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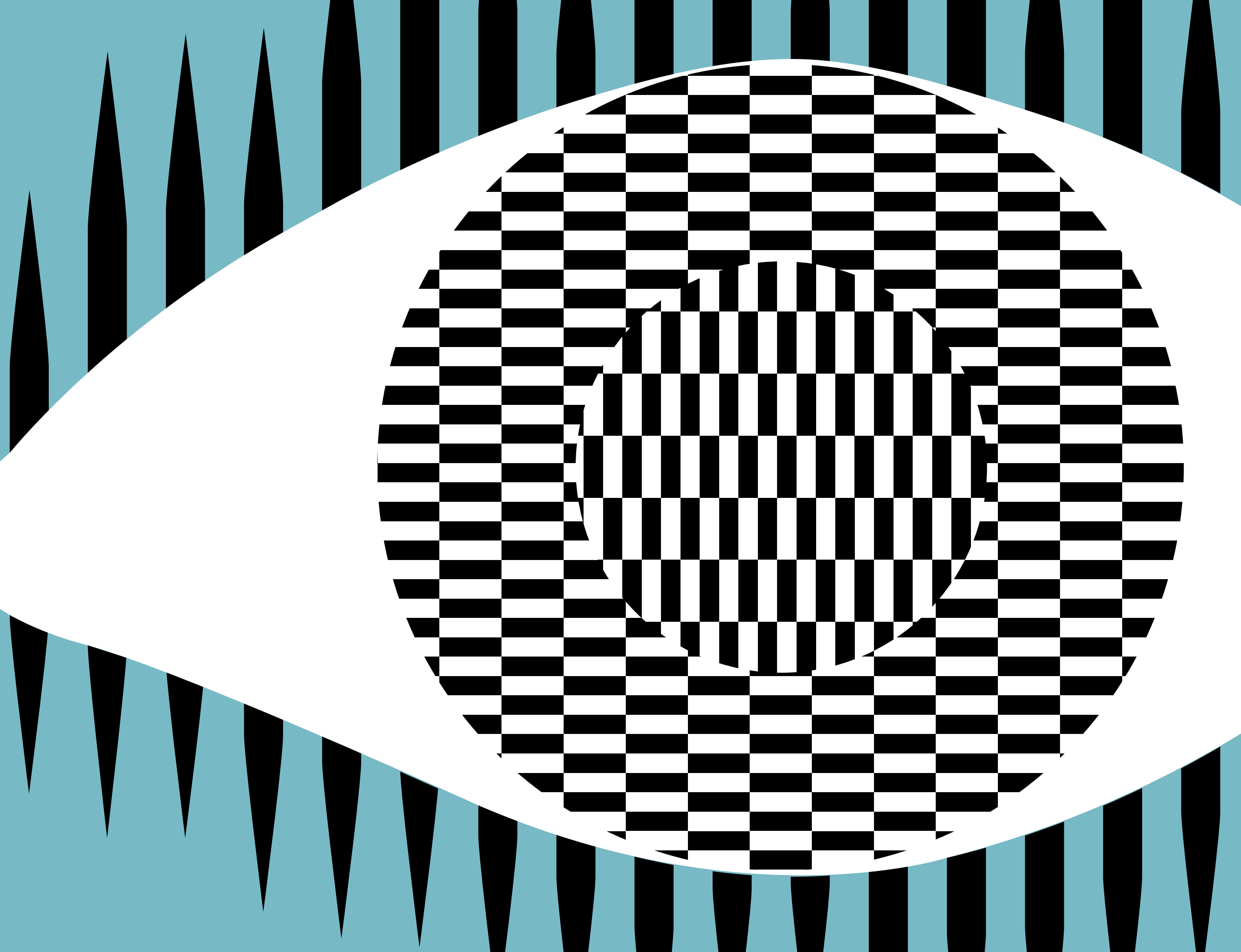
# CS4FN

Computer Science for Fun

Issue 26

# Peter W McOwan: Serious Fun



The Magic of Computing

The Perception Deception

Face Off

www.cs4fn.org/petermcowan

Queen Mary University of London

# Serious fun

**Peter McOwan, who died in 2019, was a wonderfully kind friend. We created cs4fn together aiming to show that Computer Science was both serious and fun.**

Peter was a serious researcher of biologically inspired computing, though he found fun twists to everything he did. He worked on many topics including understanding how we really 'see' the world; how, in the future, we will live with robots, and intriguing applications of artificial intelligence. He was also concerned with the ethics of computing. As a serious magician, who loved illusions of all kinds, it was his idea that we teach computing using magic shows. He even helped create a magic trick that would only work in space, performed on the International Space Station. He supported the work of very, many others, getting the best out of undergraduates and researchers alike. Tens of thousands of school students and their teachers have also been inspired by his work. This issue is a mixture of old and new articles about Peter's work, of those he mentored, and the topics he loved.

- Paul Curzon

# Snakey bites back

**How do you ensure that a game is just the right difficulty for each player? Breed a virtual zoo full of versions of the game!**

QGames, an artificial intelligence (AI), developed by Peter's student Milan Verma, was a fun new way of creating games. It used an AI technique known as a genetic algorithm to breed lots of evolved versions of the Snake game. QGames was the first time this technique was used to create mobile phone games.

The AI created lots of different versions of Snake at random, changing game play factors like speed, snake camouflage, environment and snake mobility. These were automatically tested for difficulty. It was a case of survival of the fittest. As with Darwin's natural selection that drives evolution in the natural world. Only the fittest solutions for each level of difficulty survive to the next round of evolution. From the successful ones, more variations are created and tested. After lots of rounds of evolution you have versions of the game perfectly fitted to each level.

Genetic algorithms use a 'fitness function' to decide what survives. Here it is a way to rank the difficulty level of each game variation. To do this, Milan built a game playing program with human-like abilities. The program was based on data from real human game players to give it realistic properties. It played each version of the game to decide its difficulty.

A new user then played a few games so the AI could get a measure of their ability. It then sent them a game tailored to their game playing ability.

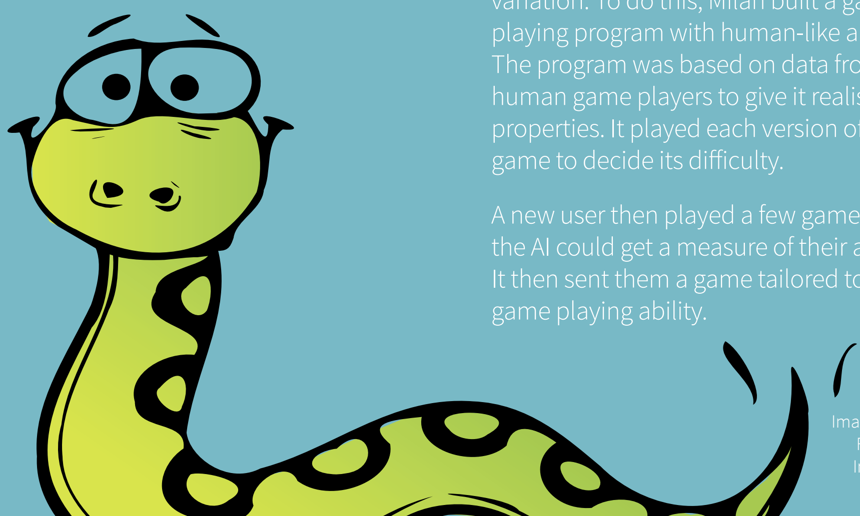


Image by Clker-Free-Vector-Images from Pixabay

# Programming pogoing punk robots

**Punk band Neurotic and the PVCs sound great tonight. The crowd are clapping and cheering. With them, at the front, three robots are jumping up and down, doing the punk pogo dance. Since Neurotic came on, the robots can hardly keep still. They are the perfect band for these three robots. Their frontman, Fiddian, made them learn to like the same music he does.**

How do you program a punk? The robots' programmers created a network of computerised connections like the ones in a real brain - a 'neural network'. Then they let the robots listen to different kinds of music and told them what it was, like reggae, pop, and of course, Fiddian's collection of classic punk. The more they listened, the stronger the connections in the neural network became, and the easier it was for them to recognise the music they were listening to.

The last step was to tell the robots to go enjoy some punk. The programmers turned off the robots' neural connections to other kinds of music, so Beyoncé or Bob Marley would no longer satisfy them. They would only dance to the angry, churning sound of punk guitars. The robots dressed up in spray-painted leather, studded belts and safety pins, so they looked like extra-tough boxing gloves on sticks. Then the three two-metre tall troublemakers went to their first gig.

## The robots' first gig

Whenever a band begins to play, the robot's computer brain looks at the patterns in the music. If it matches the idea of punk music they've learned, the robots dance, firing a cylinder of compressed air to make them jump up and down. If the pattern isn't quite right, they stand still. For lots of songs they hardly dance at all. It's the 'wrong' kind of punk music. It's too different from Fiddian's favourites. They've developed taste, and it's the same as Fiddian's.

As the robots jump wildly up and down, it's clear that Neurotic and the PVCs now have three tall, tough, robot superfans.

The Pogoing robots' first gig was at the Institute of Contemporary Arts in London in July 2006. This unique event was a collaboration between Peter and digital artists SoDA. Fiddian's band played, the robots danced and Peter was there to explain how the robots worked and to discuss the computer science and neuroscience with the audience.

# Perception deception

## Getting an angle on the brain

**People have always been better than technology at seeing. It takes lots of computing power for us to see, and, more to the point, understand what we see, whether it's faces, letters or even a café wall (but more of that wall later). Imagine if you could build a computer with the same ability? Computer Scientists are looking at how our brains work to build better machines.**

### Bits of brains

Your brain is doing some amazing calculations as you read these words. Not only are your recognising the letters, the upright and top cross of the 'T', but you are also understanding what they mean. Around half your brain is involved in processing information from your eyes. Scientists have started to get a better understanding of the early stages of vision, but seeing is a complex process and there is much more to discover. Your visual cortex at the back of your brain takes the nerve signals from your eyes and starts to calculate with them. From this calculation some of the basic 'building blocks' of seeing are created. We see things moving and in colour, and we also know very accurately how the parts of the scene we are looking at slope. Slopes, or 'spatial orientations', are a very important part of the early visual calculations. Slopes tell us something about an object. A rectangular table, for example, has straight edges, and slopes also tell us something about how far an object is away and how it's positioned in the scene. Think of the table again. If you are looking straight down on it all the sides are parallel. If you are looking from a distance the sides seem to slope. It's called perspective and was one of the key discoveries in the middle ages that made Renaissance art so realistic. All those sloping lines give us lots of useful information about the world.

### New directions

We can build computer models of how humans perceive a whole range of properties of the scene like movement, colour, or slopes (orientations). When it comes to slopes we know that in your brain you measure the orientation at each point in the scene at various different angles, not just at one or two. This brain structure is called an 'orientation column', and is probably there to help our computation be more robust. Modelling these orientation columns, and building a computer model as close to the biology as possible allows two things.

First, we can see if our model performs like a human would. We can use it to predict how a human would see a particular pattern, then test with a real human to see if we were right. If we were, then our model got something right, and we have a better understanding of how our brains compute. This is one way that computational thinking is changing the way we do science.

Second, since the model is mathematical, it doesn't matter if it is run on biological 'stuff' like your brain, or on electronics 'stuff' in a computer, so we can build computer vision systems with human-like abilities.

### Useful illusions

So where does the café wall come into this? If you look at a brick wall you can sometimes get a strange effect. The straight lines of the mortar can sometimes look sloped. It's an optical illusion. Your brain is making a 'mistake' in its slope calculations. A mathematical model developed by Peter's research team at Queen Mary suffers the same sorts of mistakes. It miscalculates like a human does, and in effect it is 'seeing' the illusion too...and because an optical illusion is an unusual miscalculation for our brains to make, the fact that the model makes the same mistake is useful evidence for us to say that the model has caught the essence of the human brain calculations.

We have built a bit of a brain and can use it for many different computer vision applications. Biology has found some great solutions to hard engineering and computing problems. It would be a shame not to re-use them.

### Discovering a new illusion

Peter's team wrote their vision model software and then needed to test it to make sure there were no bugs. They showed it different patterns and it reported what it 'saw'. The only trouble was in one test they were showing it a stationary pattern but it was claiming it was seeing a moving pattern. For days they looked for the bug in the code, until eventually they gave up. They couldn't work out what was wrong with the code. Then someone had the idea of showing that particular pattern to humans. Lots said it was moving too! The model was seeing an illusion. It had discovered a new human optical illusion!

**Perspective was a key discovery in the middle ages that made Renaissance art so realistic.**

Image by tookapic from Pixabay

# Ethics: what would you do?

by Peter W. McOwan

Image by TheDigitalArtist from Pixabay

**You often hear about unethical behaviours, be it politicians or pop stars, but getting to grips with ethics, which is about what behaviours are right and wrong, is an important part of computer science too. Try our ethical puzzle and learn something about your own ethics...**

### Is that legal?

Ethics concerns the customs and beliefs that a society has about the way people should be treated. These beliefs are different in different countries, which is why you have to be careful on holiday. Ethics form the basis of countries' laws and regulations, combining general agreement with practicality. Sticking your tongue out is rude and therefore unethical, but the police have better things to do than arrest every rude school kid. Slavery was once legal, but was it ever ethical? Laws and ethics have other differences. Individuals judge unethical behaviour, and shun those who behave inappropriately. Countries judge illegal behaviour using a legal system of courts, judges and juries to enforce laws with penalties.

### Dilemmas, what to do?

Now imagine you have the opportunity to tread on the ethical and legal toes of people across the world... just from a computer in your home. Suddenly, the geographical barriers that once separated us vanish. The power of computer science, like any technology, can be used for good or evil. What is important is that those who use it understand the consequences of their actions, and choose to act legally and ethically. Understanding legal requirements like computer misuse, contracts and data protection are important parts of a computer scientist's training.

Computer scientists study ethics to help them prepare for situations where they have to make decisions. This can be done by considering ethical dilemmas. These are the computer science equivalent of soap opera plots. You have a difficult problem, a dilemma, and have to make a choice (on TV this choice is followed by a drum roll as the episode ends).

### Give it a go

Here is your chance to try an ethical dilemma. What would you do? Like all good 'personality tests' you find out something about yourself: here which type of ethical approach you have, according to some famous philosophers.

### Your dilemma

You work for a company who are about to launch a new game. The adverts have gone out, social media is ready for the launch ... then the day before you are told the software has a bug. It means players sometimes can't kill the dragon at the end of the game. If you hit the problem you have to start the final level again. It can be fixed but it will take a week. The code is hard to fix because it's been written by 10 different people and 5 are in the Andes back-packing so can't be contacted.

It's your call. What would you do?

1) Go ahead and launch. After all, there are still plenty of parts to the game that do work and are fun, there will always be some errors, and for this game in particular thousands have been signing up for text alerts to tell them when it's launched. It will make many thousands happy.

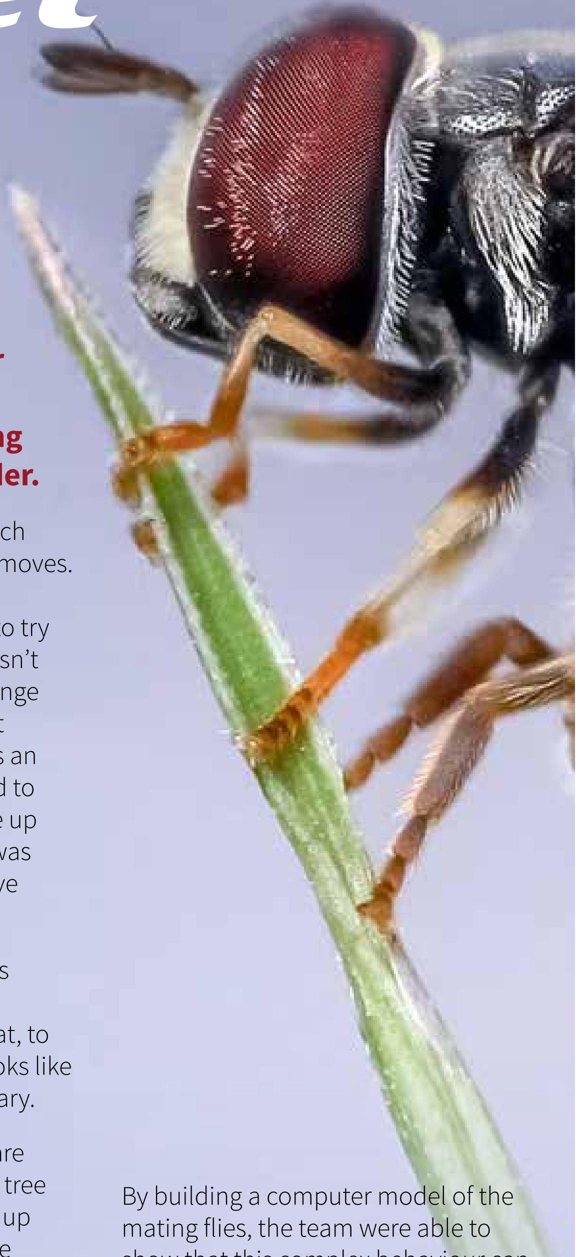
2) Cancel the launch until the game is fixed properly. No one should have to buy a game that doesn't work 100%

3) Go ahead and launch. After all it's almost totally working and the customers are looking forward to it. There will always be some errors in programs: it's part of the way complicated software is, and a delay to game releases leads to disappointment.

### Your ethical personality

Decide now then find out about your ethical personality at **www.cs4fn.org/society/dilemmas.php**

# Hoverflies: comin' to get ya!



**By understanding the way hoverflies mate, computer scientists found a way to sneak up on humans, giving a way to make games harder.**

When hoverflies get the hots for each other they make some interesting moves. Biologists had noticed that as one hoverfly moves towards a second to try and mate, the approaching fly doesn't go in a straight line. It makes a strange curved flight. Peter and his student Andrew Anderson thought this was an interesting observation and started to look at why it might be. They came up with a cunning idea. The hoverfly was trying to sneak up on its prospective mate unseen.

The route the approaching fly takes matches the movements of the prospective mate in such a way that, to the mate, the fly in the distance looks like it's far away and 'probably' stationary.

How does it do this? Imagine you are walking across a field with a single tree in it, and a friend is trying to sneak up on you. Your friend starts at the tree and moves in such a way that they are always in direct line of sight between your current position and the tree. As they move towards you they are always silhouetted against the tree. Their motion towards you is mimicking the stationary tree's apparent motion as you walk past it… and that's just what the hoverfly does when approaching a mate. It's a stealth technique called 'active motion camouflage'.

By building a computer model of the mating flies, the team were able to show that this complex behaviour can actually be done with only a small amount of 'brain power'. They went on to show that humans are also fooled by active motion camouflage. They did this by creating a computer game where you had to dodge missiles. Some of those missiles used active motion camouflage. The missiles using the fly trick were the most difficult to spot.

It just goes to show: there is such a thing as a useful computer bug.

Image by Ronny Overhate from Pixabay

# As easy as a bee sees?

**If it wasn't for the bees we would be in trouble, and biologists need to know more about their lives to help. Samia Faruq, then a computer science undergraduate supervised by Peter, did her bit to help these scientists peer into the world of the bees.**

Bees are the main way that flowers get pollinated. As the bees sup the nectar they carry pollen from flower to flower, allowing new generations of flowers to grow. But the way a flower looks to our eyes isn't the same way a bee sees it. For example, bee vision works in the ultraviolet part of the spectrum and under the correct lighting in a laboratory the wonderful, normally invisible, patterns that bees can see are revealed. Biologists all over the world have been collecting information about the sorts of patterns that particular flowers display. This display is called a 'spectral profile'.

Samia's project involved creating a massive online database of worldwide spectral profile information, allowing scientists to search this information easily. It lets them combine information to help discover new facts using a method called clustering, where the computer pulls together all data with similar properties.

She enjoyed the project: "I met and worked with amazing biologists. It was great to find out what they needed and to be able to create it for them. I got to collaborate and publish material together with them too. To know it will be used in their research is also very rewarding."

# Understanding Ultron: A Turing test for world domination

by Peter W. McOwan

**Avengers: Age of Ultron is yet another film about robots or artificial intelligences (AI) trying to take over the world. AI is becoming ever present in our lives, at least as software tools that demonstrate elements of human-like intelligence. AI in our smartphones apply and adapt their rules to learn to serve us better, for example. But fears of AI's potential negative impact on humanity remain, as seen in its projection into characters like Ultron, a super-intelligence accidentally created by the Avengers.**

But what relation do the evil AIs of the movies have to scientific reality? Could an AI take over the world? How would it do it? And why would it want to? AI movie villains need to consider the whodunnit staples of motive and opportunity.

### Motive

Let's look at the motive. Few would say intelligence in itself unswervingly leads to a desire to rule the world. In movies, AI are often driven by self-preservation, a realisation that fearful humans might shut them down. But would we give our AI tools cause to feel threatened? They provide benefits for us and there also seems little reason in creating a sense of self-awareness in a system that searches the web for the nearest Italian restaurant, for example.

Another popular motive for AIs' evilness is their zealous application of logic. In Ultron's case the goal of protecting the earth can only be accomplished by wiping out humanity. This destruction by logic is reminiscent of the notion that a computer would select a stopped clock over one that is two seconds slow, as the stopped clock is right twice a day whereas the slow one is never right. Ultron's plot motivation, based on brittle logic combined with indifference to life, seems at odds with today's AI systems that reason mathematically with uncertainty and are built to work safely with users.

### Opportunity

When we consider an AI's opportunity to rule the world we are on firmer ground. The famous Turning Test of machine intelligence was set up to measure a particular skill – the ability to conduct a believable conversation. The premise is that if you can't tell the difference between AI and human skill, the AI has passed the test and should be considered as intelligent as humans.

So what would a Turing Test for the 'skill' of world domination look like? To explore that we need to compare the antisocial AI behaviours with the attributes expected of human world domination. World dominators need to control important parts of our lives, say our access to money or our ability to buy a house. AI does that already - lending decisions are frequently made by an AI sifting through mountains of information to decide your credit worthiness. AIs now trade on the stock market too.

An overlord would give orders and expect them to be followed. Anyone who has stood helplessly at a shop's self-service till as it makes repeated bagging related demands of them already knows what it feels like to be bossed about by AIs.

### Kill?

Finally, no megalomaniac Hollywood robot would be complete without at least some desire to kill us. Today, military robots can identify targets without human intervention. It is currently a human controller that gives permission to attack but it's not a stretch to say that the potential to auto-kill exists in these AIs, though we would need to change the computer code to allow it.

### Working together

These examples arguably show AI in control in limited but significant parts of life on earth. But to truly dominate the world, movie style, these individual AIs would need to start working together to create a synchronised AI army. That bossy self-service till would talk to your health monitor and deny selling you beer. They would then gang up with a credit scoring system, say, to only raise your credit limit if you first buy a pair of trainers with a built in GPS tracker, and the shoe data shows you have completed the required five mile run.

It's a worrying picture but fortunately I think it's an unlikely one. Engineers worldwide are developing the 'Internet of Things', networks connecting all manner of devices together to create new services. These are pieces of a jigsaw that would

Image by DrSJS from Pixabay

need to join together and form a big picture for total world domination. It's an unlikely situation - too much has to fall into place and work together. It's a lot like the infamous plot-hole in Independence Day - where an Apple Mac and an alien spaceship's software inexplicably have cross-platform compatibility.

Our earthly AI systems are written in a range of computer languages, hold different data in different ways and use different and non-compatible rule sets and learning techniques. Unless we design them to be compatible there is no reason why adding two safely designed AI systems, developed by separate companies for separate services would spontaneously blend to share capabilities and form some greater common goal without human intervention.

### World domination?

So could AI, and the robot bodies containing them, pass the test and take over the world? Only if we humans let them, and help them a lot, and why would we do that?

# Face off* SPOILER ALERT *

The gory plot of John Travolta and Nicolas Cage's 1997 movie Face/Off involves face transplants. Agent Sean Archer must find a ticking bomb planted by terrorist Caster Troy. He takes on Troy's identity by having Troy's face surgically transferred onto him so he can infiltrate the terrorist's prison group. To complicate things the real Troy (the baddy) gets hold of Archer's (the goody) face. The real Archer is left in prison, looking like the baddy, while Troy, looking like the goody, destroys everything that proves the swap took place. If successful Archer will be left to rot in jail as Troy...It all shows that faces are key to our personal identity and shifting them around is very confusing. Medical science can now transplant faces to help people whose own have been disfigured and computer scientists have developed ways to digitally transfer faces in less gruesome ways.

**Identikit faces**

Building faces from components is at the heart of using identikits to recreate the face of a criminal in a police investigation. Originally, the witness was given a book of different eyes, ears, hairlines, etc, selecting those they thought matched the criminal. Unfortunately, we don't see faces as a combination of bits but as whole faces, so often identikit pictures didn't actually look like the criminal. The digital E-Fit system tries to solve this by blending together the face building elements from the database to form a realistic looking face. A problem is that the witness building the face needs to say what's wrong, and that's difficult. The University of Stirling's Evo-Fit overcomes this by creating lots of similar faces, not one. The witness picks those closest to the criminal, which is easier. It then uses genetic algorithms (computer-based evolution), to breed more similar faces. Step-by-step, the system lets the witness focus in on the best likeness.

**The principle of Principal Components**

The Evo-Fit system works by having, not a database full of different ears, noses, eyes and so on, but one containing something more cunning: 'Principal Components' of faces.

Principal Components are a way to represent lots of complicated data in a simple way. Pictures of faces are stored as collections of numbers. A good-quality image contains thousands of numbers. If we combine many different face images, the amount of data becomes gigantic, and each new face adds more muddle to this big set of numbers. All faces are still in there but they are all mixed up. We need a way to reduce this muddle to just a few images that capture as much of the useful 'face stuff' in the full set as possible. That's where statistics comes in.

You may already have come across variance in maths. It is calculated from the data you are analysing and indicates how spread out the numbers are. A large variance means the numbers are spread out. A small variance means they are close together. We can use similar mathematical tricks on our face images. We want to find a few images that account for the most variation in the data: after all it's the variations that make faces different.

Once we turn the handle on the Principal Component Calculating Machine, we get a set of images. The first image (the first 'Principal Component') accounts for most of the variation in the data, the second Principal Component accounts for the next highest level of variation, and so on. Rather than storing all the

images we just store as many Principal Component images as we need (this is called data reduction). By adding and subtracting Principal Component images we can recreate a good approximation to any of the original faces that we mangled together in the first place (this is called data reconstruction).

## Face painting

If all this maths is confusing, think of it this way. You know from art that you can make any colour by mixing together red, yellow and blue paint (the primary colours). Think of the Principal Component images as ‘primary colours’, which you can mix together to ‘paint any colour’ – or in this case make any face. The Principal Component images are all faces so they have the standard overall arrangement of the face. That means the software won’t mistakenly add a nose where it doesn’t belong. The system just paints new faces with combinations of the Component images until the best match to the criminal is found.

## Digital Face/Off

We can apply the Principal Component trick to videos of faces too, because videos are just still frames stacked together. It’s just vastly more data. Now video, not static images, come out of the Principal Component Calculating Machine. The first Principal Component video accounts for most of the variation in the original set, the second Principal Component video accounts for… and you know the rest. We can now ‘paint’ with these videos to create new video sequences, by combining Principal Component videos. That’s exactly what Peter’s team of computer scientists at Queen Mary did with psychologists at UCL in the early 2000s!

## The Digital Face/Off illusion

Suppose we take lots of video of one person, say Troy, behaving in typical baddy style, and put this set of videos through the Principal Component Calculating Machine. We can now paint new videos of Troy by combining the components. If we can combine the right components we can make his face do anything, even give us a cheery smile.

If we do the same with goody, Archer: take lots of videos of him and put this set of videos through the Principal Component Calculating Machine, we could now paint new Archer videos. Suppose instead we have a video of Archer pulling a silly face. We can take this single video and work out the mix of Archer Principal Component videos he uses to do this. In effect, we have an instruction list of how to add and subtract the Archer components to make him look silly.

Now we take this instruction list from Archer but apply it to combine Troy’s’ video components instead. The result: a new video where the baddy pulls exactly the same funny face – a face he never pulled in reality! We have taken Archer’s movements and transplanted them onto Troy’s face without a scalpel. The illusion is complete: Archer’s face can work Troy’s face like a puppet, and there is nothing Troy can do about it.

## Facing up to the future

These techniques can be used to allow actors to impersonate other, possibly dead, actors, make fake videos of politicians or just let you pretend to be someone else on a video call. You could even create a face ‘graphics equaliser’ where rather than mixing music together by a set of sliders you mix facial expressions to create subtle performances for computer generated actors.

With computer science, virtually nothing can be taken at face value.

Image by Gerd Altmann from Pixabay

# Beheading Hero's mechanical horse

Stories of Ancient Greece abound with myths but also of amazing inventions. Some of the earliest automatons, mechanical precursors of robots, were created by the Ancient Greeks. Intended to delight and astound or be religious idols, they brought statues of animals and people to life. One story holds that Hero of Alexandria invented a magical, mechanical horse that not only moved and drank water, but was also impossible to behead. It just carried on drinking as you sliced a sword clean through its neck. The head remained solidly attached to body. Myth or Mystery? How could it be done?

The Ancient Greeks were clever. With many inventions we think of as modern, the Greeks got there first. They even invented the first known computer. Hero of Alexandria was one of the cleverest, an engineer and prolific inventor. Despite living in the first century, he invented the first known steam engine (long before the famous ones from the start of the industrial revolution), the first vending machine, a musical instrument that was the first wind-powered machine, and even the pantograph, a parallelogram structure used to make exact copies of drawings, enlarged or reduced. Did Hero invent a magical mechanical horse? He did, and you really could slice cleanly through its robotic neck with a sword, leaving the head in place.

**Magic, myth and mystery**

Peter was fascinated by magic and especially Hero's horse as a child, and was keen to build one. When TEMI, a European project was funded he had his chance. TEMI aimed to bring more showmanship, magic and mystery to schools to increase motivation. By making lessons more like detective work, solving mysteries, they can be lots more fun. The project needed lots of mysteries, just like Hero's horse, and artist Tim Sargent was commissioned to recreate the horse.

If you're ever in Athens, you can see a version of Hero's horse, as well as many other Greek inventions at Kotsanas Museum of Ancient Greek Technology.

**How does it work?**

The challenge was to create a version that used only Ancient Greek technology - no electricity or electromagnets, only mechanical means like gears, bearings, levers, cogs and the like. It was actually done with a clever rotating wheel.
As the sword slices through a gap in the neck, it always connects head and body together first in front, then behind the blade. Can you work out how it was done? To see a video of the mechanism in action follow the links from **www.cs4fn.org/petermcowan/**

Image by Dorota Kudyba from Pixabay

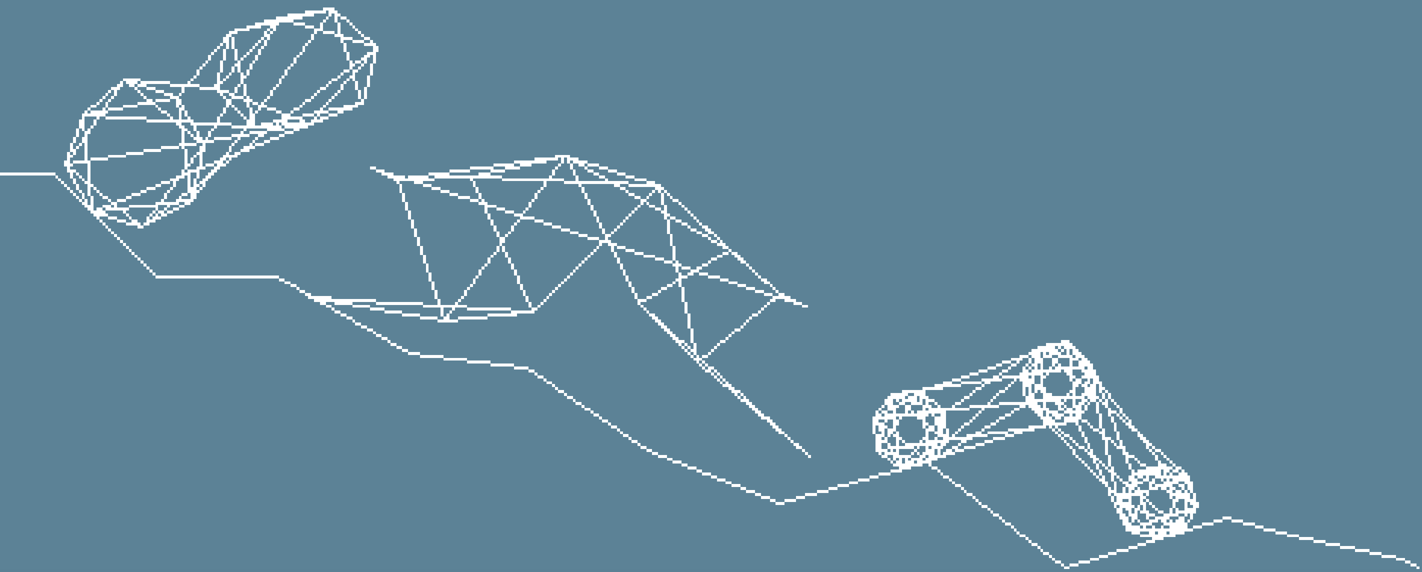
The island of Rhodes in Ancient Greece was covered with automata according to an Ode by Pindar

*The animated figures stand*
*Adorning every public street*
*And seem to breathe in stone, or*
*move their marble feet.*

Can you write an Ode to modern technology?

Find more about the educational mysteries that TEMI developed by following the links at **www.cs4fn.org/petermcowan**

# Sodarace

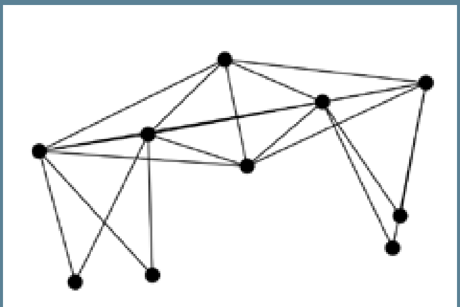


Humans versus machine intelligence is the stuff of many a good Hollywood movie. Sodarace, Peter's collaboration with digital arts company SoDA, building on the BAFTA winning Sodaplay, gave everyone the chance to play with the ideas in a clash of creativity between humans and machines.

The challenge was to create a creature that outruns those designed by others from around the world. And if you could, how about beating those created by artificial intelligences? It allowed people worldwide to pit their wits against machine intelligence.

Who can create the fastest creatures to race over a given digital terrain?

Humans use their ingenuity, drawing and engineering skills to hand craft a life-like 2-dimensional creature out of virtual masses and springs that can roll, scurry or run as fast as possible over a given terrain in a virtual world.



**Let the AI create a creature**
Sodarace players could also use genetic algorithms to create artificial racers, combining human and machine creativity. Once you've designed the terrain, take an already developed racer, for example a Daintywalker (as above), and breed a better version. This is done using a genetic algorithm to find the best set of springs and values for the way they move to get your racer over the course the fastest. It is similar to the process of evolution by natural selection in nature, where animals find the best way to survive in different environments. Only the most successful offspring go on to have children of their own, passing on what was special about them.

SoDA is aiming to relaunch Sodaconstructor at sodaplay.com before the end of 2020.

**Mutations by computer**
One of the keys to good survivability is mutation. Small random changes to the racer sometimes produce racers that are better than any other. As good mutations build up over generations, the racers get better and better. When the first ever Sodarace went public, Queen Mary computer scientists spent lots of time creating a super Daintywalker to cover the racetrack faster than any previous one. They used computer generated mutations to find a superfast solution, and then posted it to the Sodarace forum. Job done, they set to work writing a press release to tell the world of their accomplishments the next day.

**Meanwhile, somewhere in Canada**
That night a kid in Canada found the race, and set about the challenge: to manually try to find a better mutation to beat the Queen Mary racer ... and he did. The next day, the scientists found that they had been beaten and had to quickly rewrite the press release. So in the first ever public Sodarace, human ingenuity, creativity and a strong desire to solve a problem had triumphed over Artificial Intelligence. News of the human victory went around the news websites of the world. Round one to humanity.

Actually, machine intelligence still had some tricks up its digital sleeve ... but that's a different story.

# Manufacturing magic

by Howard Williams, Queen Mary University of London

Can computers lend a creative hand to the production of new magic tricks? That's a question our team, led by Peter have been wrestling with for the past few years. The idea that computers can help with creative endeavours like music and drawing is nothing new - turn the radio on and the song you are listening to will have been produced with the help of a computer somewhere along the way, whether it's a synthesiser sound, or the editing of the arrangement, and some music is created purely inside software. Researchers have been toiling away for years, trying to build computer systems that actually write the music too! Some of the compositions produced in this way are surprisingly good! Inspired by this work, we decided to explore whether computers could create magic.

The project to build creative software to help produce new magic tricks started with a magical jigsaw that could be rearranged in certain ways to make objects on its surface disappear. Pretty cool, but what part did the computer play?

A jigsaw is made up of different pieces, each with four sides - the number of different ways all these pieces can be put together is very large; for a human to sit down and try out all the different configurations would take many hours (perhaps thousands, if not millions!). Whizzing through lots of different combinations is something a computer is very good at. When there are simply too many different combinations for even a computer to try out exhaustively, programmers have to take a different approach.

## Evolve a jigsaw

A genetic algorithm is a program that mimics the biological process of natural selection. We used one to intelligently search through all the interesting combinations that the jigsaw might be made up from. A population of jigsaws is created, and is then 'evolved' via a process that evaluates how good each combination is in each generation, gradually weeding out the combinations that wouldn't make good jigsaws. At the end of the process you hope to be left with a winner; a jigsaw that matches all the criteria that you are hoping for. In this particular case, we hoped to find a jigsaw that could be built in two different ways, but each with a different number of the same object in the picture, so that you could appear to make an object disappear and reappear again as you made and remade it. The idea is based on a very old trick popularised by Sam Lloyd, but our aim was to create a new version that a human couldn't, realistically, have come up with, without a lot of free time on their hands!

To understand what role the computer played, we need to explore the Genetic Algorithm mechanism it used to find the best combinations. How did the computer know which combinations were good or bad? This is something creative humans are great at - generating ideas, and discarding the ones they don't like in favour of ones they do. This creative process gradually leads to new works of art, be they music, painting, or magic tricks. We tackled this problem by first running some experiments with real people to find out what kind of things would make the jigsaw seem more 'magical' to a spectator. We also did experiments to find out what would influence a magician performing the trick. This information was then fed into the algorithm that searched for good jigsaw combinations, giving the computer a mechanism for evaluating the jigsaws, similar to the ones a human might use when trying to design a similar trick.

## More tricks

We went on to use these computational techniques to create other new tricks, including a card trick, a mind reading trick on a mobile phone, and a trick that relies on images and words to predict a spectator's thought processes. You can find out more at **www.Qmagicworld.wordpress.com**

## Is it creative, though?

There is a lot of debate about whether this kind of 'artificial intelligence' software, is really creative in the way humans are, or in fact creative in any way at all. After all, how would the computer know what to look out for if the researchers hadn't configured the algorithms in specific ways? Does a computer even understand the outputs that it creates? The fact is that these systems do produce novel things though - new music, new magic tricks - and sometimes in surprising and pleasing ways, previously not thought of.

Are they creative (and even intelligent)? Or are they just automatons bound by the imaginations of their creators? What do you think?

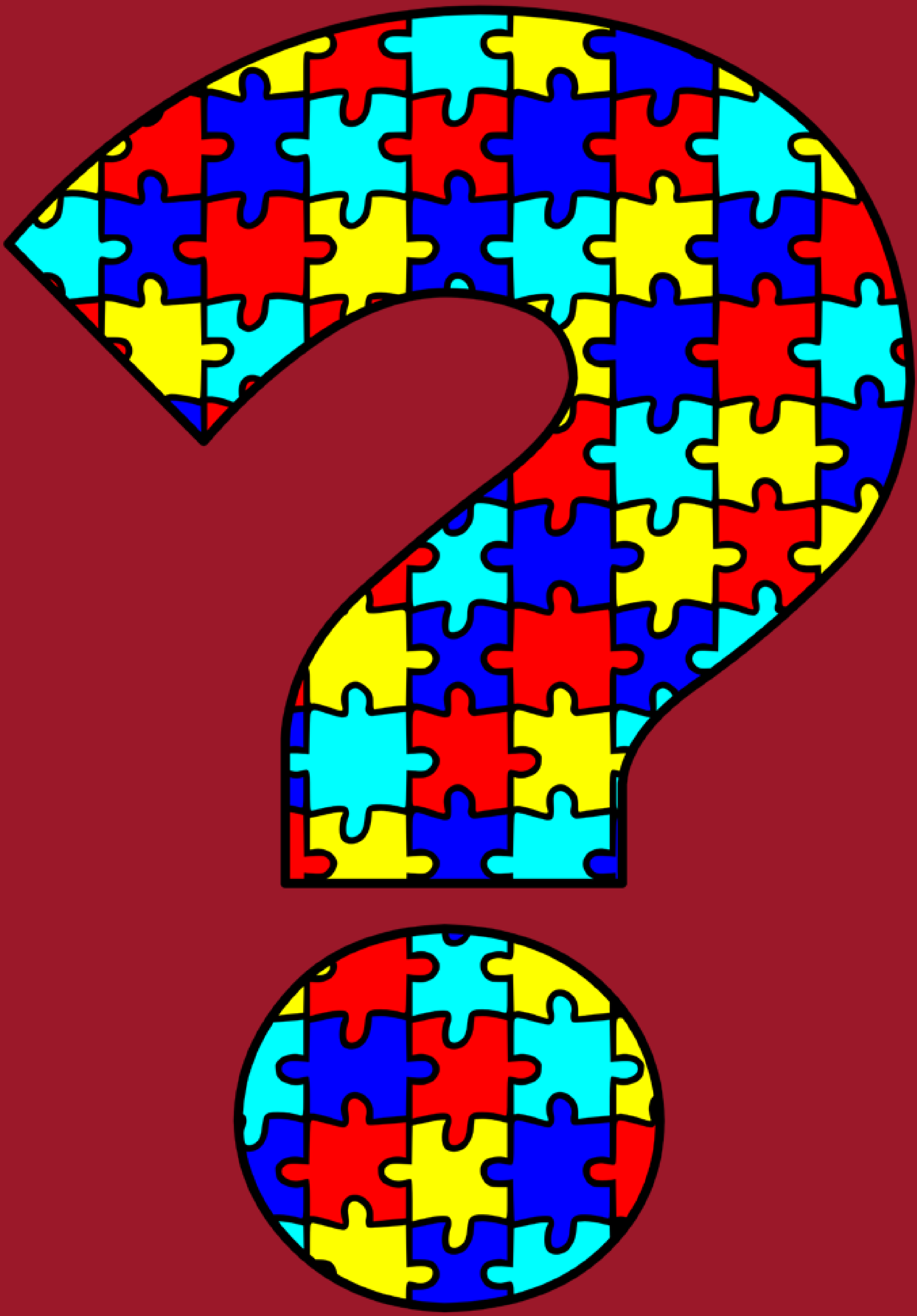


Image by Bikki from Pixabay

# DragonflyAI
# I see what you see

**What use is a computer that sees like a human? Can't computers do better than us? Well, such a computer can predict what we will and will not see, and there is BIG money to be gained doing that!**

Peter's team spent 10 years doing exploratory research understanding the way our brains really see the world, exploring illusions, inventing games to test the ideas, and creating a computer model to test their understanding. Ultimately they created a program that sees like a human (see page 4). But what practical use is a program that mirrors the oddities of the way we see the world. Surely a computer can do better than us: noticing all the things that we miss or misunderstand? Well, for starters the research opens up exciting possibilities for new applications, especially for marketeers.

A fruitful avenue to emerge is 'visual analytics' software: applications that predict what humans will and will not notice. Our world is full of competing demands, overloading us with information. All around us things vie to catch our attention, whether a shop window display, a road sign warning of danger or an advertising poster.

Imagine, a shop has a big new promotion designed to entice people in, but no more people enter than normal. No-one notices the display. Their attention is elsewhere. Another company runs a web ad campaign, but it has no effect, as people's eyes are pulled elsewhere on the screen. A third company pays to have its products appear in a blockbuster film. Again, a waste of money. In surveys afterwards no-one knew the products had been there. A town council puts up a new warning sign at a dangerous bend in the road but the crashes continue. These are examples of situations where predicting where people look in advance allows you to get it right. In the past this was either done by long and expensive user testing, perhaps using software that tracks where people look, or by having teams of 'experts' discuss what they think will happen. What if a program made the predictions in a fraction of a second beforehand? What if you could tweak things repeatedly until your important messages could not be missed.

Queen Mary's Hamit Soyel turned the research models into a program called DragonflyAI, which does exactly that. The program analyses all kinds of imagery in real-time and predicts the places where people's attention will, and will not, be drawn. It works whether the content is moving or not, and whether it is in the real world, completely virtual, or both. This then gives marketeers the power to predict and so influence human attention to see the things they want. The software quickly caught the attention of big, global companies like NBC Universal, GSK and Jaywing who now use the technology.

Image by Skeeze from Pixabay

It isn't just marketing though, ultimately to design a good experience playing a game, watching a film, browsing an e-shopping site, or in fact using any software application, requires a good understanding of where people will look, and of being able to control it. That is the way to give users a positive experience, ensuring they achieve whatever they are trying to do.

Software that can predict how our brains see the world may one day be giving us all better experiences helping us only see the things that matter to us personally.

### A start-up is born

DragonflyAI actually came about from a public talk Peter and Hamit gave at the Science Museum about robots. At the last moment they added a slide about their latest vision research. It sparked the interest of a marketing specialist who happened to be in the audience. They immediately realised there were business opportunities in the research. From the ensuing conversation, DragonflyAI was born.

### Magic misdirection

Many magic tricks depend on misdirection. The magician makes the whole audience look in the wrong place at the wrong time so that they miss something critical (like an elephant walking onto the stage!). DragonflyAI can be used to check how well a particular misdirection will work.

## Impressionistic AI art

**If you are creative, you can do lots with a program that simulates how humans see the world. Milan Verma turned the Queen Mary one into an AI artist.**

The early versions of the program Peter's team developed, of how we see the world, worked on static images. Given an image it created a 'saliency map' of it, rating each area by how much our eyes should be drawn to that place (see image below). For example, an area with a lot of contrast would pull our eyes towards it, so was given a high rating. Areas with little contrast were given low ratings.

The AI artist even held an exhibition of its work at a London gallery.

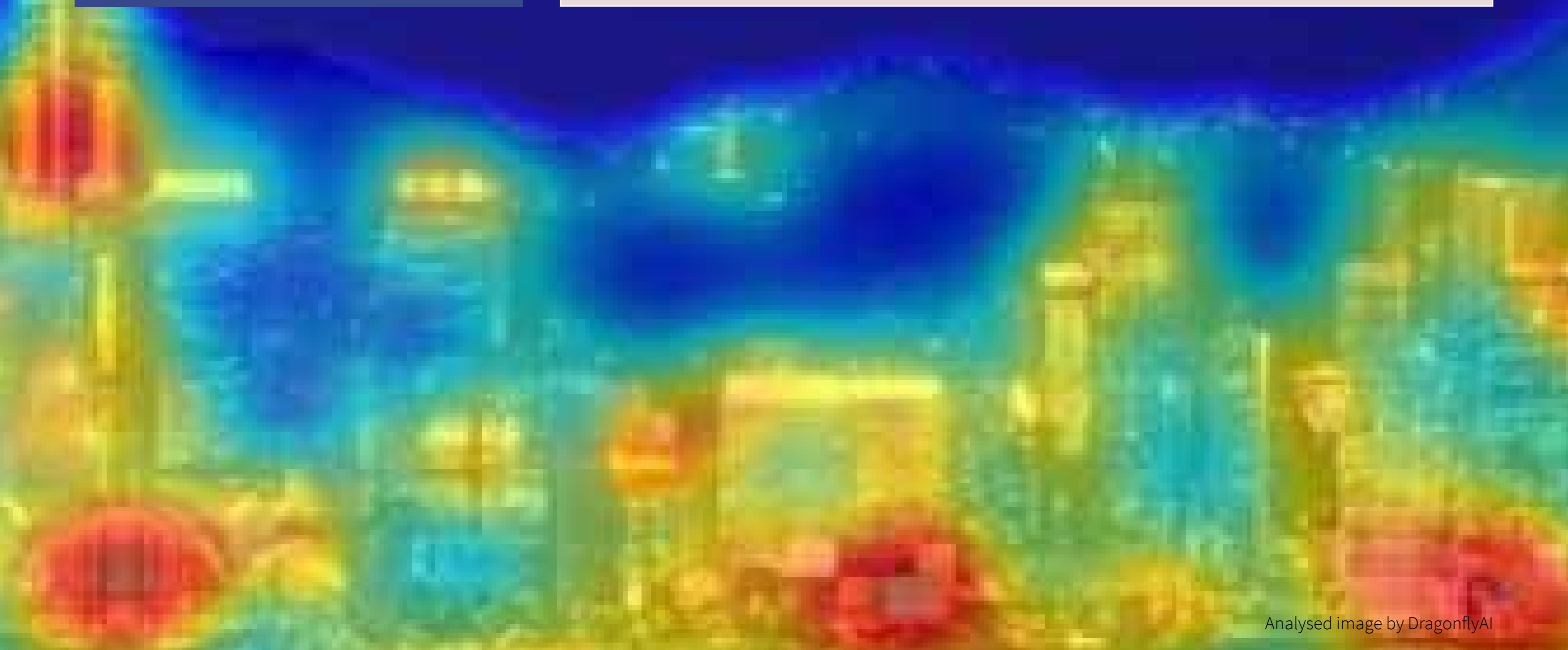
Milan built it into an AI painter. Having created the saliency map of the image, it picked up its virtual paintbrush and painted its own interpretation. The places where it predicted our eyes would be drawn were painted using a fine brush with lots of detail. For areas our eyes were predicted to slide over, the paint was just slapped on as the detail shouldn't matter. The result was an AI variation of impressionist art, with detail only where it mattered.

### Spot the difference

Try our spot the difference puzzles: Milan used the AI to change the details of some pictures in places where the changes should be easy to spot. Other pictures were changed in places where the AI predicted we would struggle to see even when big areas were changed. Go to **www.cs4fn.org/spotdifference/**

### Any Images

The DragonflyAI program can analyse all kinds of imagery whether still images, web pages, videos, surveillance camera footage, dynamic images like social media feeds and video on demand views, and even 360 degree immersive video. It is fast enough to do it all as it happens. Find out more at **www.dragonflyai.co**



Analysed image by DragonflyAI

# When I see you smile...

### When does a machine stop being a toy and become a companion?

The team of researchers, Ginevra Castellano, Iolanda Leite, Ana Paiva, and Peter, wanted to find out how to make robots that behaved less like a mere machine and more like a companion. They thought that such robots would need to be able to understand our emotions and also to behave in a socially intelligent way. They would need not just the kind of intelligence that allows them to play games like chess, but be socially intelligent too.

### Playing chess with friends

To find out, as part of the EU funded LIREC project, they ran a series of experiments, getting children to play chess with a game-playing robot. This gave them the basis to build their own, better, robot. They found that to be a really effective playing companion, the robot did need to understand and react to the emotions of the children it played with. They also showed that by observing a child's behaviour when playing games like chess it was actually possible to work out the emotion the child was feeling. Hints to their emotions included not just obvious things like whether they were smiling or not, but also, for example, where they were looking.

Based on their discoveries, the team built a new emotionally-aware robot to play chess with children. By taking into account both the children's behaviour and the state of the game, their robot worked out when the child started to feel unhappy. It then behaved appropriately. For example, when they were sad it might give them help or offer encouragement, just as a supportive friend would. The robot was setting up what is called an 'affective loop' with them: recognising emotions then changing behaviour to match and change those emotions. The primary school children in the experiments thought the robot was much more engaging and helpful when it behaved like this, reacting directly to their emotions. It was becoming more like a true companion.

### Friends for life

Robots of the future, if they are to be true companions, will need to work out our emotions, be sensitive to them, and behave supportively, just as a human friend would. That is much more than developers currently mean when they say their software is user-friendly, but it is what future software must become. Only then will the machines be on the road to switching from being, throw-away, tools and toys, to true, long-term friends and companions.

This research won a special award, judged 10 years after publication, for being seminal research.

Image by engin akyurt from Pixabay

# Blade: the emotional computer

**Communicating with computers is clunky - we have IT classes to learn to talk to them. It would be so much better if they did the learning instead. We talk, we listen, but we also use expressions and our tone of voice to communicate. Zabir, an undergraduate student of Peter's (who went on to work for a merchant bank) experimented with these ideas for his final year project. He programmed Lego Mindstorm to create Blade... a robot face that expressed emotion and responded to tone of voice.**

Shout at Blade and he looked sad. Talk softly and, despite not understanding a word, he would look happy again. Why? Because your tone says what you really mean whatever the words - that's why parents calm babies by talking gobbledegook softly.

Blade was programmed as a neural network, software modelled on the way brains work, so he had a brain similar to ours. Blade learnt very much like children learn, tuning his neurons based on his experience. Zabir spent a lot of time shouting and talking softly to Blade, teaching him what the tone of his voice meant, and so how to react. Blade's behaviour wasn't directly programmed, only the ability to learn was.

Eventually we had to take Blade apart which was surprisingly sad. He seemed to be more than a bunch of lego bricks. Something about his very human-like expressions pulled on our emotions.

# Music-making mates for Mortimer

by Louis McCallum, Queen Mary University of London

**Robots are cool. Fact. But can they keep you interested for more than a short time? Over months? Years even?**

Roboticists (that is what we're called) have found it hard to keep humans engaged with robots once the novelty wears off. They're either too simple and boring, or promise too much and disappoint. So, at Queen Mary we've built a robot called Mortimer that not only plays the drums, but also listens to humans play the piano and jams along. He can talk (a bit) and smile too. We hope people will build long term relationships with him through the power of music.

## Would we believe their concern if a robot asked how we were feeling?

Robots have been part of our lives for a long time, but we rarely see them. They've been building our cars and assembling circuit boards in factories, not dealing with humans directly. Designing robots to have social interactions is a completely different challenge that involves engineering and artificial intelligence, but also psychology and cognitive science. Should a robot be polite? How long and accurate should a robot's memory be? What type of voice should it have and how near should it get to you?

It turns out that making a robot interact like a human is tricky. Even the slightest errors make people feel weird. Just getting a robot to speak naturally and understand what we're saying is far from easy. And if we could, would we get bored of them asking the same questions every day? Would we believe their concern if they asked how we were feeling?

Music is emotionally engaging but in a way that doesn't seem fake or forced. It also changes constantly as we learn new skills and try new ideas. Although there have been many examples of family bands, duetting couples, and band members who were definitely not friends, we think there are lots of similarities between our relationships with people we play music with and 'voluntary non-kin social relationships' (as robotocists call them - 'friendships' to most people!). In fact, we have found that people get the same confidence boosting reassurance and guidance from friends as they do from people they play music with.

So, even if we are engaged with a machine, is it enough? People might spend lots of time playing with a guitar or drum machine but is this a social relationship? We tested whether people would treat Mortimer differently if it was presented as a robot you could socially interact with or simply as a clever music machine. We found people played for longer uninterrupted and stopped the robot whilst it was playing less often if they thought you could socially interact with it. They also spent more time looking at the robot when not playing and less time looking at the piano when playing. We think this shows they were not only engaged with playing music together but also treating him in a social manner, rather than just as a machine. In fact, just because he had a face, people talked to Mortimer even though they'd been told he couldn't hear or understand them!

So, if you want to start a relationship with a creative robot, perhaps you should learn to play an instrument!

Image by skeeze from Pixabay

# Back(page) to the beginning

by Peter W. McOwan, selected by Jo Brodie, Queen Mary University of London

**Peter wrote the back pages to cs4fn magazine for over 15 years, finding quirky but true stories about computing and technology (and writing terrible puns). Here we put together some of our favourites going all the way back to issue 1.**

### Pondering people's predictions (Issue 1)

"I think there is a world market for maybe five computers" said Thomas Watson in 1943, chairman of IBM, a company that later went on to revolutionise the home PC market.

**Saying: You say it best when you say nothing at all**

### Muslim programs (Issue 4)

In the 9th century in Baghdad the Persian Muslim scholar Abū ʻAbdallāh Muḥammad ibn Mūsā al-Khwārizmī wrote a book 'On the Calculation with Hindu Numerals'. It was responsible for the subsequent widespread use of the Hindu-arabic number system we use today. He also wrote rules for doing arithmetic using this system. The word algorithm, derived from his name, started to be used to refer to such rules that could be followed to achieve a calculation. Once computers were eventually invented in the 20th century this whole idea of algorithms suddenly became crucial as that is really all a computer program is: a set of instructions that if followed precisely in the given order lead to some task being achieved…but now followed by a computer rather than by a mathematician.

**Life Lesson: Always have a plan and stick to it!**

### The importance of nothing (Issue 14)

Computers live in a binary world of 1s and 0s, but where did 0 come from? We owe the big something that is nothing to the Indian mathematician and astronomer Brahmagupta (598–668 AD). Brahmagupta was the first person to use zero as a number: he invented nothing! He also founded the modern rule that two negative numbers multiplied together equals a positive number. Like other Indian scholars at the time, he wrote his books in verse, so his work was not only mathematical but poetic.

**Motto: nothing can turn out to be a really big something**

### Sick of tweeting (Issue 15)

Twitter, the popular social media platform, lets people tell the world what they are up to, from buying beans in the supermarket to feeling a bit ill. Computer scientists are working to develop ways to extract key words from tweets that indicate the onset of particular diseases, so that preparations can be made to treat them. This way of crowdsourcing information on the spread of disease could prove useful in the future.

**Diagnosis: saying you're sick doesn't make you a tweet**

### Doh, ray, me, F.A. sew, la, T… (Issue 21)

Football associations world-wide realise that getting a good crowd roar in the stadium enhances the spectators' appreciation of the game. Stadiums are often computer designed to reflect the sound back into the field, or microphones are used to pick up the sounds that are then played back on speakers.

**Note: sounds like a gooooooallllllllll**

### And finally expect the unexpected (Issue 2)

In the early days of electronic computers, they used relays, electromechanical switches that rocked up and down to switch the electrical circuits. Grace Murray Hopper, who was in charge of the team working with the Mark II computer, found that a moth had flown through the window and blocked one of the relays, so shutting the system down. This is arguably where the term computer 'bug' comes from.

**The moral: The things some moths get into can be shocking!**

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