CHAPTER 8

Artificial intelligence, simulation and modelling

Syllabus outcomes

5.2.1 Describes and applies problem-solving processes when creating solutions.
5.2.2 Designs, produces and evaluates appropriate solutions to a range of challenging problems.
5.2.3 Critically analyses decision-making processes in a range of information and software solutions.

Overview

This chapter examines artificial intelligence and simulations. First, you gain a basic understanding of artificial intelligence and the areas of artificial intelligence, such as expert systems and neural networks. Second, you will learn the requirements, purposes, advantages and limitations of models and simulations. The chapter concludes by discussing the use of modelling and simulation programs.
Artificial intelligence (AI) aims to give computers the ability to think like human beings. It is the behaviour of a computer that, if exhibited by a person, would be called intelligent. Some people argue computers will never have intelligence. They reason a computer is an electronic tool that can only process data very quickly but cannot actually think up any new ideas, it does not have any intelligence. For a computer to be called intelligent, its behaviours and capabilities must be compared to our own ways of doing things and thinking.

Consider a simple problem that requires you to choose a piece of fruit—a banana, an orange or a pineapple. In making your decision let us assume that you cannot see, touch or taste the fruit, but are told the piece of fruit is a sphere. Immediately you know the fruit must be an orange, but how did you make this deduction? You have seen many bananas, oranges and pineapples, and from this experience you know that the oranges are a sphere and that the other fruits are not. Your intelligent response is probably not based on having ever been told an orange is a sphere, but from your own observations. Could a computer solve this simple problem? The computer is faced with two problems: understanding human or natural language and recognising the difference between bananas, oranges and pineapples. It has not learned from observations and experience that oranges are spheres.

This simple problem raises some interesting questions. Is choosing a piece of fruit intelligent behaviour? The computer does not find this task easy. However, it can perform arithmetic operations many times faster than any person. What is intelligence? It is difficult to define and understand intelligence. People use the word intelligent to describe somebody who can solve difficult problems. Intelligence might also be described as the ability to reason or the power of thought. The Macquarie Dictionary defines intelligence as ‘the ability to understand, learn and to control behaviour in any new event’. Is a computer intelligent? AI research has produced some impressive results. Computers can communicate in human languages, computers have been programmed to be experts in a range of fields and a computer can beat the best human in chess. However, most people would not describe a computer as intelligent.
Historical perspective

Artificial intelligence became available with the development of the first electronic digital computer called the Colossus in 1943. It was built by a team led by Alan Turing to break German military codes (see Figure 8.1). After building this computer Turing wrote a paper titled ‘Computing Machinery and Intelligence’ in 1950. It effectively started the field of artificial intelligence. The paper contained a concrete test for determining whether a machine was intelligent. The ‘Turing test’ involves two people at the computer. One person sits alone in a room and types questions into a terminal. The questions are on any topic. The answers to the questions appear on the terminal and the person has to determine whether the answer is written by another person or the computer. If the person repeatedly chooses the computer then it has demonstrated intelligent behaviour.

The term artificial intelligence was first used at a conference in Dartmouth, USA in 1956. The conference was organised by John McCarthy who is regarded as the father of AI. In the past fifty years the progress in artificial intelligence has been steady rather than spectacular. It includes the following developments:

• John McCarthy headed a team that developed the programming language called LISP (LISr Processing) in 1958. LISP was completely different from the popular procedural languages such as FORTRAN. Every expression is a list of calls to functions. LISP dominated AI research for many years and is still used today.

• Joseph Weizenbaum wrote a program called Eliza (Eliza Doolittle) in the 1960s. The program acted as a therapist and encourages the user to talk. For example, if the user types ‘My father never liked me’, the program, recognising the keyword of father, would respond with ‘Tell me more about your family’. If the user did not type any keywords the program would respond with a neutral sentence such as ‘That’s very interesting’. Weizenbaum was surprised that people took his program seriously and thought the computer intelligent. He spent several years arguing against artificial intelligence.

• PROLOG (PROgramming in LOGic) was developed in 1970 at the University of Marseille in France by Alain Colmerauer and Philippe Roussel. The decision by Japanese computer designers to work with PROLOG instead of LISP made it very popular.
Many of the features that were once unique to PROLOG are used in modern object-oriented programming such as Java.

- **Expert systems** first appeared in the 1970s. They could predict the probability of a solution under certain conditions. **Expert systems** were introduced to a range of applications. **MYCIN** was a famous expert system developed at Stanford University. It was designed to assist non-specialist doctors in the diagnosis and treatment of bacterial blood infections.

- **David Marr** outlined new theories on artificial vision in the 1970s. For example, how is it possible to distinguish an image based on the shading of an image, basic information on shapes, colour, edges and texture?

- Artificial intelligence started to gain pace in the 1980s. Expert systems were in demand because of their efficiency. Large organisations such as Boeing and General Motors relied heavily on expert systems. **Neural networks** were considered possible ways of achieving artificial intelligence.

- The world’s first intelligent **robot eye** was created in 1990 by Fujitsu Laboratories. It is capable of detecting high-speed motion by following a similar procedure to the human brain.

### Requirements of artificial intelligence

Artificial intelligence requires more processing power and storage capacity than most other applications. Processing speed and memory are important requirements for artificial intelligence. ‘Intelligent’ computers also require a range of input devices to receive data from the environment. For example, images are collected using cameras, audio using microphones and data from the environment using sensors. Sensors are used to detect different physical conditions such as temperature, light, position and touch. Output devices for ‘intelligent’ computers include conventional devices such as screens and printers, as well as speech synthesisers and a range of robotic devices to provide movement.

**Robots** are often used in artificial intelligence. They are built to carry out tasks similar to the tasks carried out by people. Robotic arms are used to make a response involving movement. They are programmable and generally consist of a trunk, joints and end effectors. Some robotic joints only allow linear movement within one plane and are called prismatic, while other joints enable rotation and are called revolute. End effectors are tools attached to the end of the robotic arm to perform the required tasks.
Artificial vision enables computer-controlled devices to ‘see’ through the use of cameras, scanners and sensors (see Figure 8.2). Visual images are captured by a camera and digitised by an analog-to-digital converter. These images are stored on the computer as a grid of individual dots called pixels. Artificial intelligence techniques are used to analyse and interpret the image. In addition to robots that are equipped with cameras and sensors, artificial vision is used for security screening. A camera can digitise the image of a person’s face or fingerprint to decide entry into a security area.

Artificial intelligence needs software to receive data from input devices, to process and store this data, and then to make logical decisions to produce an intelligent response. Software for artificial intelligence is written using non-procedural languages. Non-procedural languages are used in which the programmer specifies what to do and the system determines how to do it. The two most popular non-procedural languages are LISP and PROLOG.

Exercise 8.1

1 Which person was responsible for this development in AI?
   a Outlined new theories on artificial vision in the 1970s.
   b Developed the programming language called LISP.
   c Started the field of artificial intelligence.
   d Developed the programming language called PROLOG.

2 Copy and complete the following sentences:
   a _______ aims to give computers the ability to think like human beings.
   b MYCIN was a famous_______ system developed at Stanford University.
   c _______ allow intelligent systems to make a response involving movement.
Activities

3 True or false?
   a Most people describe a computer as intelligent.
   b John McCarthy is regarded as the father of AI.
   c John Weizenbaum spent several years arguing for artificial intelligence.
   d LISP and PROLOG are two procedural languages.

4 a What is the meaning of the word intelligence?
   b Describe the Turing test?
   c What is artificial vision?
   d Why does artificial intelligence need software?

Development

5 Some people argue that computers are capable of making intelligent responses. Other people argue that computers are machines that follow instructions and will never be intelligent. Discuss this issue. Your answer should contain references to current developments in AI research.

6 Construct a table to compare and contrast the intelligence of a person with that of a computer. What are the tasks performed well by a computer? What are the tasks people find easy but computers find difficult? Your answer should contain at least ten different tasks.

8.2 Areas of artificial intelligence

Areas of artificial intelligence include intelligent systems, expert systems and knowledge bases, neural networks, agents and demons.

Intelligent systems

Intelligent systems are systems that receive data from the environment, react to that data, and produce an intelligent response. People are intelligent systems. They receive data through sight, sound, touch, taste and smell, and then use reasoning, knowledge and feelings to produce speech and movement.

Information technology is being used to create intelligent systems. One example of an intelligent system is the interpretation of a natural language.

Natural languages are the languages of humans such as English, French, Chinese and Arabic. If intelligent systems are going to produce what people would consider an intelligent response, they should be able to use natural language. Natural language is the means by which we share our knowledge. It is not an easy task to teach a person or a computer a natural language. The main problems are
syntax (the rules governing the way in which the words are arranged), and understanding context to determine the meaning of a word. To interpret even simple phrases requires a vast amount of knowledge. For example, teaching the computer the word 'square' must take into account the following contexts:

- ‘this shape is a square’
- ‘fair and square’
- ‘the square of two is four’
- ‘a square meal’
- ‘out of square’
- ‘square up’
- ‘square root’
- ‘square a debt’
- ‘you’re a square’

Natural language processing is applied in many applications, however, the results must be checked by the user. Word processors contain spell checkers, grammar checkers and auto-correct features that identify and correct likely spelling errors. Voice recognition programs provide 96 per cent accuracy even for continuous speech (see Figure 8.3). Automatic translation programs are able to accurately convert data to another language. All these applications have been influenced by AI research. But the development of natural languages is one of the challenges facing artificial intelligence. It is going to require further developments in information technology before a satisfactory solution is found.

**Expert systems and knowledge bases**

**Expert systems** provide information and solve problems that would otherwise require a person experienced in that field (expert). They are used in applications such as medical diagnosis, investment analysis, equipment repair and training. Expert systems provide information based on the knowledge of the expert. However, their conclusions are not guaranteed. It is up to the user to accept or reject the information. The main advantage of expert systems is their low cost compared with the expense of paying an expert or team of specialists.
Expert systems ask users a set of questions and compare their answers to a knowledge base. The knowledge base is a set of general facts and if–then rules. If the condition is true, then a certain deduction is made. For example, if it has four legs, then it is a dog. However, this deduction is not always valid. A more accurate deduction is obtained by using a set of if–then rules. For example, if it has four legs and if it has a tail and if it barks, then it is a dog.

The inference engine is the part of the expert system that carries out the reasoning by using the facts, assumptions, theories and rules. It carries out the reasoning by following a set of strict logical processes as opposed to the richness of human reasoning. The inference engine applies the if–then rules in the knowledge base to decide what question to ask next. There are two types of inference engines:

- forward chaining is an inference strategy where the user supplies all the data before the question is asked, or inference made
- backward chaining starts with one or more possible solutions and searches back through the system to determine the questions to be asked.

A knowledge base is often constructed using expert system shells, or simply shells. Expert system shells are a ready-made expert system except they contain no knowledge. When the knowledge is entered it results in an expert system. Shells provide an interface to assist the user in creating an expert system. The shell queries the user for facts and links between the facts. It enters this data into the knowledge base. The majority of shells represent knowledge using the if–then rules. The shell displays the word ‘if’ on the screen and the user enters the conditions. The deductions are added after the conditions. When a set of if–then rules are completed the shell builds a knowledge base. Expert system shells allow expert systems to be built very quickly. The great majority of expert systems in Australia are built using shells (see Figure 8.4).
Neural networks

A neural network is a computer system that works like the human brain and is capable of learning. It contains a large number of processors connected in a similar way to nerve cells in the human brain. These processors or nodes form a network and act like cells in the brain. A neural network finds relationships between sets of data to develop an understanding of the situation. In an early demonstration researchers trained a neural network to read aloud. It learned to do this task by being shown thousands of examples. Neural networks are very good at finding a link between the data and a result. They are being used by:

- financial firms for economic forecasting
- insurers to decide if a potential customer is a good risk
- marketers to predict which products will sell
- manufacturers to predict how much material they will need
- investment companies to make predictions.

Even though neural networks have been very successful, their applications are still limited. Most neural networks contain a few thousand nodes compared to about 100 billion in the human brain. As a result, neural networks take a very long time to train; recognising visual images requires the processing of large amounts of data. Neural networks are in the developmental stages and billions of dollars are being spent on research.

Agents and demons

Agents are pieces of software designed to search through databases for relevant data. They use the neural networks to efficiently search vast amounts of data. Agents are independent and can be launched into a computer system or network to operate in the background. The most common use of these agents is on the Internet, such as an email agent or a news agent. An email agent can screen a user’s incoming email for those requiring immediate action. Similarly a news agent is trained to scan articles in a news service and to deliver a personal bulletin based on a user’s preferences. Agents aim to carry out a task faster and more effectively than a human.

Demons are programs that spring to life when they are relevant, similar to how knowledge springs into your head when it is appropriate. Demons are an important feature in artificial intelligence as they allow computers to be self-modifying. This means that computers can teach themselves through experience. For example, if a computer observes an orange, a demon would be activated to learn from this experience.
Exercise 8.2

1. Explain the difference between:
   a. a knowledge base and an inference engine
   b. an expert system and a neural network.

2. What am I?
   a. A piece of software to search through databases for relevant data.
   b. A computer system that works like the human brain and is capable of learning.
   c. A program that springs to life when it is relevant.
   d. A ready-made expert system except that it contains no knowledge.

3. Copy and complete the following by replacing the letter in brackets with a suitable term:
   (a) systems ask users a set of questions and compare their answers to a (b). The knowledge base is a set of general facts and (c) rules. The (d) applies the if–then rules in the knowledge base.

4. a. What is an intelligent system?
   b. Why is it difficult to teach a computer a natural language?
   c. List some of the applications of expert systems.
   d. How does a neural network work?

Development

5. ‘Computers are becoming more intelligent, not allowing students to think.’ Do you agree with this statement? Give reasons for your answer. Your answer should contain examples of tasks performed by a computer that could be classified as intelligent.

6. There are many websites that use artificial intelligence, such as predicting share prices and a home-loan analyser. Investigate two websites that are applying AI. Write a report that describes the features of these two websites.

7. Use an expert system shell to create an expert system. You will need to decide on the subject area. Possible subject areas include choosing a sport, pet, computer or movie. Test your expert system.
A model is a representation of some aspect of the real world and a simulation is the use of that model. Modelling and simulation are used to make predictions and examine decisions concerning real situations. There are many different types of models used for simulations, including physical models, mathematical models and computer models. For example, a game of Monopoly® uses physical models of streets, money and houses to simulate the buying and selling of real estate (see Figure 8.5). However, since Monopoly is a game that depends on chance, the simulation is not used to make decisions concerning the real world.

People establish theories based on what they observe and measure in real life. Models are then built to test these theories to see if they are correct. If the model works it can then be used for simulation. Consider a situation in which temperature needs to be converted from Fahrenheit to Celsius. A theory is first proposed that a formula could be used to do the conversion. A model can now be developed by measuring a range of Fahrenheit and Celsius temperatures and determining their relationship. The following formula is a mathematical model used to test the theory:

\[
C = \frac{5}{9}(F - 32)
\]

\(C = \text{temperature in Celsius}\)

\(F = \text{temperature in Fahrenheit}\)

When the model has been tested using the range of Fahrenheit and Celsius temperatures and the results obtained are correct, it can be used in a simulation. The simulation uses the model (in this case the formula) to determine the Celsius temperature given the Fahrenheit temperature.

**Purposes of models and simulations**

Modelling and simulation are used when the real situation is time-consuming, expensive or impossible to reproduce. They are applied in situations where a prediction is required, or as learning tools.
• Many businesses use a spreadsheet to model the way their business works. The model usually consists of all the income and expenses of the business, with a simulation to determine its profit or loss. The data in the model can be changed and the results seen immediately. It is an invaluable tool and enables the business to run efficiently.
• Financial planners create models for different investment schemes and perform simulations. The amount invested, the interest rate and the period of the investment can be altered with each application. When the returns from each scheme are compared, the financial planners offer the best investment advice.
• Car manufacturers use the computer to simulate car crashes in order to test new cars and limit the amount of real crash testing. Engineers are able to watch a model of the car crumple under a given impact. The car’s structure is tested for its reaction to the stress of a crash at various speeds.
• Simulators are devices used for training and in experiments to simulate movement, flight or some other condition (see Figure 8.6). They are increasingly used in industry where it is too dangerous or too expensive for people to practise on the job.
• Drilling simulators are used in the oil and gas industry to train operators on the drilling rig floor. The trainee operators read gauges and dials, set drilling speeds, and use the brakes under the supervision of an instructor. The instructor can introduce faults and problems to monitor the progress of the operator.
• Simulators have also been used for the space shuttle mission. Astronauts are trained using a simulator, which is a model of the shuttle. It is very realistic and allows the astronauts to experiment and react to the conditions they will be encountering.
• Scientists use simulation in many ways. Molecular model kits are used to simulate the shape of complex molecules and have led to the discovery of chemical compounds. Computers can also create these models and allow the viewer to rotate the model on the screen. This allows scientists to examine the shape of compounds.
before they are synthesised. This can be useful in drug synthesis where the shape of the molecule is an important factor in its physiological response.

- Astronomers have used a simulation to find the position of stars that could not be seen from earth. The model uses data from radiation entering the earth’s atmosphere, and the simulation has enabled a supercomputer at NASA to construct a more detailed map of the universe. A theoretical model of a black hole has been used by scientists to simulate its flow of gases. This simulation involved 25,000 variables, 10,000 steps in each experiment and a solution consisting of 1.25 billion numbers.

**Advantages and limitations**

Modelling and simulation provide many advantages. In many situations it is safer, cheaper and quicker to use a model rather than the real situation. Designing a model of a car using a computer and simulating a range of tests is much more efficient than building the car. Minor changes to the model are easily completed and another simulation completed. In some situations, such as preparing astronauts for a space mission, a simulation is the only way of training. In business, models and simulations are used to ensure the business is profitable and to determine future opportunities.

A simulation is only as good as the model and the data used to create it. If the model is incorrect or the data entered is inaccurate then the simulation will produce the wrong result. In addition, if the model is too simple and does not take into account a major factor, the result of the simulation will be unreliable. For example, a model used by financial advisors that did not take into account rising interest rates would result in inaccurate advice when the simulation is performed.

**Exercise 8.3**

1. What am I?
   a. The use of a model.
   b. Software used by many businesses to model the way their business works.
   c. A model of the space shuttle used by astronauts for training.
   d. A type of computer used at NASA to construct a more detailed map of the universe.
Copy and complete the following sentences:

a. A _______ is a representation of some aspect of the real world.
b. If a model works it can be used for _______.
c. Modelling and simulation are used when the _______ is time-consuming, expensive or impossible to reproduce.
d. _______ create models for different investment schemes and perform simulations.

Unjumble these words:

a. nsiulaomti
b. lodme

How are models and simulation used by car manufacturers?

How are drilling simulators used by trainees?

Describe the way scientists use simulation.

What are the main advantages of modelling and simulation?

Most computer games involve a simulation. Compare and contrast a computer game to the real situation.

Modelling and simulation programs are freely available from the Internet. Use a simulation program and perform the simulation. Write a report to describe the use of this program. Evaluate the value of this program.

‘Modelling and simulation make life too predictable and are not benefiting our society.’ Do you agree with this statement? Why? Do research to find current applications of modelling and simulation to illustrate your answer.

There is a range of hardware and software that can be used to construct models and perform simulations.

Creating a model and performing a simulation can be completed on most computer systems. However, to achieve accurate and more realistic simulations hardware capable of performing computations quickly and with a high degree of precision is required. If the simulations are complex, such as scientific applications, then a supercomputer or mainframe may be required. These computers can process data at very high speeds and have extensive storage.
capabilities. Other hardware features include simulators, analog computers and parallel processors.

**Simulators** are devices used for training and experiments to simulate movement, flight or some other condition. For example, flight simulators have become an effective way to train pilots. The simulator consists of a model of a cockpit with authentic seats, realistic instrument panels and the ability to simulate movement using hydraulic legs that are controlled by the computer system. The simulation presents the trainee with different conditions to test their skills, such as the weather conditions at various airports or a mechanical failure in the aircraft. Flight simulators allow pilots to be trained without risking human life and valuable aircraft. Simulators are also used to train car drivers, racing drivers, crews of large ships or controllers of any other vehicle.

An **analog computer** is a device that processes analog data. It is designed to perform arithmetic functions on numbers that are represented by a physical quantity, such as a voltage. Analog computers can accept data directly from peripheral devices in analog form without having to first convert it into digital form. This allows analog computers to process data at very high speeds making them suitable for modelling and simulation.

**Parallel processing** is the use of several processors to share the calculations of a large task. Parallel processing is much faster than using one central processing unit to carry out several instructions one after the other. Parallel processing divides the processing task between a series of processors. Parallel processing provides high speed calculations needed in many modelling and simulation systems.

**Virtual reality** is an extension of a simulation program where a person interacts with the simulated world. It refers to a computer program and other devices that enable a person to perform tasks ‘virtually’ with all the function and effectiveness of the real situation. Images are displayed using special screens mounted in a helmet, and the user interacts through the use of a special glove that allows them to move through the simulated world by pointing and grabbing (see Figure 8.7).
Software

Software for modelling and simulation systems consists of modelling programs, programming languages, spreadsheets and simulation programs.

A *modelling program* is any program that allows the user to create models and simulate a real situation. Even though spreadsheets are used as modelling programs, there is more sophisticated software that specialises in creating models. These programs are very complex, usually containing a programming language, and have more flexibility in viewing and reporting data. One example is called EasyFlow. This modelling program is for fluid dynamics and has applications in aerospace, architecture, electronics and the environment.

All general purpose programming languages such as BASIC and C++ are used for modelling and simulation. However, specific simulation languages, such as Dynamo and Simula, have been developed for modelling and simulation applications. They contain definitions of the essential elements of a model and procedures for modifying and observing the model.

Simulation programs have been developed for many different fields, such as business, science and mathematics. These programs contain a model and allow the user to make predications and decisions based on the model (see Figure 8.8). In business, packages such as Marketplan and Brandaid are used for marketing, Callplan and Detailer for sales, and Mediac helps prepare advertising media schedules. There are also many simulation programs in science and mathematics that are used to test and teach theories. For example, a program called Catlab teaches the principles of genetics by modelling the breeding of cats with different colours.
Project: Gold Coast conference

Nita needed to organise a conference on the Gold Coast for her staff. She had to determine the cost of the conference, an outline of an itinerary and construct a budget. The problem was solved using the four stages in project development.

- **Define and analyse the problem:** A search of the Internet was completed to gather information on motels, places to visit, travel arrangements and possible dates. A project plan was written and some initial ideas discussed with her supervisor.

- **Design possible solutions:** Four possible solutions were examined in a feasibility study. Nita recommended a three-day conference at Conrad Jupiter’s. PowerPoint was used to present the solution to her supervisor for approval. The supervisor approved the solution if the cost could be reduced by 10 per cent.

- **Produce the solution:** A proposed budget was developed using a spreadsheet program. Nita used what-if predictions to obtain the cost reduction. The venue and air travel were booked. Each member of staff was advised of the arrangements and their responsibilities during the conference. The conference was completed and invoices received.

- **Evaluate the solution:** The cost of the conference was below the proposed budget. Each staff member completed an evaluation of the conference. The report on the conference, including the budget, was submitted to the supervisor for accountability.

**Tasks**

1. Why was a spreadsheet program used to construct a budget?
2. Investigate any templates that could be used to construct a budget. Describe the labels, values and formulas in these templates.

**Exercise 8.4**

1. True or false?
   - a. Analog computers can accept data directly from peripheral devices in analog form.
   - b. A special screen mounted in a helmet is often used for parallel processing.
   - c. Programming languages cannot be used for modelling simulation.
   - d. Simulation programs have been developed for many different tasks.

2. Copy and complete the following sentences:
   - a. The ability to perform_____ quickly is an important aspect in modelling and simulation systems.
b In virtual reality the user interacts with the simulated world using a _______.
c If simulations are complex, such as scientific applications, then _______ may be required.

3 What am I?
   a A device used for training and experiments to simulate movement, flight or some other condition.
   b A program that allows the user to create models and simulate the real situation.
   c An extension of a simulation program where a person interacts with the simulated world.
   d It divides the processing task between a series of processors.

4 a List some of the advantages of using a simulator.
   b What is an analog computer?
   c Describe two specific simulation languages.
   d Describe a simulation program.

Development

5 Simulation of natural disasters, such as earthquakes, is an attempt to save lives at the risk of interfering with nature. Does this application of technology further separate society from natural systems and result in a heartless attitude to the environment? Give reasons for your answer.

6 The requirements of models and simulations are constantly changing. Do research to examine the hardware needs for operating simulation programs. Write a summary of your investigation.

8.5 Using models and simulation programs

Data in a simulation represents the state of the model at any particular time. If the data is changed in the model then so is the simulation. Data is stored in variables and parameters.

Variables are items of data that may change. A variable name is used to store the data or value of the variable in a location of memory. For example, if A5 is used as a variable and given the value 10 (A5 = 10), then a specified memory location referred to as A5 will hold the number 10. In a modelling and simulation program, data that is stored in variables can be easily changed.

Parameters are variables whose values cause particular instructions to be completed. During the course of the simulation a parameter’s value might be continually changing, the model uses these values.
to help determine the result of the simulation. For example, in a modelling and simulation program the variable A5 might also be a parameter. If its value is 10 (A5 = 10) then a set of instructions is completed. However, if its value is 12 (A5 = 12), a different set of instructions is completed. The result of the simulation depends on the parameter A5.

**Spreadsheets**

A spreadsheet is a software package that can be used for modelling and simulation. It is a rectangular grid made up of rows and columns to organise and store data that require some type of calculation. A spreadsheet creates a model using formulas to represent the real situation. For example, a spreadsheet could be used to calculate loan repayments. It would use a formula that relates the interest rate, time period and present value of the loan. Spreadsheets can present data in tables and charts and make predictions based on trends.

All spreadsheets consist of rows that run horizontally across the screen and columns that run vertically down the screen. Rows are usually numbered 1, 2, 3, 4, and so on, while columns are often named in alphabetic terms A, B, C, up to Z; then AA, AB, AC up to AZ; then BA, BB and so on. The intersection of a row and column in a spreadsheet is called a cell. The position of the cell in the spreadsheet is called its cell address (or cell reference) such as A2. A range is a group of adjacent cells in a single row or column, or in several adjacent rows and columns. For example, the range B5:C7 contains the data in cells B5, B6, B7, C5, C6 and C7.

A spreadsheet is very particular about the type of data that is entered into each cell. There are three main types of data called labels, values and formulas (see Figure 8.9):

- **Label** is text entered into a cell to provide some explanation of the spreadsheet. Calculations...
are not carried out using this data. Labels are used for headings in rows and columns.

- **Values** are numbers stored in a spreadsheet on which calculations can be carried out.
- **Formulas** are instructions to perform a calculation. The answer to the calculation will always appear in the cell that contains the formula. The formula itself is not shown. The user can create a formula or select a predefined function such as 'average'. Formulas often contain cell addresses that are used as parameters.

Spreadsheets have many features that make them easy to use. Some of the features include editing data, workbooks, templates, macros and charts.

- **Editing data** is completed on the spreadsheet or using the formula bar. Cut and Paste, Copy and Paste, or Drag and Drop are used to copy values, labels, cell references and formulas into other cells. The Fill down or Fill right instruction copies the contents of a cell into a range of adjacent cells.
- **A workbook** is made up of one or more spreadsheets called worksheets or sheets. These sheets allow the user to organise related information in a single file.
- **A template** is a document created for repeated use. A spreadsheet template contains labels and formulas to solve a particular problem. The user enters the values to obtain the required solution. A template saves time and effort.
- **A macro** is a series of commands stored in a file that can be executed by pressing a few keys. Macros allow many operations to be performed automatically, such as opening menus, choosing commands or entering text.
- **A chart** is a graphical representation of numerical data. Charts convert data in rows and columns into a picture that is read at a glance. Charts make data easy to understand. Trends are revealed and comparisons can be made instantly. Charts assist people to make quick and accurate decisions.

**What–if predictions**

What–if predictions are a process of making changes to the data and observing their effects. It answers ‘what–if?’ questions: What if the interest rate increases by 1 per cent, what would be the effect on my loan repayments? What if I buy a car with a fuel consumption of 8
L/100 km instead of 10 L/100 km? How would this affect the cost of fuel over the next two years? Spreadsheets instantly give the user the answer to 'what–if' questions. You change the data and observe the effect.

Goal Seek is a command used to make what–if predictions. If the user knows the result of a particular formula, but not the value to be entered, then Goal Seek will determine this value. For example, in Figure 8.10 Goal Seek is used to determine the sales of cola in December that will result in average monthly sales of eighty for the past six months.

Spreadsheet design

A spreadsheet must be well designed and easy to use. There is no correct way to design a spreadsheet. Each particular problem has its own design requirements. However, a well designed spreadsheet has four easily identifiable areas called the instruction, input, calculation and output (see Figure 8.11):

- **Instruction area**—information about the spreadsheet or directions for use of the spreadsheet. It is usually at the top of the spreadsheet and includes a title, a description, the author and date. Larger spreadsheets include a brief outline of their structure, directions and parameters.

- **Input area**—labels for headings and values on which calculations are based. The format of values and labels is often completed after the data has been entered. For example, when entering money values do not include the $ sign as these values can be format to currency after the numbers have been entered. All inputs should be labelled clearly so the user knows where and how to enter the data.
• **Calculation area**—formulas and functions complete the work of the spreadsheet. The calculation area is the heart of a spreadsheet.

• **Output area**—displays the result of the spreadsheet. In many spreadsheets the output area and the calculation area will be the same. All outputs should be clearly labelled so the user understands the results. Presentation of data should be suitable to the type of data and its use. Often a chart will display the information in more understandable form for a decision to be made.

### Exercise 8.5

1. Explain the difference between:
   a. variables and parameters
   b. labels and values
   c. templates and macros
   d. an instruction area and an input area of a spreadsheet.

2. What am I?
   a. The instructions in a spreadsheet to perform a calculation.
   b. One or more worksheets.
   c. The process of making changes to the data and observing the effects.
   d. A graphical representation of numerical data.

3. Copy and complete the following by replacing the letter in brackets with a suitable term:
   All spreadsheets consist of (a) that run horizontally across the screen and (b) that run vertically down the screen. The (c) of a row and a column is called a cell. A range is a group of (d) cells in a single row or column.
4  a  What is a spreadsheet?
   b  How are rows and columns numbered in a spreadsheet?
   c  List the three main types of data in a spreadsheet.
   d  How is data edited in a spreadsheet?

Development

5  Create the three spreadsheets shown in this section. Answer the following questions by referring to these spreadsheets.
   a  What is the parameter? Give an example.
   b  Use the 'Fill Down' command to enter data. Describe the steps to use this tool.
   c  Explain the difference between an absolute and relative reference. Give an example.
   d  What is a function? List ten different types of functions and give an example using correct syntax.
   e  Use Goal Seek to perform a ‘what–if’ prediction. Describe the steps in your prediction.

6  Design a spreadsheet to analyse your time management. For each day of the week, enter the amount of time (in hours) you spend on sleep, eating, television, homework, study and other activities. Use the spreadsheet to total the hours for each activity and find the weekly averages. Design the spreadsheet using four easily identifiable areas. Construct appropriate charts from this spreadsheet.
Part A: Multiple choice questions

Select the alternative (a), (b), (c) or (d) that best answers each question.

1. Which of the following is the person who effectively started the field of artificial intelligence?
   a. Joseph Weizenbaum
   b. John McCarthy
   c. David Marr
   d. Alan Turing

2. Which of the following describes artificial intelligence?
   a. Aims to give computers the ability to think like human beings
   b. The ability to understand, learn and to control behaviour in any new event
   c. A computer system that works like the human brain and is capable of learning
   d. The ability to give an intelligent response using natural languages

3. Which of the following is the set of general facts and if–then rules in an expert system?
   a. Database
   b. Knowledge base
   c. Inference engine
   d. Intelligent agent

4. Which of the following describes expert system shells?
   a. Receive data from the environment, react to that data and produce an intelligent response
   b. Provide information and solve problems that would otherwise require a person experienced in that field
   c. Carry out the reasoning by using the facts, assumptions, theories and rules
   d. Software used to construct a knowledge base in an expert system

5. Which of the following is a representation of some aspect of the real world?
   a. Model
   b. Simulator
   c. Demon
   d. Agent

6. Which of the following is not an advantage of modelling and simulation systems?
   a. Predicts the result of an event
   b. Teaching tool to prepare trainees
   c. Inexpensive to use compared to the real situation
   d. Results of the simulation cannot be changed

7. What is the name of a device used for training and experiments to simulate movement, flight or some other condition?
   a. Virtual reality
   b. Simulator
   c. Experimenter
   d. Training machine

8. Which of the following is a simulation language?
   a. Simula
   b. Sim City
   c. Java simulator
   d. Simlang
9 Which of the following is an instruction to perform a calculation in a spreadsheet?
   a Formula
   b Value
   c Label
   d Macro

10 Which of the following is not a method of editing data in a spreadsheet?
   a Cut and paste
   b Drag and drop
   c Fill down
   d Formula bar

Part B: Matching the term
For each of the following statements (1 to 10), select from the list of terms (a to j) the one that most closely fits the statement.

Statements
1 Provides information and solves problems that would otherwise require a person experienced in that field.
2 A system that works like the human brain and is capable of learning.
3 A set of general facts and if-then rules.
4 A representation of some aspect of the real world.
5 A device used for training and experiments to simulate movement, flight or some other condition.
6 Item of data that may change.
7 A rectangular grid made up of rows and columns to organise and store data that require some type of calculation.
8 A process of making changes to the data and observing their effects.
9 A system that receives data from the environment, reacts to that data and produces an intelligent response.
10 It aims to give computers the ability to think like human beings.

Terms
a Artificial intelligence
b Expert system
c Intelligent system
d Knowledge base
e Model
f Neural network
g Simulator
h Spreadsheet
i Variable
j What-if predictions
Part C: Extended-response questions

Write at least one paragraph for each of the following:

1. Why is it so difficult to define artificial intelligence? How would you test whether a computer was ‘intelligent’?

2. ‘Developments in information technology will eventually allow computers to create their own knowledge bases.’ Explain this statement.

3. You are a passenger on a plane and have just learned that it will be landing automatically using an expert system. What is an expert system? How do you feel about this situation? Give reasons for your answer.

4. Describe a situation that uses a model and simulation. What are the advantages of this simulation? Outline the requirements of this simulation.

5. Describe the requirements of models and simulations. Divide your answer into hardware and software.

6. Spreadsheets are often described as the first ‘killer application’. People bought personal computers to use spreadsheets. Why are spreadsheets so popular? Outline the advantages of spreadsheets compared to manual methods of performing the same tasks.

Project: Pizza shop

A pizza shop is having problems meeting its costs. It needs to decide whether it should increase or decrease its prices. Visit a local pizza shop to obtain current price structures, types of pizzas and the typical sales during the week. Design a spreadsheet model that could be used to estimate the effects of different prices on revenue and the quantity of pizzas purchased. Survey students on their pizza preferences and use this information to make a recommendation to the owner of the pizza shop. Demonstrate the use of what-if predictions to assist your decision. Your solution should be developed using the four stages in project development.