CHAPTER 2

Input and output devices

In this chapter you will learn about:

- input devices:
  - the uses of each device
  - the advantages of each device
  - the disadvantages of each device
- output devices:
  - the uses of each device
  - the advantages of each device
  - the disadvantages of each device
- control applications and the uses of each device.

2.1 Input devices

As the name suggests, input devices are hardware devices that allow data to be input into a computer. Many such devices exist, ranging from the more common ones, such as the keyboard, through to the more specialist devices, such as barcode readers. A number are described in this section.

Keyboards

These are the most common input devices and are used to input text, numbers and instructions into the computer. Most use the **QWERTY** layout (this name comes from the keys on the top row, which spell out 'QWERTY').

Ergonomic keyboards have also been developed recently. These are designed to reduce health-related problems associated with the standard keyboard (e.g. carpal tunnel syndrome or repetitive strain injury (RSI) – see Section 6.7).

Uses

- Keyboards are used to input data into applications software (e.g. text into word processors, numbers into spreadsheets, etc.).
- They are also used for typing in commands to the computer (e.g. Prnt Scrn, Ctrl+P to print out, etc.)

Advantages

- Keyboards enable fast entry of new text into a document.
- They are a well-tried technology and a well-known method of entry.
- Most people find them easy to use.
- It is easy to do **verification** checks as data is entered, as it appears on the screen simultaneously.

Disadvantages

- Users with limited arm/wrist use can find keyboards hard to use.
- Entering data using a keyboard is slow when compared to direct data entry (e.g. **optical mark recognition**).
- Keyboards are fairly large devices that use up valuable desk space.

The **concept keyboard** uses icons or phrases instead of standard letters. These are often used in, for example, fast food restaurants, offices and shops, where a single key represents an item. For example, the symbol shown in the photo represents 'add tax'. The person using the keyboard only needs to touch this key to calculate the tax on an invoice.

Advantages

- Concept keyboards enable fast data entry, as there is no need to type in whole commands.
- They are waterproof, which is useful in a restaurant environment.
- These keyboards are tamper proof and so are useful in certain applications (e.g. at unmanned airport information kiosks), preventing people from keying in information which could potentially corrupt the computer system.

Numeric keypads

A **numeric keypad** is used to enter numbers only (although some have a function key to allow input of alphabetic characters).

Uses

- Numeric keypads are used in **automatic teller machines (ATMs)**, where customers can key in their **personal identification number (PIN)**, an amount of money, etc.
- Telephones have numeric keypads to allow phone numbers, etc. to be keyed in.
- **Electronic point of sale (EPOS) terminals** have numeric keypads in case the barcode reader fails to read the barcode and the number has to be keyed in manually by the operator.
- Chip and PIN devices have numeric keypads for entry of PIN, amount of money, etc.
- They are used to enable fast entry of numeric data into a spreadsheet.

Advantages

- Numeric keypads are faster than standard keyboards for entry of numeric data.
- Since many are small devices (e.g. mobile phones), they are very easy to carry around.

Disadvantages

- They can be difficult to use, due to very small keys.
- It is difficult to use them for entering text.
- Sometimes the order of the numbers on the keypad isn't intuitive.

Mice

The **mouse** is an example of a **pointing device**. A ball is used underneath the mouse to detect movement, so by moving the mouse around the user can control the position of a pointer on the screen. There are usually two buttons, which have different functions: very often the left button is used to select something by double clicking it and the right button brings up drop-down menus (see Figure 2.1).

Many mice also have a scroll button, which speeds up the process of moving through a document.

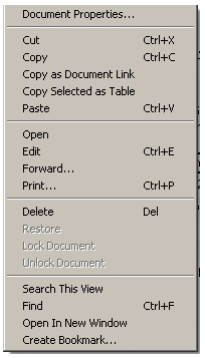

Figure 2.1 Example of a drop-down menu

Recent developments have produced the **optical mouse** (where movement is detected by reflected light rather than the position of a moving ball) and the **cordless mouse** (which is an example of a wireless device). The advantage of an optical mouse is it has no moving parts and it also doesn't pick up any dirt. This makes it more robust and improves its performance, since the older type of mouse can 'skid' on certain surfaces reducing the control of the pointer.

Uses

- Mice can be used for opening, closing and minimising software.
- They can be used for grouping, moving and deleting files.
- They are very useful when editing images, for example controlling the size and position of a drawing pasted into a document.
- Mice are used for controlling the position of a pointer on the screen to allow selection from a menu or selecting an icon and for scrolling up and down/left to right.

Advantages

- It can be faster to select an option using a mouse rather than a keyboard.
- Mice enable rapid navigation through applications and the internet.
- Mice are small and so take up little area.

Disadvantages

- People with restricted hand/wrist movement can find it hard to operate a mouse.
- Mice are easily damaged and the older type of mouse also quickly becomes clogged up with dirt.
- They are difficult to use if there is no flat surface readily available (e.g. on an aeroplane).

Touchpads

Touchpads are used in many laptop computers as a pointing device. The pointer is controlled by the user moving their finger on the touchpad and then gently tapping it to simulate the left hand button of a mouse (i.e. selection). They also have buttons under the touchpad which serve the same function as the left and right buttons on a mouse.

Uses

The uses of a touchpad are the same as those of a mouse.

Advantages

- It can be faster to select an option using a touchpad rather than a keyboard.
- Touchpads enable rapid navigation through applications and the internet.
- Since the touchpad is integrated into the laptop computer, there is no need for a separate mouse, aiding portability.
- They can be used even when there are no flat surfaces available.

Disadvantages

- People with limited hand/wrist movement find touchpads difficult to use.
- It can be more difficult to control the pointer when compared with a mouse.
- They are more difficult to use when doing certain operations such as 'drag and drop'.

Trackerballs

Trackerballs are similar to a mouse, except that the ball is on the top of the device and the user controls the pointer on the screen by rotating the ball with the hand. Some trackerballs have two buttons which have the same function as the left- and right-hand mouse buttons. If they have a third button, this is equivalent to a double click.

Uses

- They have the same pointing/cursor control capability as a mouse.
- They are used in applications where the user has a disability (such as RSI).
- They are used in a control room environment, where it is faster than a mouse to navigate through process screens and is more robust than a mouse.

Advantages

- Trackerballs do not need the same fine control as a mouse.
- People with limited hand/wrist movement find it easier to use than a mouse.
- The pointer can be positioned more accurately on the screen than with a mouse.
- They take up less desk space than mice since they are stationary.

Disadvantages

- Trackerballs are not supplied with the computer as standard, so they are more expensive.
- User may need training since they are not standard equipment.

Remote controls

A **remote control** is used to control the operation of other devices remotely by using infra red signals. The buttons on the keypad are used to select options (such as television stations, sound levels on a hifi, timings on a DVD recorder, etc.).

Uses

- Most home entertainment devices such as a television, satellite system, DVD player/recorder, hifi systems, etc. have remote controls.
- Remote controls are also used to control multimedia systems.
- They are used in industrial applications to remotely control processes, stop and start machinery, etc.

Advantages

- Remote controls enable devices to be operated from any distance, which is particularly useful for people with disabilities.
- Some chemical processes are hazardous, so it is safer to operate equipment from a distance.

Disadvantages

- People with limited hand/wrist movement can find them hard to use.
- The signal between the control and the device can be easily blocked.

Joysticks

Joysticks have similar functions to mice and trackerballs. By gripping the stick, a pointer on the screen can be controlled and buttons are used to make selections. Often they have another button on the top of the stick that is used for gaming purposes, e.g. to fire a weapon.

Uses

- Video/computer games are often controlled by joysticks.
- They are used in **simulators** (e.g. flight simulators) to mimic actual controls.

Advantages

- It is easier to navigate round a screen using a joystick rather than a keyboard.
- Control is in three dimensions.

Disadvantages

- It is more difficult to control the on-screen pointer with a joystick than with other devices, such as a mouse.

Touch screens

With this system the user can choose an option by simply touching the button/icon on the screen. The selection is automatically made without the need for any pointing device.

Uses

- Touch screens are used for self-service tills, e.g. petrol stations, where the user just touches the screen to select the fuel grade and payment method.
- Touch screens are used where selections are made on screen, for example ATMs, point of sale terminals (e.g. at restaurants), public information systems at airports, railway stations, tourist offices.
- Personal digital assistants (PDAs), mobile phones and satellite navigation systems use touch screens.
- Interactive white boards used for education are large touch screens.
- Touch screens are used in computer base training (CBT) where selections are made in answering on screen testing.

Advantages

- Touch screens enable faster entry of options than using a keyboard or a mouse.
- It is very easy to choose options.
- It is a user friendly method for inputting data, so no training is necessary.
- Touch screens are tamper proof, preventing people from keying in information which could potentially corrupt the computer system (e.g. at unmanned ticket collection kiosks).

Disadvantages

- There is a limited number of options available.
- Using touch screens frequently can lead to health problems (e.g. straining of arm muscles, RSI, etc.).
- The screen can get very dirty with constant touching.

Magnetic stripe readers

Figure 2.2 The magnetic stripe on a credit card

These are used to read information on the **magnetic stripe** found, for example, on the back of a credit card (see Figure 2.2). The stripe contains useful information, such as the account number, sort code, expiry date and start date.

Uses

- Credit and debit cards have magnetic stripes that are used by ATMs or EFTPOS (electronic funds transfer point of sale) terminals.
- Security cards for entry to buildings, hotel rooms, etc. use magnetic stripes.
- Travel systems (e.g. train and underground tickets) use magnetic stripes.

Advantages

- Data entry is faster compared with keying in using a keyboard or keypad.
- The system is error free, since no typing is involved.
- The information held on the magnetic stripe is secure: because it cannot be read directly by a person; and, since there is no typing, there is not the risk of somebody observing your key strokes.
- They can prevent access to restricted/secure areas.
- Magnetic stripes are unaffected by oil, water, moisture, etc.
- There are no moving parts, so they are physically very robust.

Disadvantages

- If the magnetic stripe gets damaged (e.g. due to exposure to a strong magnetic field or excessive use) the data is lost.
- The card needs to be in close contact with the reader, so magnetic stripe readers don't work at a distance.
- Since the information is not human readable, this can be a disadvantage in some applications (e.g. hotel room numbers are not printed on the card, so there needs to be another way of showing the information for the customer).

Smart card readers

Figure 2.3 The chip on a smart card

Smart cards contain chips (see Figure 2.3) and are similar to magnetic stripe cards. With these cards the information is stored on the chip (e.g. PIN and personal data). The data stored on the chip can be updated (e.g. on loyalty cards). For example, certain oil companies use these cards: when a customer buys fuel at a filling station, the loyalty card is swiped and 'points' are added to the card; these points can be used for air miles, money off next purchases, and so on. The storage capacity of the chip is much greater than a magnetic stripe, so more information (such as customer details) can be stored.

Uses

- Loyalty cards, ID cards and public transport passes use smart cards.
- Smart cards can be used to track customer/passenger movements (e.g. on a metro system).
- They are used with satellite systems to decode program signals.
- Smart cards are used for electronic passports and driving licences.

Advantages

- Some smart cards (e.g. transport tickets) are used instead of money, reducing the need to carry cash.
- The chip on the card does not need to be in contact with reader, so there is less damage compared with a magnetic stripe reader.
- Data is more secure, since it is easier to copy information on a magnetic stripe than it is to copy information on a chip.

Disadvantages

If the card is lost, information stored on the chip could be used in identity theft.

Chip and PIN readers

Chip and PIN readers are similar to smart card readers, but are used at EFTPOS terminals. The device has a slot into which the card is placed and the chip is read. The PIN is entered using the keypad. A small screen is also part of the reader, which gives instructions to the operator.

Uses

- Chip and PIN readers are used where payments are made using cards (restaurants, supermarkets, travel agents, etc.).

Advantages

- Chip and PIN readers provide a more secure payment system than requiring a signature or using a magnetic stripe, since the PIN typed in must match up with PIN stored on chip.
- Chip and PIN readers provide a more robust system than magnetic stripe readers, since the chip does not need to be in contact with the reader.

Disadvantages

- Since the customer types in the PIN, they need to be careful that it isn't read by somebody else, thus giving an opportunity for fraud.

Scanners

Scanners are used to enter information on hard copy (e.g. text documents, photographs) into a computer. The most common type is the flat bed (as shown here) which is made up of a glass panel and lid. The hard copy document or photo is scanned by a light source and produces a computer-readable image.

The subsequent image can then be manipulated using a drawing package. Images can also be used with optical character recognition (OCR) software to allow the information to used in a word processor, desktop publishing, presentation software, etc. Specialist scanners exist which are designed to carry out a specific task, e.g. barcode scanners (discussed later in this section).

Uses

- Scanners are used to scan in documents and convert them into a format for use in various software packages.
- Old and valuable documents and books can be scanned, thus protecting the originals from damage through handling and also producing records in case the paper copies are lost or destroyed.
- Non-digital photographs need to be scanned if they are to be stored on computer.

Advantages

- Images can be stored for editing at a later date (paper documents cannot be edited unless they are scanned first).
- Scanners are much faster and more accurate (i.e. no typing errors) than typing in documents again.
- It is possible to recover damaged documents and photographs by scanning them and then using appropriate software to produce an acceptable copy.

Disadvantages

- The quality can be limited, depending on how good the scanner resolution is.

Barcode readers

Barcode readers are used to read information in the form of a bar code (illustrated in Figure 2.4). The readers are usually in the form of a barcode scanner and are often built into POS terminals in supermarkets. *Handheld scanners or wands* (as shown here) are also very common for reading barcodes if portability is required (e.g. if the barcodes are on large or fixed objects).

Figure 2.4 A barcode

Uses

- Barcode scanners are used in supermarkets and other shops where the goods are marked with a barcode; the barcodes are used to give information about the product, which enables automatic stock control, itemised billing, etc. to take place.
- They are used in libraries, to scan both users' library cards and barcodes on books, in order to keep track of books on loan.
- They are used as a safety function in many companies to ensure that electrical equipment is checked on a regular basis. Barcodes are placed on an item to identify it and a database holds all the information related to that barcode so it is possible to interrogate the system as part of a safety audit.

Advantages

- Scanning barcodes is much faster than keying in data manually and fewer mistakes are made.
- When barcodes are used as a way of recording data, they can improve safety.
- Barcodes enable automatic stock control.
- Barcode scanning is a tried and trusted technology.
- When an item price is changed, only the central database needs to be updated. There is no need to change the prices individually on each item.

Disadvantages

- Barcode scanning is a relatively expensive system to administer since every item in the shop needs a barcode and every barcode needs to be entered on to the central database. Also, there is a need to invest in the computer technology together with staff training, which can all be very expensive.
- The system is not foolproof – barcodes can be swapped around on items!

OMR devices

Optical mark recognition (OMR) is a system which can read marks written in pen or pencil. The places where the pen or pencil marks can be made are clearly shown on the form, for example:

1 ●–● 2 ● ● 3 ● ●

In this example, a pencil mark has been made between the dots on answer 1. The position of the mark is stored in the computer's memory after being read by the OMR device.

Uses

- OMR devices are used to read questionnaires, multiple-choice examination papers and many other types of form where responses are registered in the form of lines or shaded areas.

Advantages

- It is a very fast way of inputting the results of a survey, etc. – the documents are fed in automatically and there is no user input.
- Since there is no typing, it is more accurate than keying in the data.
- OMR is more accurate than OCR (discussed later in this section).

Disadvantages

- The forms need to be carefully designed to make sure that the marks/shading are correctly positioned to gather accurate information.
- There can be problems if the forms haven't been filled in correctly and sometimes they have to be manually checked before being read by the OMR device – this is both time consuming and expensive.

OCR readers

Optical character recognition (OCR) is the name given to software that takes scanned text and converts it into a computer readable form. The text can then be used in various application packages such as word processors, desktop publishers and presentation software.

Uses

- One of the most recent uses is in the processing of passports and identity cards.
- OCR is used when scanning in documents so that they can be modified using a word processor or desktop publisher package.

Advantages

- It is a much faster data entry system than manually keying in data.
- Since no manual data entry, the number of errors is also reduced.

Disadvantages

- The system still has difficulty reading handwriting.
- It is still not a very accurate technique.

MICR devices

Magnetic ink character recognition (MICR) is a system which can read characters printed in a special ink (containing iron particles). Only certain characters written in a standard font can be read, for example the characters at the bottom of a bank cheque (see Figure 2.5). These characters are converted into a form that the computer can understand and then stored in a computer file.

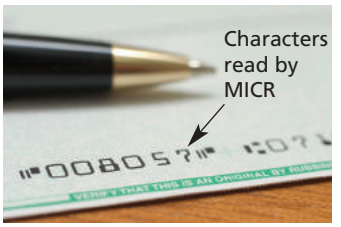

Figure 2.5 A bank cheque

Uses

- It is primarily used to process cheques in banking operations. When a cheque is presented its value is then printed on the cheque in the special ink. The cheques are all gathered together (either at the end of the day or after some specified period) and then read using a **batch processing** method (see Section 7.9).

Advantages

- MICR offers greater security than OCR since the printed characters cannot be altered.
- There is no manual input, thus errors are reduced.
- Even if somebody writes over the magnetic ink characters (e.g. with a signature) they can still be read.

Disadvantages

- Only certain characters can be read and the number of different characters is very limited.
- It is a more expensive method than other methods used in direct data entry.

Digital cameras

Figure 2.6 USB connectors

Digital cameras are rapidly replacing traditional, film-based cameras. Once photographs are stored in memory, they are easily transferred to a computer using a **universal serial bus (USB)** connection (see Figure 2.6). Once saved, the images can be manipulated (e.g. cropped, re-sized, contrast altered, etc.).

Uses

- Digital cameras produce photographs for transfer to a computer directly or to print out by connecting directly to a printer.
- Many digital cameras also allow short video clips to be produced.
- Photographs can be uploaded directly into applications software such as word processors, desktop publishers, etc.

Advantages

- It is easier to produce better quality photographs than with a traditional camera.
- It is easier and faster to upload photographs to a computer rather than having to scan in hard copies when using traditional methods.
- There is no need to develop film and print out photographs any more – this saves money and is also environmentally more acceptable (saves paper and no longer need the chemicals used in developing the films).
- It is easy just to delete an image from memory if it is not satisfactory and take the photograph again.
- The memory cards can store several hundred photographs. A traditional camera was limited by the number of photographs that could be taken on a roll of film.

Disadvantages

- The camera user needs to be computer literate to use the cameras properly; also the transferring, storing and manipulating of the images via a computer requires some understanding of how computers work.
- There is some artistry lost since clever software now corrects errors in the photographs (e.g. incorrect exposure, removal of red eye, etc.).
- The resolution is not yet as good as traditional cameras, although this is improving all the time. The quality of photographs depends on the number of **pixels** (many cameras now offer more than 10 mega pixels per image), quality of lens, etc.
- Images often need to be compressed to reduce the amount of memory used (a single image can use more than 2 Mbytes of memory, for example).
- It is possible to fill up computer memory very quickly with several photographs of the same subject in an attempt to find the 'perfect' snap shot.

Webcams

Webcams are similar to digital video cameras; however, they are connected directly to the computer (through a USB port) and they do not have a memory. The information that the webcam picks up is transmitted directly to the computer. Many computer systems now have webcams built into the top of their monitors as standard equipment.

Uses

- While chatting online, many people use webcams as a more personal way of having a conversation.
- They are used to enable video conferencing to take place (discussed in Chapter 4).

Advantages

- Webcams can be left on constantly, only being activated as required.
- They allow people to keep in contact with each other without the need to travel, so they are particularly useful for elderly or disabled people.

Disadvantages

- Webcams have very limited features and the picture is often of poor quality.
- They need to be connected to the computer, although this is less of an issue with laptop computers when the webcam is built into the monitor lid.

Microphones

Microphones can be connected directly to a computer. Sounds can be inputted and then manipulated. The input sound is converted to an analogue signal and then converted into a digital signal. The computer's sound card usually does this automatically (i.e. it acts as an **analogue to digital converter (ADC)**.

Uses

- Microphones are used to input speech/sounds to be used in various applications, e.g. presentations, sampling (in films, music, etc.), special effects (films).
- They are used in voice recognition software, which can have a number of purposes, for example:
  - conversion of speech into text that can be used in, for example, a word processor
  - recognition of commands (e.g. some cars now have voice-activated systems to switch on the lights, turn up the radio volume, etc.).

Advantages

- It is faster to read in text than to type it in using a keyboard.
- Using special software, it is possible to manipulate sound in real time rather than working on a recording done at some earlier stage.
- If used in a voice activation system, this has the advantage of improving safety since, for example, car drivers don't need to take their hands off the wheel to operate a switch or alter the radio station etc.

Disadvantages

- Sound files can use up a lot of computer memory.
- Voice recognition software isn't as accurate as typing in manually (for example, the software can't distinguish the difference between 'their' and 'there').

Sensors

This section deals with **analogue sensors**. A sensor is a device which inputs data to a computer, where the data is a measurement of some physical quantity which is continuously changing (e.g. temperature, light, moisture, etc.). These physical quantities are analogue in nature. Since computers only understand digital data (i.e. 1s and 0s), the information from the sensors needs to be converted into a digital form. This is done using an analogue to digital converter (ADC).

Uses

Sensors are used in monitoring and control applications – the type of sensor depends on the application (see Table 2.1). When monitoring, the data sent to the computer is often transferred directly to a spreadsheet package (e.g. taking measurements in a scientific experiment, measuring atmospheric pollution, etc.).

Type of sensor	Applications
Temperature	Automatic washing machines, central heating systems, automatic greenhouses, ovens
Pressure	Burglar alarm systems, washing machines, robotics, environmental monitoring
Light	Automatic greenhouses, automatic doors, burglar alarm systems, street lighting control
Sound	Burglar alarm systems, monitoring liquid and powder flow in pipes
Humidity/moisture	Automatic greenhouses, environmental monitoring, factories where moisture levels are crucial (e.g. manufacture of microchips, paint spraying)
pH	Automatic greenhouses, chemical processes, environmental monitoring

Table 2.1 Applications of different types of sensors

Advantages

- Readings taken using sensors are generally more accurate that those taken by human operators.
- Readings are continuous, so there is no break in the monitoring.
- Because it is a continuous process, any necessary action (control system) or warning (monitoring system) will be initiated immediately.
- The system can be automatic, removing the need for human intervention. This is particularly important if the process is hazardous or needs precise control/monitoring.

Disadvantages

- Faulty sensors can give spurious results (e.g. if the sensors on the rear bumper of a car which monitor for obstacles become dirty, they may either not identify an obstacle or give a continuous alarm).

Graphics tablets

A **graphics tablet** is used with a stylus to produce freehand drawings for example. The images produced can then be stored in a file on a computer.

Uses

- Graphics tablets are used to produce drawings, computer graphics, etc.
- In countries where characters are complex (e.g. China, Japan), they are used as a form of input since it is faster than typing in the characters using a keyboard.
- They are used in **computer aided design (CAD)** work.

Advantages

- It is possible to modify drawings before they are input.
- They offer a very accurate method of drawing, which is better than using a mouse or trackerball.

Disadvantages

- They are more expensive than other pointing devices, such as a mouse.

Light pens

Light pens contain sensors that send signals to a computer whenever light changes are detected. At the moment, the devices only work with **cathode ray tube (CRT) monitors** (see Section 2.1) because they rely on the screen image being built up row by row by an electron beam. The screen is refreshed 50 times every second, so the computer is able to determine the pen's position by noting exactly when the light pen detected the electron beam passing its tip. Systems to operate with **thin film transistor (TFT) monitors** are still at the development stage.

Uses

- Light pens are used for selecting objects on CRT screens.
- They are also used for drawing on screen (e.g. with CAD packages).