

Chapter 6: Sensors

Learning objectives

By the end of this chapter you will:

- be able to define the term sensor
- understand how a range of sensors input data into a computer system
- describe how a range of sensors are used in many areas of our lives.

6.01 Introduction

SYLLABUS CHECK

Describe how a range of sensors can be used to input data into a computer system, including light, temperature, magnetic field, gas, pressure, moisture, humidity, pH and motion.

Describe how these sensors are used in real-life scenarios, for example: street lights, security devices, pollution control, games, and household and industrial applications.

A **sensor** is another type of input device. It is a device that records data about the physical environment around it. This data is output in the form of a signal for a computer to process. It is this signal that becomes the input of data for the computer.

To find out more about input devices, see Chapter 5.

Sensors can replace the need for a human to detect and record these changes. As it is a device and not a human doing this it may be less prone to error and natural variance in results. Sensors can also be used in situations to collect data where it is too dangerous for a human to work.

There are many different kinds of sensor that record data about many different aspects of the environment.



KEY TERM

Sensor – a type of input device that detects changes in the environment surround it.

Ambient light – the brightness or darkness at the current time.

6.02 Light sensors

A light sensor is a device that detects light. It will detect the **ambient light** level, meaning how bright or dark it is. In this way light sensors are like our eyes: we can detect how bright or dark it is and respond to this. We may put on sunglasses if we think it is too bright or we may switch on a lamp if we think it is too dark.

Light sensors can be used in street lights. We could set our street lights to turn on at a certain time each evening and turn off at a certain time each morning. However, the rate at which it gets dark each evening and light each morning changes throughout the year, even from day to day. This would mean we would regularly need to change the time we have set the street lights to turn on and off again. This could also mean that electricity is wasted if we get a particularly light evening and the street lights are turned on whilst it is still light. We could put a light sensor in street lamps to measure the ambient light level. When it gets too dark the lights will be automatically turned on and automatically turned off when it becomes light again.

Light sensors are used in many different ways and are built into many of the devices and systems we use on a daily basis. A security system can make use of light sensors. The sensors can beam light from one sensor to another. If a beam of light is broken by a person or object going through it, the next sensor will recognise this and send a signal to a computer to tell it the security system has been breached. This could then cause a response such as an alarm to sound. You may have seen an example of this kind of security system guarding precious items in movies.

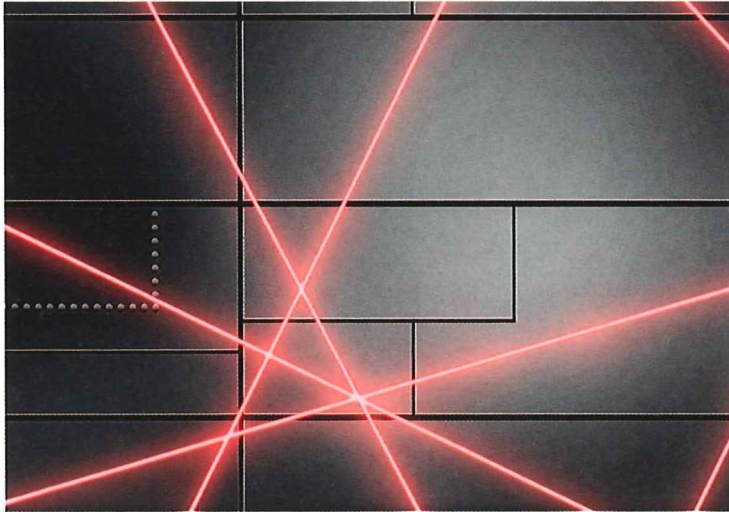


Figure 6.01 Light beams and light sensors can be used to create a security system

A light sensor can be used in regular devices in our household. We may have a garage door that opens and closes at the push of a button. However, if the button to close the garage door gets pushed accidentally, when a car or another item is in the way, there could be a lot of damage done. A beam of light can be sent from sensors lining the doorway that can check if anything is in the way. If the beam gets from one side to the other without being interrupted then the garage door can be triggered to close safely. Otherwise, if the beam is interrupted then the garage door can be stopped from closing to prevent any accidental damage.

Light sensors can be used in mobile phones for various different purposes. We can set the brightness of our screen to react to the ambient light around us. A light sensor will detect how bright or dark it is at the time and adjust the brightness of the mobile phone screen accordingly.

Other input devices that use light sensors are barcode and QR code scanners. These types of scanner shine light on the barcode or QR code. The light will then reflect back to the device. The white areas of the code will reflect more light than the black areas. The scanner will then convert the light reflections and create a series of binary digits that can be read by a computer.



Figure 6.02 Light beams and light sensors are used to read barcodes

Light sensors are used in many developing technologies such as robots. Light sensors can give the robot the ability to 'see'. Whilst navigating around a room a robot could be constantly beaming light from itself. When the light beam bounces back more quickly, the robot will know that it is close to an object and can change direction.

TEST YOURSELF

Design a security system for your household that uses light sensors. What kind of things will you need to consider?

6.03 Temperature sensors

A temperature sensor is a device that measures heat generated by an object or system. By measuring the change in heat, the sensor can detect changes in temperature.

A temperature sensor will normally be one of two types, contact sensors and non-contact sensors. Contact temperature sensors need to have actual physical contact with an object to measure its temperature. The object could be solid, liquid or gas. A non-contact temperature sensor measures energy that is transmitted or radiated from an object.

Many household items use temperature sensors to regulate their temperature. We normally set our refrigerator to be at a constant certain temperature, for example 5°C. The temperature conditions surrounding our refrigerator will be constantly changing and will affect the temperature inside. Also the temperature inside the refrigerator will be affected by opening the door to get things out of it. A temperature sensor will take regular samples of the temperature inside the refrigerator and adjust the temperature to keep it at a constant level. A temperature sensor in an oven will do the same thing to keep it at the temperature set.

A heating system in our household uses a particular kind of temperature sensor called a **thermostat**. On a very basic level a thermostat has two pieces of metal that will close together or open up depending on the current temperature. When the pieces of metal close together a circuit is created and electrical current will flow to heat up or cool down the atmosphere. If the atmosphere is at the correct temperature the metals will not touch and the circuit is broken to stop any electrical current flowing.

KEY TERM

Thermostat – a device that keeps temperature at a consistent level.



Figure 6.03 A thermostat can be used to control the temperature in a home or work place

Another sensor that measures temperature is an infrared sensor. Infrared sensors detect infrared radiation that emits from a person or object. Infrared waves are emitted by many things but they cannot be seen by the human eye.

We can use an infrared sensor to control our television. A television has an infrared sensor that will detect infrared waves from a remote control. A signal to change the channel or volume on the television can be sent as an infrared wave. The sensor will then interpret the signal and pass on the instruction to the television.

Infrared sensors can be used in a special kind of camera. The infrared camera will detect infrared waves being radiated by a person or object. This kind of technology can be used in many ways. It can be used when pursuing a criminal on the run from their crime. An infrared camera used from a helicopter will detect heat from a person. This way law enforcement can see if a criminal is hiding in, for example, a bush. A person will radiate more heat than a bush, so their shape will be able to be identified in the bush.

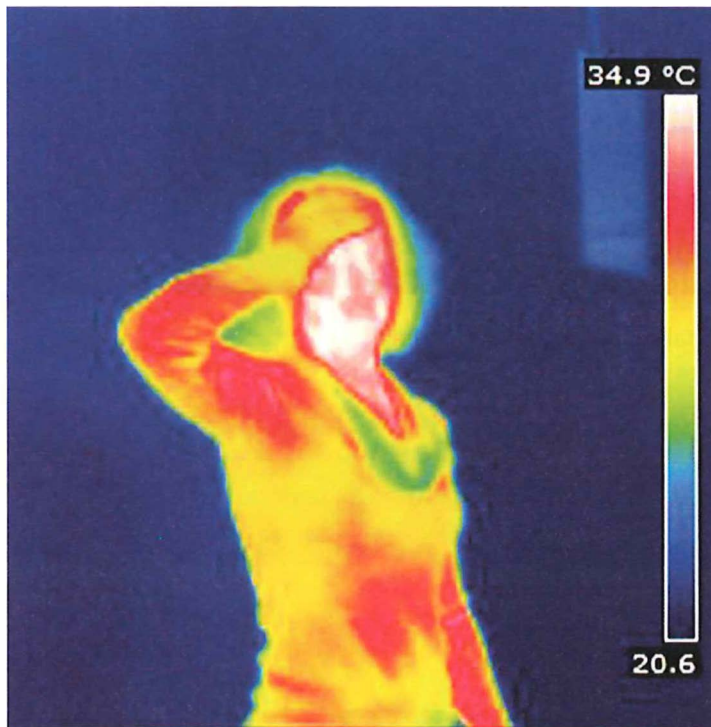


Figure 6.04 An example of infrared waves radiated by a human, taken by an infrared camera

Infrared cameras can also be used to measure the temperature of many things. For example, they are used in Formula 1 racing to show how hot the tyres on a car are. This allows a team to see if their current set of tyres is too hot. A viewer is often shown this image too in the television coverage and this can make interesting viewing for fans.

Infrared sensors can be used in security systems along with, or in place of, light sensors. They will detect the heat of a human and can trigger an alarm when this occurs.

Infrared technology is used in many other areas. It is used in astronomy to view objects in the universe that cannot be detected through the use of a normal camera. Most objects in the universe, such as stars, radiate infrared waves. These waves cannot be seen by the human eye, but when using a telescope they can be seen, allowing us to view the beauty of the sky. Aerospace engineers can also use infrared technology, to monitor the heat of an aeroplane in flight to see if any areas are in particular stress and at risk of damage.

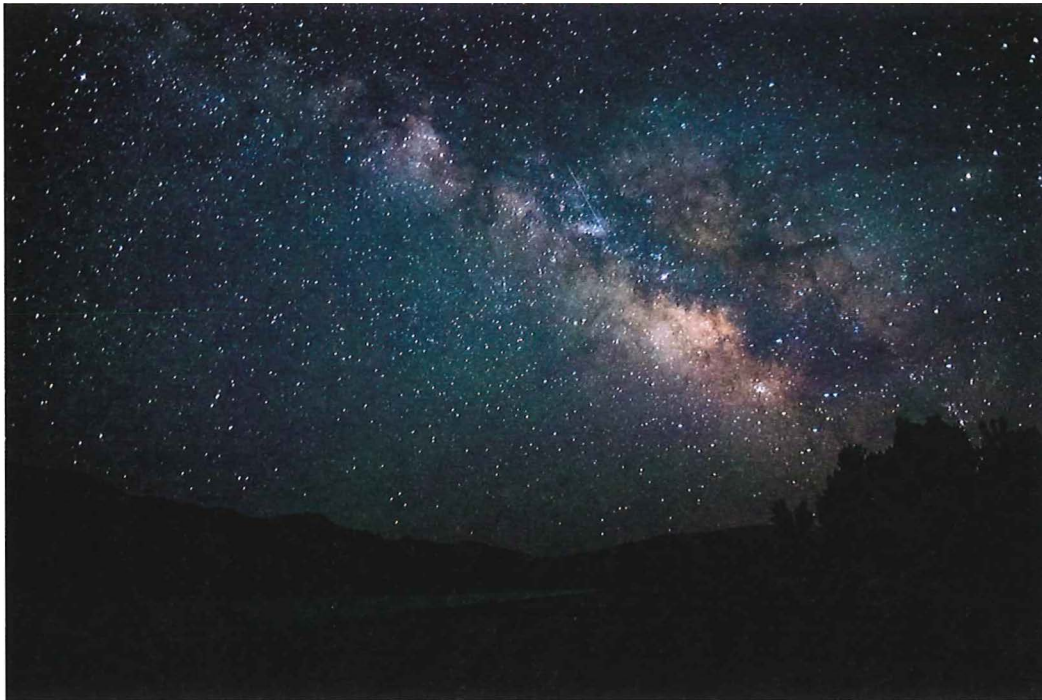


Figure 6.05 Infrared technology can be used to take detailed astronomy images

TEST YOURSELF

Add infrared sensors to the security system you designed for your home with light sensors. How will the introduction of infrared sensors into the security system improve it?

6.04 Motion sensors

A motion sensor detects movement. They are also known as motion detectors. One of the most common uses of motion sensors is in a security system. The motion sensor will detect the movement of an intruder and can sound an alarm when this occurs. Motion can be detected in different ways. The two main ways are through detecting heat (this would use infrared technology) or by sending out microwaves that bounce off objects and would detect a change in the usual pattern if a moving object were to interrupt them.

Motion sensors can be used in lighting rooms in a business or even a household. Businesses have started using motion sensors to detect when a person walks into a room so that the lights are turned on when they do. Once the sensor stops detecting motion in the room it will automatically switch the lights off. This can help save energy and also money for the business as lights are only turned on when they are needed and are not left on in a room wasting energy.

Motion sensors can also be used in automatic doors. The sensor will detect when a person is approaching and open the doors in time for them to walk through. This can be a great benefit for people with disabilities who may struggle to open a door with ease. Allowing a door to automatically open so they can pass through can improve their access to many businesses, for example retail stores.

A developing use of motion sensors is in gaming. Motion sensors allow a person to interact with a game using the movement of their body. The first system to create this kind of gaming experience was the Nintendo Wii in 2006. Both Sony and Microsoft now have their own versions of movement-controlled gaming, Microsoft using a device called the Kinect and Sony using a device called the Move. The controller for the Nintendo Wii makes use of a particular kind of motion sensor called an **accelerometer**. This kind of motion sensor will detect any rotation, tilting and direction of the remote and communicates this to the computer system. This kind of sensor is also used in mobile phones and tablets to rotate the screen depending on the angle at which the user is holding the device.

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KEY TERM

Accelerometer – a device that detects rotation and tilt.



Figure 6.06 Accelerometers can be used in a remote to detect different types of motion

6.05 Magnetic field sensors

Magnetic sensors detect changes in magnetic fields. They measure the strength and direction of a magnetic field and respond to its changes. The earth itself has a magnetic field and magnetic field sensors can be used to detect where north, south, east and west are. These kinds of sensor exist in our mobile phones and are called 'magnetometers'; they allow an application on our phone to act as a compass for us.

Magnetic sensors in a mobile phone could also be used to 'wake up' the phone by turning the screen on. A magnet can be placed inside the cover of a mobile phone case. When the magnetic field sensor detects the magnet is close by, the mobile phone screen will turn off as it will assume the cover is closed. When the magnetic field gets weaker as the cover is opened and moved away from direct contact with the mobile phone, the screen will turn on. This kind of technology can also be used in tablet computers.

6.06 Gas sensors

A gas sensor detects the presence of gas in a certain area and can trigger a response if the amount gets too high or too low.

Gas sensors are often used to detect the presence of carbon monoxide in our home, business or larger area. A carbon monoxide detector, that contains a gas sensor, can be placed in the rooms of a household or business that makes use of a gas central-heating system or gas fireplace. They will measure the level of carbon monoxide in the room and trigger an alarm or warning when the level gets too high. This is extremely important as humans can suffer from carbon monoxide poisoning that can be fatal to us if we are exposed to too much.

Gas detectors can be used in many areas of industry. They can be used in a nuclear energy plant to detect any gases that could cause fire and a potentially critical situation. They can also be used in waste water treatment plants to detect any toxic gases that may be present when trying to purify the water.

TEST YOURSELF

Can you think of any other industries where the detection of gas could be vital?

6.07 Pressure sensors

A pressure sensor measures the pressure of a liquid or a gas. Lots of pressure sensors are used in our daily lives to measure the pressure of liquid flowing through pipes. It is extremely important for the pressure of such things to be measured as if too much liquid is flowing through a pipe it may burst.

Pressure is measured by causing a certain material used in the area, for example inside the pipe, to conduct electricity at a certain rate. The level will be matched to a set level of pressure that can be monitored. If more liquid flows through, causing too much pressure, the level of electricity conducted will increase and this can trigger a warning of too much pressure occurring in that area.

6.08 Moisture and humidity sensors

A moisture sensor measures the amount of moisture in a certain material whereas a humidity sensor measures the amount of moisture in the air, along with its temperature.

The most common use of a moisture sensor is in detecting the moisture levels in soil. Getting the correct level of moisture into soil is vital when farming crops. In order to get the best quality crop, a farmer would benefit from measuring the level of moisture in the soil on their land. This way they can keep it at a constant level and the best level to get the highest quality crop. Through measuring the moisture in the soil, a farmer can create an **automated** system that will water the crop automatically when the moisture levels of the soil get too low. It will also alert them when the water levels become too high so that action can be taken to make sure the crop is not ruined.



KEY TERM

Automated – a process that is automatic.

Another name for a humidity sensor is a hygrometer. They measure the amount of water vapour present in the air and the current temperature of the air. The two of these measures together are known as humidity. There can be many reason why a person would need to measure the humidity of air. A person who has an illness or a condition that can be affected by humidity may have a humidity sensor in their home. High humidity can cause the growth of bacteria that can affect health and, with certain illnesses, if the air gets too dry this can cause them to have problems with their breathing.

Humidity sensors can also be used in places such as museums and art galleries. It may be damaging to certain artefacts and paintings if the air is too humid, so it needs to be monitored to make sure that this doesn't happen.

6.09 pH sensors

A pH sensor measures how acidic or alkaline a material is. The pH is measured on a scale. The value 7 of a pH scale means a material is pH neutral. A pH of less than 7 indicates a material is acidic and a pH of more than 7 indicates a material is alkaline.

It is extremely important that the pH is correct for the water that we drink in order for us to remain healthy. The pH of the most pure water would be 7, so most water treatment plants will try and get as close as possible to this. A water treatment plant will measure the pH of the water that it holds to make sure that it does not become too acidic or too alkaline. It could be very damaging to their reputation if they were to risk this happening.

The level of pH in water is also monitored in aquariums, the tanks that fish are kept in. It is important for the pH level to be set at a certain point for different types of fish. It is even more important that the pH level remains consistent; any changes could be fatal for the fish.

Summary

- A sensor is a type of input device.
- There are many different kinds of sensors that record data about many different aspects of the environment.
- A light sensor is a device that detects light. It will detect the ambient light level, meaning how bright or dark it is.
- A temperature sensor is a device that measures heat generated by an object or system. By measuring the change in heat, the sensor can detect any changes in temperature.
- Another sensor that measures temperature is an infrared sensor. Infrared sensors detect infrared radiation that emits from a person or object.
- A motion sensor detects movement.
- Magnetic sensors detect changes in magnetic fields. It will measure the strength and direction of a magnetic field and respond to its changes.
- A gas sensor detects the presence of gas in a certain area. It measures the amount of gas in certain area and can trigger a response if the amount gets too high or too low.
- A pressure sensor measures pressure. Lots of pressure sensors are used in our daily lives to measure the pressure of liquid flowing through pipes.
- Moisture sensors measure the amount of moisture in a certain material whereas a humidity sensor measures the amount of moisture in the air, along with its temperature.
- A PH sensor measures how acidic or alkaline a material is.

Exam-style questions

- 1 Define the term 'sensor'. (1 mark)
- 2 Identify three different sensors that could be used to increase safety in a nuclear plant and describe how they would do this. (3 marks)
- 3 Explain two drawbacks of using motion sensors in a security system and suggest how they could be overcome. (4 marks)
- 4 Explain how the use of moisture sensors can improve farming. (3 marks)
- 5 Describe how an infrared sensor works. (2 marks)
- 6 Describe how a light sensor is used to read a barcode. (4 marks)