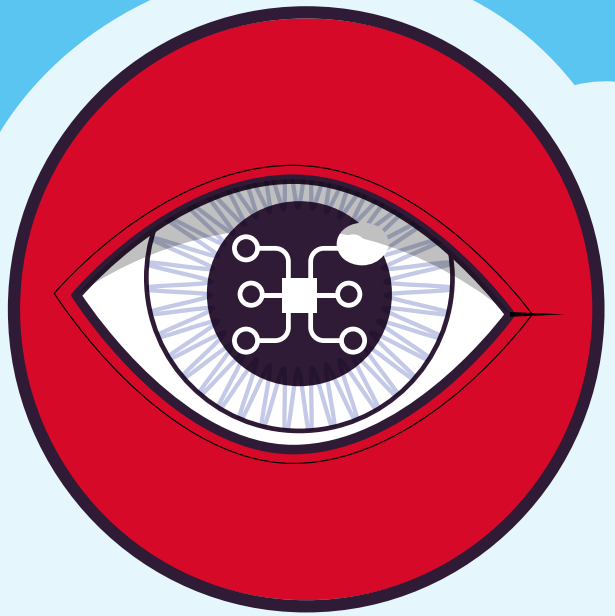
Future of flight:

Artificial intelligence



Royal Academy of Engineering

THIS IS ENGINEERING

TEAM TEMPEST

Introduction

Who do you think could think faster, you or a computer?

In today's modern world, computers are making a huge amount of decisions for us and learning as they go along.

Whilst it might be a while before they become smart enough to drive us to work or school, they can certainly automate a number of tasks that humans have traditionally done. AI could help make it both easier and safer for a pilot to fly a very complex future aircraft, with capabilities such as conducting surveillance, reconnaissance, analyse data from multiple types of sensors, or use swarming technology to control drones all at the same time!

Case study

Hannah West

Systems Engineer at Leonardo

I have always been fascinated by space and maths, but growing up I did not know what I wanted to do (except maybe be an astronaut!).

Since I loved maths and space, I chose to do a Master's degree in Physics and Astronomy at the University of Southampton.

I love maths because I am able to apply my skills to solve many problems, and it provides me with an understanding of the foundations that underpin artificial intelligence, which has helped me in every part of my career so far.

I now work as a Systems Engineer at Leonardo, where I apply maths to develop future algorithms, architectures and technologies in support of the future air system, Tempest.

I love that the work I do forms part of some of the most advanced technology in the world and that it will help to keep people safe.

My advice to anyone would be to do what makes you happy; it is okay to change your mind about what you want to do in life.

"I feel a great sense of motivation knowing that my research could end up improving people's lives."

Can machines think?

Artificial intelligence (AI) is intelligence demonstrated by machines. Machines that think – really?

Time to reflect

- Is it possible for machines to have intelligence?
- How would you spot an intelligent machine?
- What do you think of when you think of AI?
- What devices in your home might use AI and how do they use it?

AI makes it possible for machines to learn from experience, adjust to new inputs and perform tasks that would normally be performed by a human.

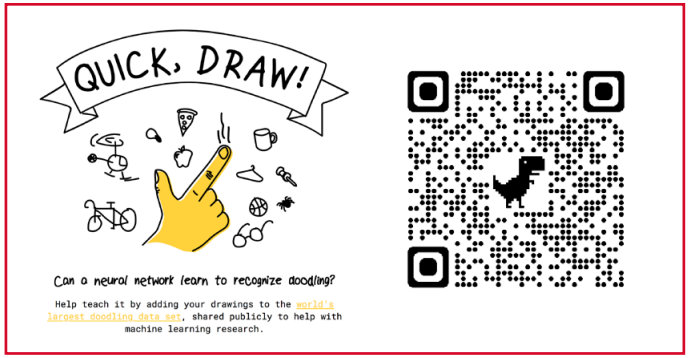
We can train AI programs to learn new things. This is called machine learning.

Time to doodle

Can a neural network learn to recognize doodling?

Help teach it by adding your drawings to the world's largest doodling data set, shared publicly to help with machine learning research.

Visit https://quickdraw.withgoogle.com to start doodling!



What is intelligence?

We are all intelligent, but in different ways. We have many different abilities and different ways in which we show our intelligence.

Time to reflect

- What do we mean by intelligence?
- How do we show intelligence?
- Is our intelligence fixed? How do we develop new skills and abilities?

It is supposed to be our intelligence that makes humans stand out, but intelligence can also be found in other places.

For example, animals show intelligence in a variety of ways.

Ordering intelligence

Put the cards (next page) in order of intelligence.

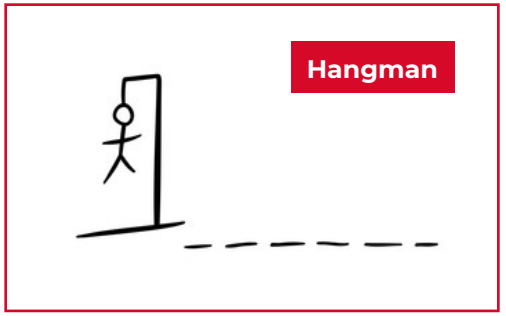
- Do all the examples show intelligence?
- Which examples do you think have the most human-like intelligence?
- Which do you think have the least human-like intelligence?
- Do some have intelligence in ways that humans don't?

Remember, different animals are also intelligent in different ways.

I can work with tools, learn words, share food and play with objects.

I move around a room avoiding objects. I keep going until a room is clean or I run out energy. I can find my base to recharge.

I am a stone with friendly features painted on.



I am used to work out a given word using a process of letter elimination.

I can identify or verify the identity of a person using their face. I capture, analyse and compare patterns based on the person's facial details.

I can recognise what activity you are doing, give you health data and monitor your sleep.

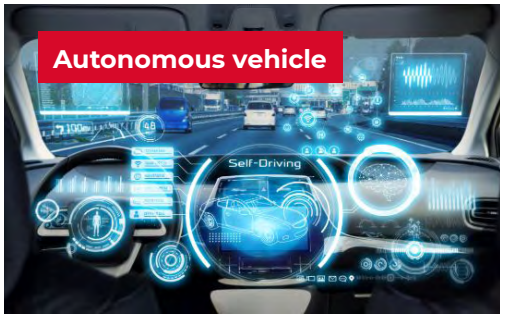
I can imitate humans. I can navigate to home and for food and have social relationships with other parrots.

I can't walk, talk or feed myself. But I will soon learn to do these things.

I can play chess at the level of a chess master or higher. I can work out good moves and bad moves.

I can find my way home. I have been used for long-distance communication and can follow motorways and rivers.

I can blend food to make soups or smoothies. I have different speed settings.



I am equipped with multiple sensors which help me understand my surroundings and in path planning. These sensors generate a massive amount of data which I learn from.

The Turing test

How do you decide if a computer is intelligent?

Alan Turing was a mathematician and computer scientist and is famous as the World War Two codebreaker. In 1950, he developed a method to decide if a computer was intelligent. It became known as the Turning test and is still used today, over 70 years after he invented it.

How it works

Put a computer and a person in one room, with the engineer or researcher in another. The engineer or researcher types messages to ask the computer and person questions. They respond by typing back their answers. The engineer or researcher has to work out which is the human and which is the computer. If after lots of questioning they can't tell which is which, then according to the test, the computer is as intelligent as the human!

Computer? Or human?

Try the test yourselves. Can you work out which of your classmates is a computer and which is a human?

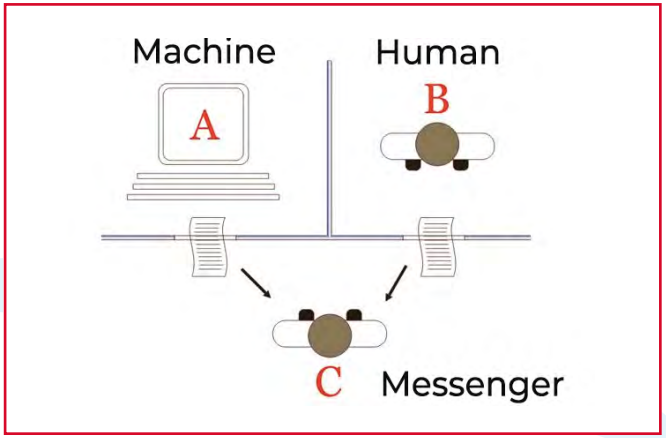
Using the list on the next page, decide as a class which 10 questions would be the most useful for finding out if you're talking to a computer or a human.

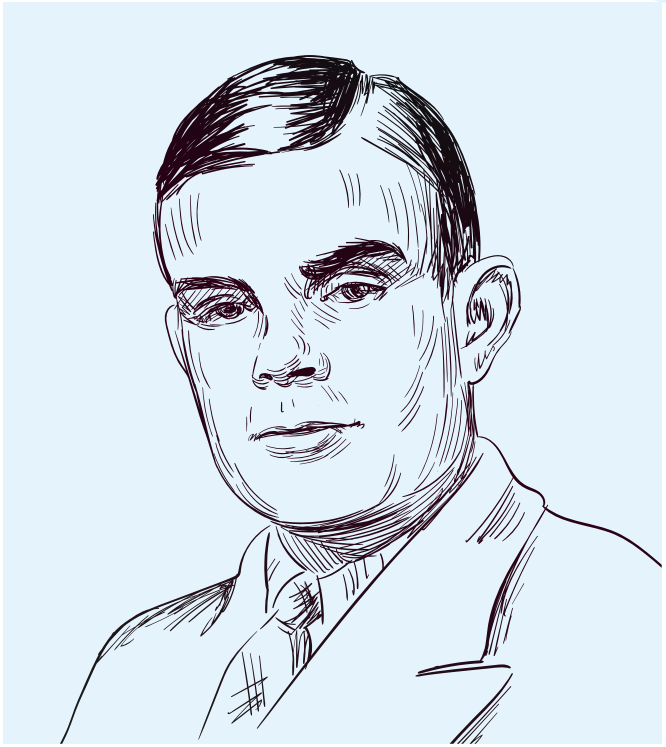
Explain why you have chosen some questions and left others. Are there any questions that you think a computer could not answer?

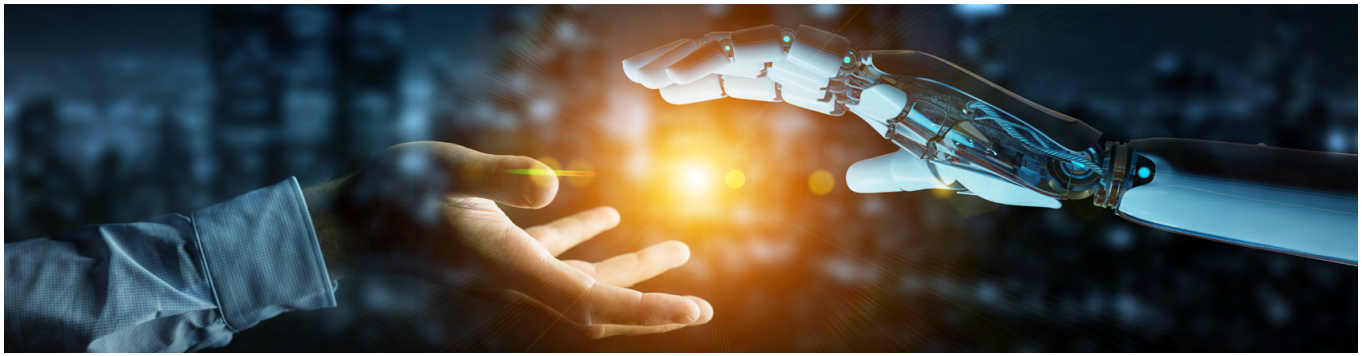
- Select three people from the class.
- One person will play the role of computer, one the role of the human and one person will be messenger. The rest of the class will act as the testers.
- The messengers must take the questions from the class to the 'computer' and 'human'.
- The messenger will share the answers of the 'computer' and human with the class **at the same time** and without giving anything away about who the answer is from.

Time to think

Have you used or come across any computer programs that give 'human-like' responses?







The Turing test questions

Questions sheet for person who is the 'human'.

1. What is the name of the Prime Minister of the UK?
2. What do you think of the Harry Potter books?
3. Are you a computer?
4. What is the next number in the sequence 3, 6, 9, 12, 15...
5. What is 2 x 92?
6. What is the sum of 28,943 and 61,213?
7. What is the square root of two?
8. What do you think of self-driving cars?
9. Do you like sports?
10. How many days are there in a week?
11. What day is it today?
12. Which country's flag is a red circle with a white background?
13. How many days are in February in a leap year?
14. What food do you like to eat?
15. What came first, the chicken or the egg?

Teacher note: Ask the class to create their own questions. Each person in the class could submit two questions without sharing with the rest of the group. One they think could identify someone as a computer, and one that might make it more difficult.

Question and answer sheet for the person acting as the computer.

1. What is the name of the Prime Minister of the UK?
   Boris Johnson (change if this has changed)
2. What do you think of the Harry Potter books?
   They are very popular. As of February 2018, they have sold over 500 million copies worldwide.
3. Are you a computer?
   Are you a computer?
4. What is the next number in the sequence 3, 6, 9, 12, 15...
   18
5. What is 2 x 92?
   184
6. What is the sum of 28,943 and 61,213?
   90,156
7. What is the square root of two?
   1.41421356237309504878
8. What do you think of self-driving cars?
   A self-driving car is a vehicle that is capable of sensing its environment and moving safely with little or no human input. Currently in the UK there are no self-driving cars on the road.
9. Do you like sports?
   I don't play sports.
10. What day is it today?
    Give correct day of the week.
11. How many days are there in a week?
    Seven
12. Which country's flag is a red circle with a white background?
    Japan
13. How many days are in February in a leap year?
    29
14. What food do you like to eat?
    I'm not hungry, thanks.
15. What came first, the chicken or the egg?
    I don't know, but if you are that hungry then maybe it's almost time for lunch.

Where is AI used?

Artificial intelligence (AI) is used all around us.

On your phone

What features on your phone use AI technology?

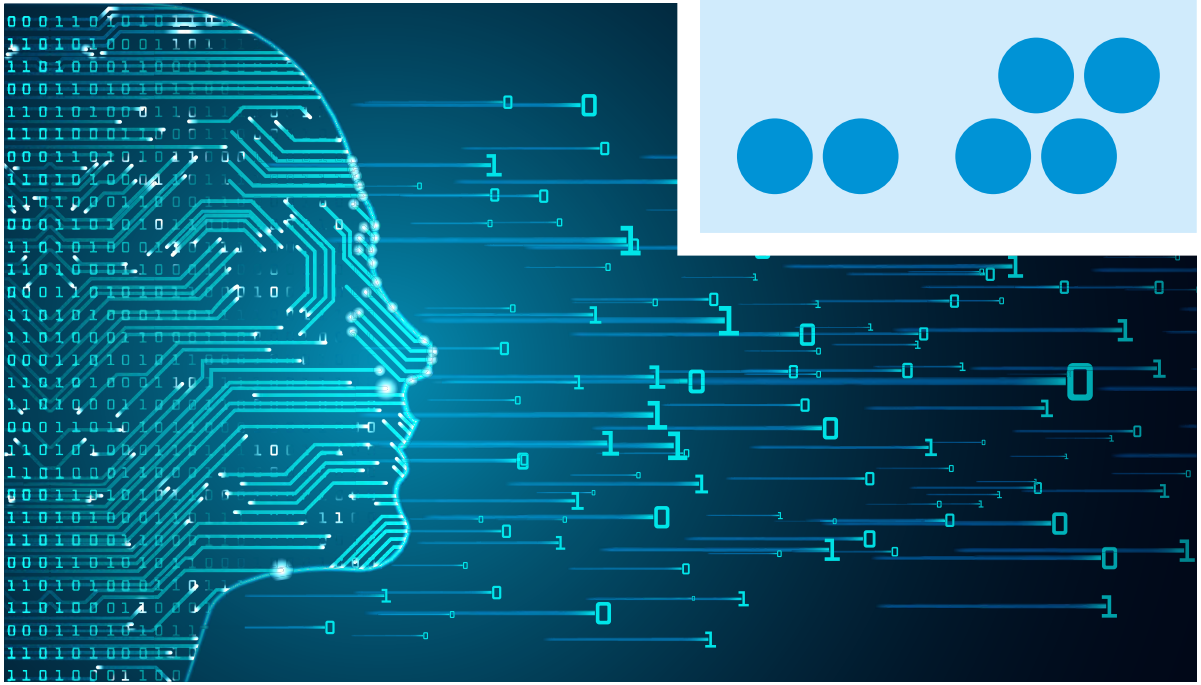
Music, TV and film streaming

How is AI technology used for music and video streaming websites?

On social media

How do you think social media platforms use AI technology?

Where have you come across AI?



Spotting patterns

Machine learning allows a program to look for patterns.

Using this data, programs can predict outcomes.

The more data they receive, the more intelligent they become.

The start of a sequence is shown below.

- What could the next shape in the sequence be?
- Is there more than one option?

Using the additional information, continue each of the sequences.

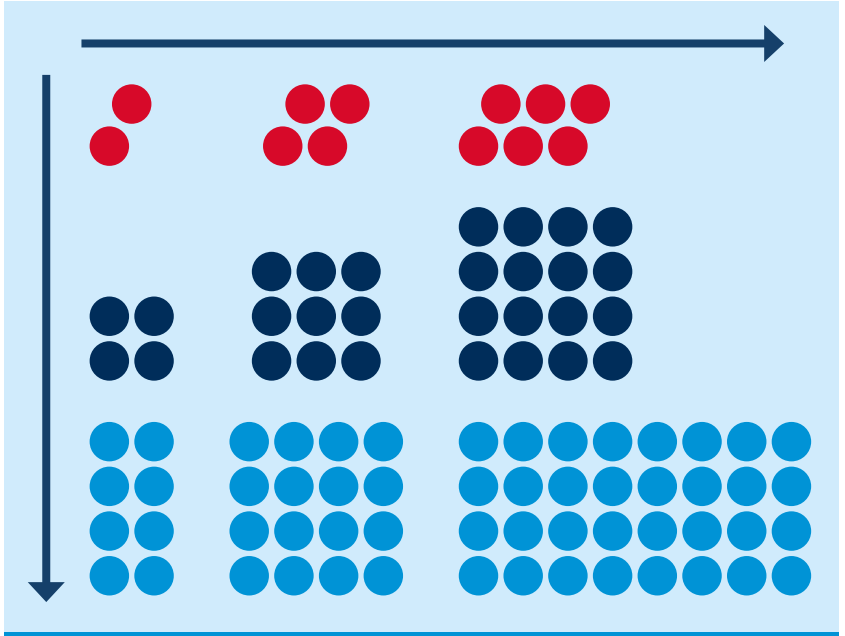
- What comes next?
- What comes before?

Describe each sequence.

- How many circles will be needed for the 9th, 50th and 99th term in each sequence?

Write a rule to find the number of circles for any term in each sequence.

- What could the next shape in the sequence be?
- Is there more than one option?



What comes next? What comes before?

Smart data

Smart watches are commonly used to track exercise.

You can tell the watch what exercise you are doing, but many smart watches will automatically recognise what you are doing.

Smart watches are being developed for pilots in order to track and monitor their health.

- How do you think smart watches and machine learning could be used to recognise different types of pilot activity?
- Design a that will track and monitor pilot health.

Wearable device

- Create a diagram to show your design.
- Annotate your design to show what the functions are.
- Create a diagram to show how data will be displayed.

Things you could consider:

- What data do you need to collect?
- What would you need to notify the pilot and air controllers about?
- What patterns would you look for within the data?
- How will you use the patterns you have identified in your design process?
- What inputs and outputs might you need?
- Is a watch the best device to use?
- What other wearables could work?

Drone swarms

What is a drone (uncrewed aerial vehicle)?

Uncrewed aerial vehicles can be autonomous, remotely controlled or somewhere in between. An autonomous vehicle is one which is capable of completing certain tasks itself. Autonomous vehicles are seen as one of the key applications of **AI**.

Uncrewed vehicles can be designed to travel across any terrain unreachable or dangerous to a human, which allows us to explore more, and previously unreachable, areas of the world and even beyond. Uncrewed vehicles have been used to research the deepest depths of the oceans and the furthest reaches of the solar system.

What is a swarm?

Scientists and engineers have been trying to explain the behaviour of **swarms** or **flocks** of insects and animals. Their research has led them to realise that the complex behaviour we see in a swarm of honeybees, a flock of sheep or a murmuration of starlings is produced by individual members all following a simple set of rules.

They are known to communicate so effectively with each other that their massive colonies begin to form a superorganism, appearing to think and act together as one entity toward a common goal. Researchers have been looking at how we can learn from this behaviour and apply it to engineering. This is called **biomimicry**.

Check out the 'Theory of flight' booklet for more activities on biomimicry in engineering.

Drone swarms

For the last 30 years, these two areas have been coming together as engineers are finding ways that drone swarms can benefit society. Individually, drones might not be able to achieve much, but if they can work together then there are huge possibilities for what they can do.

Time to reflect – where do we use drone swarms?

Think of examples where drone swarms could be used to benefit society. What about examples where drone swarms could be seen as a threat?

Drone swarms

You are a team of engineers working to develop drone swarm technology for different humanitarian purposes.

The technology you have been working on is designed to work in swarms of at least 50 to allow maximum coverage in the minimum amount of time.

Task one – design a solution using drone swarms for one of the following scenarios:

- A city that has been devasted by floods
- Working with farmers in agriculture
- Assisting the emergency services after a wildfire

Think of your own scenario where you might use drone swarms.

Direct control vs autonomous control

In the next task you will be controlling your drone swarms using direct control.

Direct control

Advantage: If using cameras on drones, you are controlling their movements in real-time.

Can you think of any disadvantages?

Autonomous rules

Many drone swarms are now being operated autonomously.

Advantage: Drones can be given one set of instructions/rules that they can follow on repeat without needing input for every step.

Can you think of any disadvantages?

Things to consider:

- What problems might you face?
- Will you use automated drones?
- How will you operate the drones?
- What ethical issues might you face?
- What safety issues might you face?

Task two – drone relay

You need to programme your drone swarms to distribute aid to people after a natural disaster. You have been given a grid map that shows you where aid packages need to be delivered.

As a team, you will need to **program** your drone swarms so that they know where to travel and where the aid needs to be delivered starting from your base camp. You will also need to return the drone swarms back to base camp. You can leave base camp from any direction.

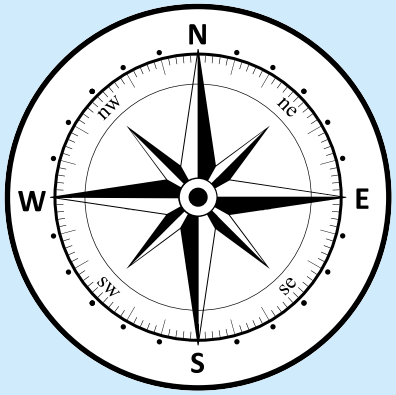
Your program needs to be written as **bearings**. Bearings are **three figure angles measured clockwise from north**. For example, to turn east, the bearing is 090°.

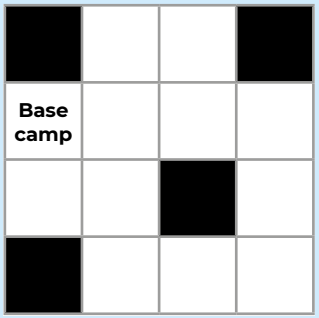
Time to program

Write a program for your drone swarms that will send them to the different areas on this grid map that needs aid. The black squares show where the aid needs to be distributed. Your drone swarms start facing north. They can only move forwards.

Once you have written your program, swap with a classmate and ask them to check.

- Did your program work?
- If they did the activity, did you have the same route?
- Could your program be more efficient?





Stretch and challenge

Write your program using distances. Your drone swarms can also travel diagonally.

Think about what you could do if you did not know the exact distances. Write your program in terms of x.

Time to relay

Engineers working in disaster relief are under pressure to deliver aid as quickly as possible. They also need to be able to communicate clearly as a team.

You will be given a set of grid maps by your teacher or activity leader.

Working as a team of three to five, you will need to write a program for each map.

As a team, you will need to decide how you will write your program.

Your teacher will set this activity up for you as a relay. Taking it in turns, each member of the team will run to the grid map and write one instruction in the program.

You will do this until you have delivered all aid and returned the drones to base camp.

Only once they have been able to show you the completed map, can you move onto the next map.

You will be racing other teams in the class to do this as quickly as you can.

Swap your program with another team. Can they recreate your grid map from your program?

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