alternative routings of salespeople.
New marketing approaches such as targeted marketing and marketing transaction databases are heavily dependent on IT in general and on intelligent systems in particular. Intelligent systems are particularly useful in mining customer databases and predicting customer behaviour. Successful applications are visible in almost every area of marketing and sales, from analysing the success of one-to-one advertising to supporting customer help desks. With the increased importance of customer service, the use of intelligent agents is becoming critical for providing fast response.

**FOR THE PRODUCTION/OPERATIONS MANAGEMENT MAJOR**

Intelligent systems support complex operations and production decisions, from inventory to production planning. Many of the early expert systems were developed in the production/operations management field for tasks ranging from diagnosing machine failures and prescribing repairs to complex production scheduling and inventory control. Some companies, such as DuPont and Kodak, have deployed hundreds of expert systems in the planning, organising and control of their operational systems.

**FOR THE HUMAN RESOURCES MANAGEMENT MAJOR**

Human resources personnel use intelligent systems for many applications. For example, these systems can find resumes of applicants posted on the web and sort them to match desired skills. Expert systems are used in evaluating candidates (tests, interviews). HR personnel use intelligent systems to train and support employees in managing their fringe benefits. In addition, they use neural computing to predict employee job performance and to predict labour needs.

**FOR THE MIS MAJOR**

The MIS function develops (or acquires) and maintains the organisation’s various intelligent systems, as well as the data and models that these systems use. In addition, MIS staffers sometimes interact with subject-area experts to capture the expertise used in ESs.

**SUMMARY**

1. **Explain the potential value and the potential limitations of artificial intelligence.**
   Table PI4.1 differentiates between artificial and human intelligence on a number of characteristics.

2. **Provide examples of the benefits, applications and limitations of expert systems.**
   Expert systems are computer systems that attempt to mimic human experts by applying expertise in a specific domain. Tables PI4.2 and PI4.3 offer examples of expert systems.

3. **Provide examples of the use of neural networks.**
   A neural network is a system of programs and data structures that simulate the underlying concepts of the human brain. Neural networks are used to detect weapons concealed in personal belongings, in research on various diseases, for financial forecasting, to detect fraud in credit card transactions, to fight crime and many other applications.

4. **Provide examples of the use of fuzzy logic.**
   Fuzzy logic is a branch of mathematics that deals with uncertainties by simulating the process of human reasoning. Fuzzy logic is used in financial analysis, the manufacture of antilock brakes, measuring intangible assets like goodwill and finding responses to search terms in Google.

5. **Describe the situations in which genetic algorithms would be most useful.**
   A genetic algorithm is an intelligent system that mimics the evolutionary, survival-of-the-fittest process to generate increasingly better solutions to a problem. Genetic algorithms are used to design aircraft parts such as fan blades, to manage inventories more effectively, to optimise store displays, and to find optimal production schedules and distribution points.
6 Describe the use case for several major types of intelligent agents.

An intelligent agent is a software program that assists you, or acts on your behalf, in performing repetitive, computer-related tasks. Intelligent agents are used to display lists of books or other products that customers might like, based on past purchases; to find information; to manage and constantly monitor large computer networks; to detect electronic attacks early so they can be prevented; to watch competitors and send notices of price changes and special offers; to monitor internet sites, discussion groups and mailing lists for stock manipulations, insider trading and rumours that might impact stock prices; to check email, sort it according to established priority rules and alert recipients when high-value emails appear in their inbox; and to automatically fill out forms on the web.

>>> GLOSSARY

artificial intelligence (AI) A subfield of computer science that is concerned with studying the thought processes of humans and re-creating the effects of those processes via machines, such as computers.

buyer agent (or shopping bot) An intelligent agent on a website that helps customers find products and services that they need.

expert systems (ESs) Computer systems that attempt to mimic human experts by applying expertise in a specific domain.

fuzzy logic A branch of mathematics that deals with uncertainties by simulating the process of human reasoning.

genetic algorithm An approach that mimics the evolutionary, survival-of-the-fittest process to generate increasingly better solutions to a problem.

information agents A type of intelligent agent that searches for information of some kind and displays it to the users.

intelligent agent A software program that assists you, or acts on your behalf, in performing repetitive, computer-related tasks.

intelligent systems A term that describes the various commercial applications of artificial intelligence.

monitoring-and-surveillance agents (or predictive agents) Intelligent agents that constantly observe and report on some item of interest.

neural network A system of programs and data structures that simulates the underlying concepts of the human brain.

personal agents (see user agents)

predictive agents (see monitoring-and-surveillance agents)

shopping bot (see buyer agent)

Turing test A test in which a man and a computer both pretend to be women (or men), and the human interviewer has to decide which is which.

user agents (or personal agents) Intelligent agents that take action on your behalf.

>>> DISCUSSION QUESTIONS

1 Explain how your university could employ an expert system in its admission process. Could it apply a neural network to this process? What might be the outcome if a student were denied admission to the university and the student’s parents discovered that an expert system had been involved in the admissions process?

2 One difference between a conventional business intelligence system and an expert system is that the former can explain a how question, whereas the latter can explain a how and a why question. Discuss the implications of this statement.

>>> PROBLEM-SOLVING ACTIVITIES

1 You have decided to purchase a new video camera. To purchase it as inexpensively as possible and still get the features you want, you use a shopping bot. Visit several of the shopping bot websites that perform price comparisons for you. Begin with GetPrice (www.getprice.com.au), Cnet Australia (www.cnet.com.au) and My Shopping (www.myshopping.com.au). Compare these shopping bots in terms of their ease of use, number of product offerings, speed in obtaining information, thoroughness of information offered and price selection. Which site or sites would you use, and why? Which video camera would you select and why? How helpful were these sites in making your decision?

2 Access the website Job Outlook (http://joboutlook.gov.au/careerquiz.aspx). This site offers a quiz that aims to assist users to identify their ideal workplace. The quiz contains 15 questions; each question offers six
workplace scenarios from which you must choose the task you think you'd find most enjoyable. After you complete the questions, click 'see result' to view the categories (e.g. practical, technical, creative) with which your preferences are most aligned. Click through the categories to browse a list of jobs relevant to that type of work; these will hopefully be occupations you are most likely to enjoy or be good at.

3 Access My Skills (www.myskills.gov.au) and type a job title (i.e. ‘mechanic’) into the ‘What can I learn?’ box and click ‘search’. The website will generate a list of institutions, ranked by their proximity to you, where you can obtain a qualification to work in that nominated profession. Clicking on the name of the qualification will open up a description as well as job roles, employment outcomes, and even expected job openings and average weekly full time earnings.

ENDNOTES
