A BIT OF

CS4FN

Computer Science for Fun

Issue 1

- Machines that learn
- Make me invisible!
- The robot painter
- Spies like us

Queen Mary
University of London

ADA LOVELACE

Victorian computing wizard

Ada Lovelace was a Victorian countess. She loved maths and helped Charles Babbage work out how to program the first ever computer. He designed it but sadly never built it. It was another 100 years before a working computer was built.

Ada had to work out how it worked and how you programmed it to do things without an actual computer to work on.

While Charles thought of his computer as a big calculator to do hard sums, Ada realised that if you **represented** things like music with numbers then computers could do lots more. Over 150 years ago, she wrote that one day computers would be able to compose music…and now they can.

Computers use numbers as a way to represent all sorts of things: words, music, movies, photos, and lots more. It is the BIG idea behind our digital world.

As a child Ada had an amazing imagination. She dreamt of building a flying horse powered by steam! Could that now be an aeroplane? Today planes are flown by programs… and Ada and Charles were the first programmers!

Fun to do:
Draw an invention

Draw a fantastic idea you have about future inventions.

Spies like us

Spies like computer scientists because they help end wars!

In World War II, the Allies listened in to radio calls made by Hitler's armed forces. His Generals thought no one could read their messages because they used secret codes. But the Allies cracked the codes, so knew what they were planning!

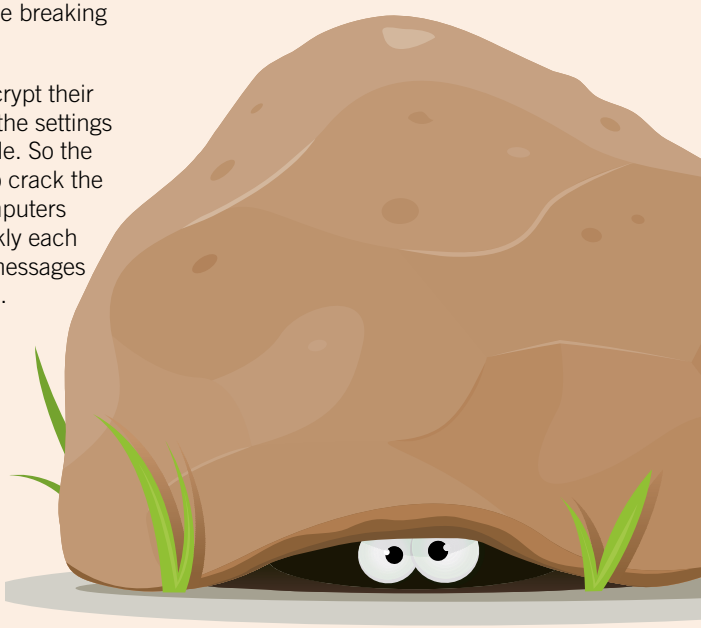
The Poles cracked it!

It was Polish mathematicians who first worked out how to crack the German codes. With help from the French resistance, they passed it on to the British. Prime Minister Winston Churchill then set up a secret team at Bletchley Park to do the code breaking. The team included Alan Turing, one of the greatest computer scientists ever. Together they made lots of code breaking breakthroughs.

The Germans used machines to encrypt their messages. Every day they changed the settings on the machines to make a new code. So the women and men at Bletchley had to crack the codes anew every day. The first computers were built to help them do this quickly each day so they could start to read the messages while the information was still useful.

Crack a code with a crib

The Brits realised that it helped that the messages followed patterns. For example, the Nazis expected messages to end "Heil Hitler". The German word for weather also appeared in the same place in military reports sent at the same time every day. These so-called '**cribs**' gave enough clues to work out the secret key.



That means...

To **encrypt** a message means to change a message into one that only people with a special **key** can easily read.

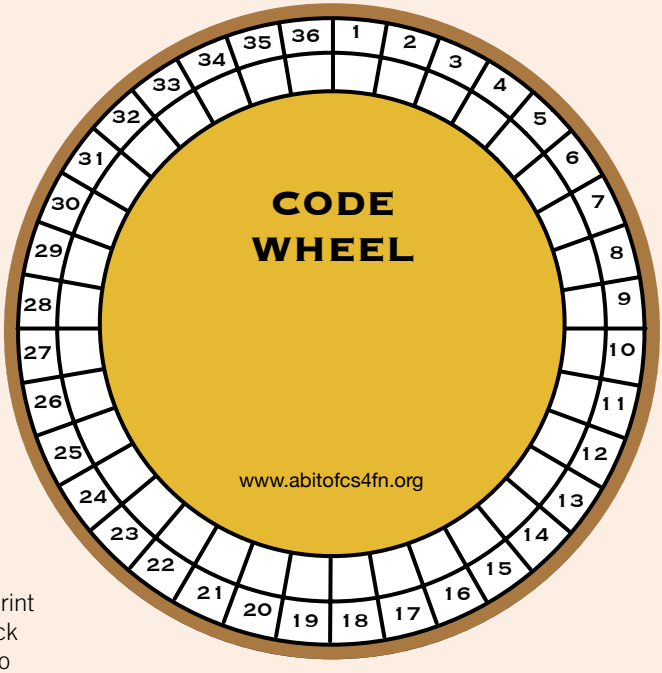
To **decrypt** a message means to work out what the original message says.

A **key** is the secret needed to **encrypt** or **decrypt** a message.

A **crib** is a known word or phrase that is likely to appear in a message and that can be used to work out the **key**.

Fun to do: Crack this!

Imagine you are a secret agent. You have listened in to two encrypted radio messages. Each letter of the alphabet is replaced by a number from a code wheel. To read the enemy's orders, you must work out what code wheel they used.



You can download a wheel from **abitofcs4fn.org/magazine/issue1/** Print it, cut it out and fill it in as you crack the code. Spin it to new positions to give new codes.

How? Use a crib!

The first message is a weather report. They always start with the word "WEATHER" followed by a space. That is the crib. Use it to work out the code wheel they used.

Look at **Message Grid 1**. W goes in the first box so W is number 3. Put W in position 3 of your code wheel too. E goes in the second space on the Message Grid. That is number 6, so put E on your code wheel against number 6. Do this with each letter in the crib, "WEATHER". Don't forget the space which is the last character in the crib. Draw a solid square to mean a space is there and then you can get to work on the rest of the message.

Use the code wheel to fill in the other letters everywhere you find their number in the Message Grid.

Next, look at the message starting to form. Is it starting to make sense? If you can fill in any blanks to make a word, you can add the new letters back into the code wheel. Think of weather words, like SUN, WIND, SNOW. Do they fit in the message?

Once you have cracked the first message, work out what the second message says using your code wheel. Even a partial code wheel may be enough to crack the second message, and so know what the enemy is planning.

MESSAGE GRID 1 ALL ABOUT WEATHER

3	6	27	9	20	6	17	2	5	23	13	13	11	2	5	1	6	4	4	5	2	18	13	2
21	19	17	13	18	13	25	2	5	9	19	17	21	5	2	3	18	13	15	2	17	27	18	13
2	5	13	19	3	2	5	4	6	6	9	2	14	11	2	6	8	6	13	18	13	25	2	6
7	9	17	6	21	6	2	26	19	4	15													

MESSAGE GRID 2 THE PLANNED ATTACK

27	9	9	27	26	24	2	27	9	2	15	27	3
13	2	18	13	2	9	3	19	2	15	27	11	5

Fun to do: Create your own coded message

Can you create your own coded message: maybe about Armistice day or another important event in WWII that you know about?

Computing and art

Digital cameras save a picture as lots of small coloured squares called pixels. The screens we use to look at digital images use pixels too. When you look at a digital image you are looking at lots of small dots of colour. Each pixel has a number that tells the screen the colour of the dot, like painting by numbers.

Pointillism

Long before digital cameras were invented, French artist Georges Seurat invented a new style of painting using dots. His paintings were very similar to our digital images now. His way of painting was called pointillism.

Robot artists

AARON is a program that paints its own pictures using a robot arm. It chooses what to paint, then follows rules telling it how to paint. The rules were written by artist-programmer Harold Cohen. AARON has made more money selling paintings than many human artists.

This picture of the Eiffel Tower is one of George Seurat's pointillism pictures.

Fun to do: Paint a Pixel Picture

Try painting your own pointillism pixel picture by painting the squares of a piece of squared paper different colours.

ROMAN COMPUTING

The Romans invented the idea behind pixels, thousands of years before computers existed. They used the idea in mosaics to decorate their floors.

They realised they could make a picture from lots of coloured squares. They called the little squares of coloured glass or stone they used 'tesserae' rather than pixels. This made it easy for them to send mosaic kits across the empire. Anyone could have the floor pattern they wanted. They didn't hit on the idea of sending the patterns as numbers though!

Can you make your own mosaic design? What materials could you use as 'tesserae'?

Fun to do: Pixel Puzzle

Colour in the squares below using the colours from the key to build this common Roman mosaic pattern.

2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	2	2	2	2	1	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	0	0	0	2	1	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	0	2	0	2	1	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	2
2	0	1	1	1	1	0	1	2	0	1	1	1	1	1	1	1	1	0	2
2	0	1	2	2	2	0	1	2	0	2	2	2	2	2	2	2	1	0	2
2	0	1	2	0	0	0	1	2	0	0	0	0	0	0	0	2	1	0	2
2	0	1	2	0	2	0	1	2	0	2	0	2	1	0	2	0	2	1	0	2
2	0	1	2	0	0	0	0	0	0	0	0	2	1	0	0	0	2	1	0	2
2	0	1	2	2	2	2	2	2	2	2	0	2	1	0	2	2	2	1	0	2
2	0	1	1	1	1	1	1	1	1	1	0	2	1	0	1	1	1	1	0	2
2	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	0	2	0	2	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	0	0	0	2	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	2	2	2	2	2	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	2
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

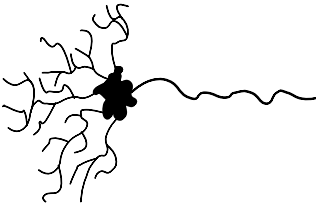
KEY

0	Black
1	Red
2	Yellow

Machines that learn

We are getting better at building 'intelligent' machines. What does it mean to be intelligent, though? Do you need to be able to think to be intelligent?

Perhaps you or your friends have a pet: a dog perhaps. How would you decide if it is intelligent?



We know a dog is intelligent because of what it can do: sit when told, catch a ball, … but most of all because it can learn to do new things.

How can a computer learn for itself, when all it can do is follow the instructions of its program?

Building brains like ours

Computer scientists have invented **algorithms** for learning: ways a computer can learn to do new things just by following rules. One way is to copy the way animals learn: copy their brains (but without blood and gore).

That means…

An **algorithm** is a series of steps that can be followed blindly to guarantee something happens.

Our brains are made of billions of cells called neurons. Each is connected to lots of others. They work by sending messages to each other. Each neuron fires (sends a message) only when it gets enough messages from other neurons.

Everything you think, feel and do (whether being happy, reading this magazine or catching a ball) involves neurons sending messages to each other. When we learn, our neurons are each changing how easily they fire.

A **neural** network is a program based on an algorithm that mimics neurons and their messages. To teach a neural network to tell cats from dogs, say, you show it lots of pictures, telling it which are cats and which dogs. With each picture it changes when its neurons fire so that eventually cat-like things make the 'like a cat' neuron fire, and dog-like things make the 'like a dog' neuron fire.

Fun to do:
Doodle Game

Work out what parts of a thing being drawn your neurons are spotting when you try to work out as quickly as possible what a friend is drawing.

MACHINES

INVENTING MUSICAL INSTRUMENTS

Rebecca Fiebrink uses machine learning to invent new musical instruments. She wants to create instruments that anyone can play, tailored to their abilities.

Suppose you want to create a new kind of instrument that you play by waving your hand. A fist means sound a hooter, waggling your fingers means ring a bell, and so on. You need to write a program that can recognise different hand movements and that is really hard. Rebecca wants anyone to be able to do it!

Can machine learning help?

She has written a program that learns. It watches, listens … senses what is happening. It then learns to link what it senses with the sound it should make.

To create your hand-waving instrument, you pick a sound, the hooter, then repeatedly move your hand in the way you want to trigger it: making a fist, say. It gradually links the pattern it is sensing with that sound. Then you select the next sound, the bell, and waggle your fingers - until it has seen enough examples so it can tell it apart from other movements. You do this with each new hand movement. Very quickly you have a working instrument to try.

It has learnt what instrument you want by example. You can try it and, if it doesn't quite do what you want, change it by showing it new examples. That is different to normal machine learning programs, as there is no right pattern for it to learn when you start. It helps you work out what you want by tinkering. It helps you be creative!

You could turn a whole room into an instrument where every movement does something: create an orchestra as you run around, jumping, twisting and turning. Playing an instrument **CAN** just be playing!

Fun to do:
Design your own instrument

Draw a table showing which hand shapes link with which sounds (like fist → hooter, waggle fingers → bell, …). Get a friend to act as the program following your table to make the sounds as you make the hand movements.

SUPERHERO POWERS:

I'm invisible!

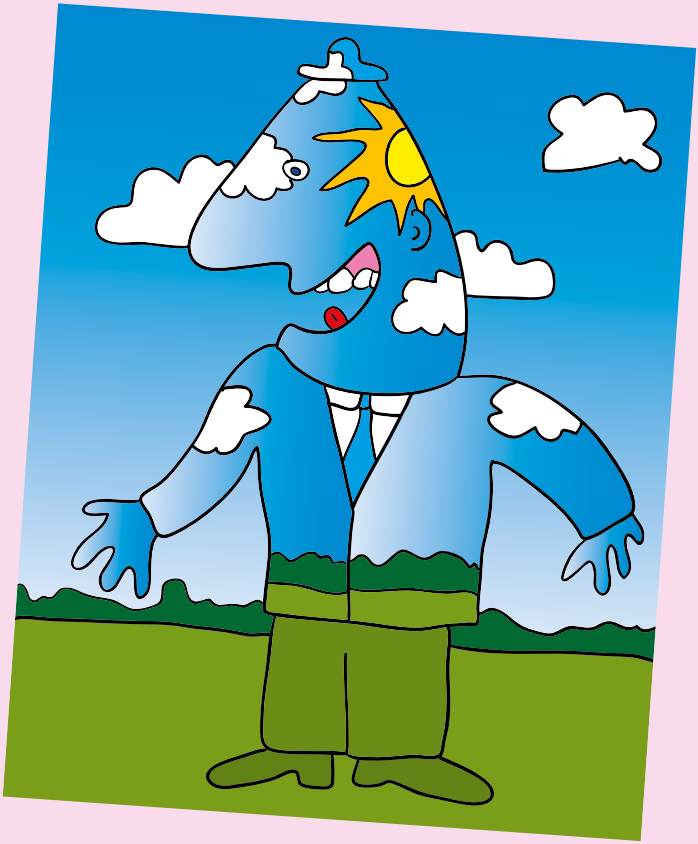
Violet from the Incredibles can make herself invisible. Harry Potter has a cloak that does the same, and Wonder Woman has an invisible plane. Even James Bond has an invisible car. But is it really possible to make things invisible? Yes! … and scientists and engineers are working on it.

Invisibility is all about light. You can see a banana that is in front of you because yellow light has bounced off it and on into your eyes.

Stop the light bouncing from the banana into your eyes and the banana becomes invisible to you.

If instead of a banana, you stop light bouncing from you to other people's eyes, you would be invisible!

Don't forget your shadow though! Just like Peter Pan you have to lose it too or it will give you away!



Here are some ways you might try to make yourself invisible.

Absorb all the light that hits you!

Then none will get back to their eyes.

PROBLEM
They wouldn't see you, but there would be a black you-shaped hole where you were. That is what blackness is – no light.

Make light pass through you, so that you are like glass.

You can't see glass!

PROBLEM
An invisibility cloak made like this won't work! It would be invisible but it won't hide anything!

Put a mirror between you and them.

Your light is blocked by the back of the mirror so never gets to their eyes. They instead see the light from somewhere else that bounces off the mirror. This is a way magicians make things disappear.

PROBLEM
The mirror needs to be at an angle, so the person sees what is at the side (not themselves!). To fool them, the scene at the side must be what they expect to see in front of them. That is difficult to do!

Make light curve around you.

The person sees what is behind you. When people see a mirage in the desert, it is because light changes direction as it passes through hot layers of air on its way to their eye. One way is to make a cloak out of **nano-machines** - tiny machines that each bounce the light on to the next machine all the way round you.

PROBLEM
So far, only a tiny bump has been hidden that way (so it works if you are a flea).

Cover yourself in tiny screens and use cameras to film what is behind you.

You record the light pattern arriving from behind and display it in front. The person sees what is behind you on the screens, not you. This has been made to work! Well, just about.

PROBLEM
It's not quite perfect round the edges and if you move quickly it can't keep up. But, hey, we are getting there.

There is a cheaper way to stop your light getting to another person's eyes of course: hide behind a tree!

In the book 'The Invisible Man' the solution was a potion that made the scientist transparent ... Even if that worked you would have to hide after eating until the food was digested as it would be seen (Yuk!) ... You would also be blind! Light would pass through your eye too, but the job of your eye is to catch light so it can tell your brain about the light from other things.

Fun to do:
Write a story

Write a story about what you would do if you were invisible.

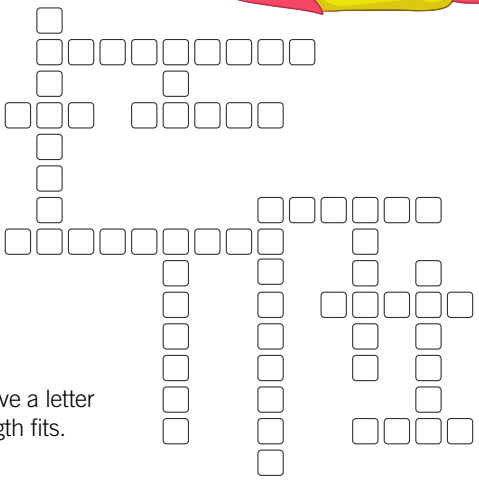
Find out more of how computer scientists play with light at:
abitofcs4fn.org/magazine/issue1/

Think Logically!

In Star Trek, Vulcans do it naturally, but even humans need to be able to think logically. You don't have to be Sherlock to be good at it either. Anyone can be good at thinking clearly. It just takes practice. Puzzles are a fun way to get better.

Fun to do: Kriss Kross

Try this Kriss-Kross about programming. You must fit all the words into the grid.



Hints

If there is only one word of any length left there is only one place it can go!

Cross off words as you use them.

Count the length of words in the grid you have a letter for, then see which unused word of that length fits.

There is lots more computing fun to be found on our website at: abitofcs4fn.org

3 letters	4 letters	5 letters	6 letters	7 letters	8 letters	9 letters
bit	byte	debug	output	program	variable	decompose
run		input	repeat			algorithm
			search			selection

KNAHT UOY ROF GNIDAER RUO ENIZAGAM!!

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