

CS4FN

Computer Science for Fun

Issue 12



***Computing
on the
catwalk!***

***Computer
evolution
creates mutant
clothing***

***The fashion
of Iron Man***

***Why are robots
always naked?***

The fashion issue

Every day, choosing what to wear gives you a chance to be creative, try on new identities, or at least keep yourself warm and dry. The possibilities don't stop at your closet though. You don't just have to wear clothes – you can wear computers too. Looking smart just got a whole lot smarter.

In this issue you'll find all sorts of ways that computer science can improve your style. You'll read about t-shirt designs made with the help of evolution, a mirror that helps you choose what to wear, and the technology behind Tony Stark's Iron Man suit. Plus we'll get to the bottom (so to speak) of why robots always insist on going naked. The computerised wardrobe of the future contains everything from LED frocks to biomechanical exoskeletons, so take a look inside.



Light up the night

Earlier this year, Katy Perry set New York alight by appearing on the red carpet at a Metropolitan Museum of Art gala in a seriously techy frock. Her dress was made from silk chiffon and illuminated by over 3000 coloured light-emitting diodes (LEDs), making her a flashy fashion icon. The dress was made by London's own CuteCircuit, who make all sorts of wearable technology. They also make shirts that contract to give you a hug, and another dress whose light-up embroidery moves as you move.

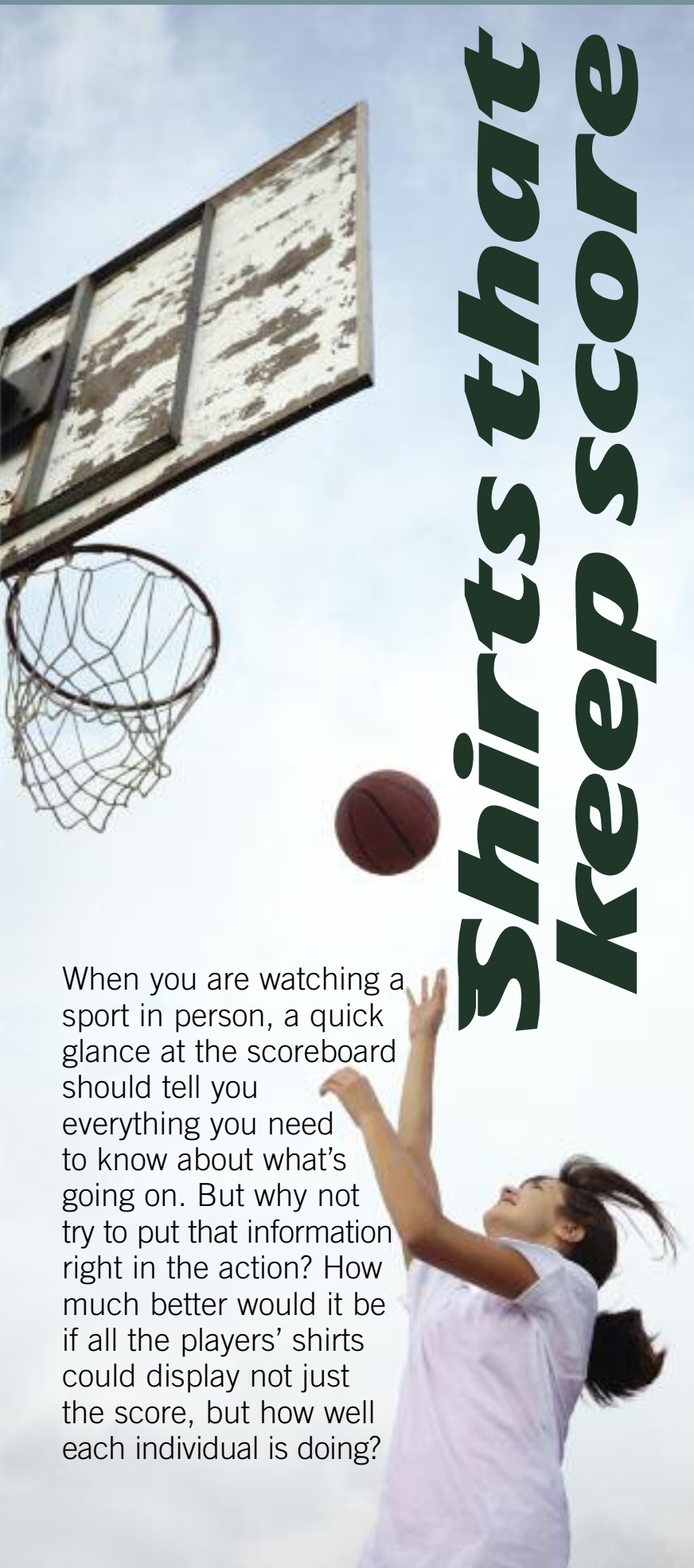
But there could be even more exciting stuff on the way for light-up clothing patterns. Noël Palomo-Lovinski from Kent State University in the USA thinks that the future is going to bring clothes whose fabric is woven with washable screens that can display whatever image the wearer wants. The technology would be similar to the organic LEDs found in today's high-definition TVs. You could download and switch between an infinite number of patterns and pictures for your clothes – kind of like an mp3 player for your wardrobe! Only one problem though: what if you were to go to a party where everyone was wearing different moving, flashing, glowing pictures on their clothes? It would be like going to a party with the neon signs from Piccadilly Circus!

What card is that?



This card trick, with its completely impossible-looking effect, requires a friend with artistic or design flair. You will also need access to the web. In the performance you have your friend draw a picture of any freely chosen card. You tease them a bit about their less than perfect artistic ability, and decide the only way to really discover

which card has been drawn is to ask the Internet. You open up your web browser. The audience watches as you type in the question on everyone's lips, 'what card is that?' On pressing return the browser shows a list of websites that contain the actual name of the freely selected (and badly drawn) card in them. After all, the web is often a useful place to find answers...but how did it know what card was drawn? Find the answer in the full version of this trick, in the magazine+ section of our website, www.cs4fn.org.



When you are watching a sport in person, a quick glance at the scoreboard should tell you everything you need to know about what's going on. But why not try to put that information right in the action? How much better would it be if all the players' shirts could display not just the score, but how well each individual is doing?

Shirts that keep score

Light up, light up

An Australian research group from the University of Sydney has made it happen. They rigged up two basketball teams' shirts with displays that showed instant information as they played one another. The players (and everyone else watching the game) could see information that usually stays hidden, like how many fouls and points each player had. The displays were simple coloured bands in different places around the shirt, all connected up with tiny wires sewn into the shirts like thread. For every point a player got, for example, one of the bands on the player's waist would light up. Each foul a player got made a shoulder band light up. There was also a light on players' backs reserved for the leading team. Take the lead and all your team's lights turned on, but lose it again and they went dark with defeat.

Sweaty but safe

All those displays were controlled by an on-board computer that each player harnessed to his or her body. That computer, in turn, was wirelessly connected to a central computer that kept track of winners, losers, fouls and baskets. The designers had to be careful about certain things, though. In case a player fell over and crushed their computer, the units were designed with 'weak spots' on purpose so they would detach rather than crumple underneath the player. And, since no one wants to get electrocuted while playing their favourite sport, the designers protected all the gear against moisture and sweat.

Keeping your head in the game

In the end, it was the audience at the game who got the most out of the system. They were able to track the players more closely than they normally would, and it helped those in the crowd who didn't know much about basketball to understand what was going on. The players themselves had less time to think about what was on everyone's clothes, as they were busy playing the game, but the system did help them a few times. One player said that she could see when her teammate had a high score, "and it made me want to pass to her more, as she had a 'hot hand'". Another said that it was easier to tell when the clock was running down, so she knew when to play harder. Plus, just seeing points on their shirts gave the players more confidence. There's so much information available to you when you watch a game on television that, in a weird way, actually being in the stadium could make you less informed. Maybe in the future, the fans in the stands will see everything the TV audience does as well, when the players wear all their statistics on their shirts! We'll see what the sponsors think of that...

That's the spot!

Researchers at Sheffield Hallam university have come up with a digital sensor that finds the sweet spot of a tennis racket. The way you begin the experiment is pleasingly low-tech though: you hit the racket with a tennis ball attached to a hammer.

Shake off that foul mood



What does the way you walk say about your mood? Maybe quite a lot if you are wearing a neat little gadget called a SHAKE.

A whole bunch of researchers are looking at ways that computers can automatically determine things about people from the way they walk. Are they male or female? How could they improve in sports like athletics? Who are they? These are all things that might automatically be determined from a person's walk.

Mostly it's done using CCTV footage or by having people walk on special pressure pads. Parisa Eslambolchilar and her master's student Richard Byrne from Swansea University, working with Andrew Crossan of Glasgow, wondered if you could come up with a simple and cheap device for a person to wear instead. They also wondered if you could use it to tell a person's mood from the way they walk.

Richard set to work on the challenge. He created a gadget that records the movement of a person's hips and shoulders. It's just a belt round the waist with a strap over the person's shoulder – a bit like one of the reflector belts that help make cyclists visible in the dark. The belt has SHAKEs fastened to it – one on the hip and one on the shoulder. What are SHAKEs? They are very simple, if nifty, little gadgets that contain accelerometers. It's the same sort of gadget that allows a smartphone to sense when it's

being shaken. An accelerometer detects movement in different directions. They may be a simple idea but lots of inventive computer scientists and electronic engineers are coming up with a whole bunch of novel ways to use them.

Richard created some neural networks to be the brains behind the belt. Neural networks are programs that work in a similar way to our brains, made up of artificial brain cells that can send simple messages to each other. Because they are modelled on our brains they can learn from experience just as we can. Give a neural network lots of training data (say the SHAKE data from a whole series of people walking, plus the emotion they were feeling at the time), and gradually it will start to pull out patterns in the data. Maybe a person's shoulders drop when they are sad, or rise when they are happy. That ability to learn from the data is the key – it meant Richard didn't need to know what the patterns were in advance. His software could work it out. Having trained the neural network it can then be given data where the answer isn't known – in this case SHAKE data where the person's emotion needs to be determined. The neural network then matches the patterns to the ones it's learnt. If the person is walking in a 'happy' sort of way, then the neural network can announce that they are happy, and likewise for other emotions like angry or sad where it has worked out a clear pattern.

Richard created two neural networks. The first was trained to recognise different people, and the second their mood. Even when trained on a dataset of only a half a dozen

people, it was 70% accurate in working out which person it was looking at. It wasn't quite as good at recognising the mood, getting it right from the three possibilities 65% of the time. That obviously needs improvement but shows that it is in theory possible to tell a person's mood from the way they walk. With more training, it may get better still. One surprising result though was that the SHAKE data from the shoulder didn't really help. The neural network was best when using just the data from a SHAKE stuck to the person's hip.

If technology like this can be perfected there are loads of applications possible in healthcare: perhaps recognising when a person who often becomes dangerously depressed is starting to do so. Then help could be sent before it is too late.

With neural networks to help us to SHAKE off bad moods, the happy times may be here again as quickly as possible.

Walk happy

You can try this with a group of friends as Parisa has done with school groups. First pick out a panel of judges. Ask the others to walk around the room while thinking of some powerful memory – perhaps it was a really happy memory, a sad memory or something that made them angry. Now get the judges to try and guess which emotion each walker is thinking of. Can your judges do it better than the computer?

The naked robot

Why are so many film robots naked? We take it for granted that robots don't wear clothes, and why should they?

They are machines, not humans, after all. On the other hand, the quest to create artificial intelligence involves trying to create machines that share the special ingredients of humanity. One of the things that is certainly special about humans in comparison to other animals is the way we like to clothe and decorate our bodies. Perhaps we should think some more about why we do it but the robots don't!

Shame or showoff?

The creation story in the Bible suggests humans were thrown out of the Garden of Eden when Adam and Eve felt the need to cover up – when they developed shame. Humans usually wear more than just the bare minimum though, so wearing clothing can't be all about shame. Nor is it just about practicalities like keeping warm. Turn up at an interview covering your body with the wrong sort of clothes and you won't get the job. Clothes are about decorating our bodies as much as covering them.

Our urge to decorate our bodies certainly seems to be a deeply rooted part of what makes us human. After all, anthropologists consider finds like ancient beads as the earliest indications of humanity evolving from apes. It is taken as evidence that there really was someone 'in there' back then.

The fashion urge

Whatever is going on in our heads, clearly the robots are missing something. Even in the movies the intelligent ones rarely feel the need to decorate their bodies. R2D2? C3PO? Wall-E? The exceptions are the ones created specifically to pass themselves off as human like in Blade Runner.

You can of course easily program a robot to 'want' to decorate itself, but if it was just following a programmed rule would that be the same as when a human wears clothes? Would it be evidence of 'someone in there'? Presumably not!

We do it because of an inner need to conform more than an inner need to wear a particular thing. That is what fashion is really all about. Perhaps programming an urge to copy others would be a start. In Wall-E, the robot shows early signs of this as he tries to copy what he sees the humans doing in the old films he watches. At one point he even uses a hubcap as a prop hat for a dance. Human decoration may have started as a part of rituals too.

Where to now?

Is this need to decorate our bodies something special, something linked to what makes us human? Should we be working on what might lead to robots doing something similar of their own accord? When archaeologists are hunting through the rubble in thousands of years' time, will there be something other than beads that would confirm their robot equivalent to self-awareness? If robots do start to decorate and cover up their bodies because they want to rather than because it was what some God-like programmer coded them to do, surely something special will have happened. Perhaps that will be the point when the machines have to leave their Garden of Eden too.



Full metal

The fashion of Iron

Industrialist Tony Stark always dresses for the occasion, even when that particular occasion happens to be a fight with the powers of evil.

In the Iron Man comic and movie franchise Anthony Edward Stark, Tony to his friends, becomes his crime fighting alter ego by donning his high tech suit. The character was created by Marvel comic legend Stan Lee and first hit the pages in 1963. The back story tells how industrial armaments engineer and international playboy Stark is kidnapped and forced to work to develop new forms of weapons, but instead manages to escape by building a flying armoured suit.

Though the escape is successful Stark suffers a major heart injury during the kidnap ordeal, becoming dependant on technology to keep him alive. The experience forces him to reconsider his life, and the crime avenging Iron Man is born. Lee's 'businessman superhero' has proved extremely popular and in recent

years the Iron Man movies, starring Robert Downey Jr, have become box office hits. But as Tony himself would be the first to admit, there is more than a little computer science supporting Iron Man's superhero standing.

Suits you

The Iron Man suit is an example of a powered exoskeleton. The technology surrounding the wearer amplifies the movement of the body, a little like a wearable robot. This area of research is often called 'human performance augmentation' and there are a number of organisations interested in it, including universities and, unsurprisingly, defence companies like Stark Industries. Their researchers are building real exoskeletons which have powers uncannily like those of the Iron Man suit.

To make the exoskeleton work the technology needs to be able to accurately read the exact movements of the wearer, then have the robot components duplicate them almost instantly. Creating this fluid mechanical shadow means the exoskeleton needs to contain massive computing power, able to read the forces being applied and convert them into

signals to control the robot servo motors without any delay. Slow computing would cause mechanical drag for the wearer, who would feel like they were wading through treacle. Not a good idea when you're trying to save the world.



al jacket

on Man

Pump it up

Humans move by using their muscles in what are called antagonistic pairs. There are always two muscles on either side of the joint that pull the limb in different directions.

For example, in your upper arm there are the muscles called the biceps and the triceps. Contracting the biceps muscle bends your elbow up, and contracting your triceps straightens your elbow back. It's a clever way to control biological movement using just a single type of shortening muscle tissue rather than one kind that shortens and another that lengthens.

In an exoskeleton the robot actuators (the things that do the moving) take the place of the muscles, and we can build these to move however we want, but as the robot's movements need to shadow the person's movements inside, the computer needs to understand how humans move. As the human bends their elbow to lift up an object, sensors in the exoskeleton measure the forces applied, and the onboard computer calculates how to move

the exoskeleton to minimise the resulting strain on the person's hand. In current strength amplifying exoskeletons the actuators are high pressure hydraulic pistons, meaning that the human operators can lift considerable weight. The hydraulics support the load, the humans movements provide the control.

I knew you were going to do that

It is important that the human user doesn't need to expend any effort in moving the exoskeleton; people get tired very easily if they have to counteract even a small but continual force. To allow this to happen the computer system must ensure that all the sensors read zero force whenever possible. That way the robot does the work and the human is just moving inside the frame. The sensors can take thousands of readings per second from all over the exoskeleton: arms, legs, back and so on.

This information is used to predict what the user is trying to do. For example, when you are lifting a weight the computer begins by calculating where all the various exoskeleton 'muscles' need to be to mirror your movements. Then the

robot arm is instructed to grab the weight before the user exerts any significant force, so you get no strain but a lot of gain.

Flight suit?

Exoskeleton systems exist already. Soldiers can march further with heavy packs by having an exoskeleton provide some extra mechanical support that mimics their movements. There are also medical applications that help paralysed patients walk again. Sadly, current exoskeletons still don't have the ability to let you run faster or do other complex activities like fly.

Flying is another area where the real trick is in the computer programming. Iron Man's suit is covered in smart 'control surfaces' that move under computer control to allow him to manoeuvre at speed. Tony Stark controls his suit through a heads-up display and voice control in his helmet, technology that at least we do have today. Could we have fully functional Iron Man suits in the future? It's probably just a matter of time, technology and computer science (and visionary multi-millionaire industrialists too).



Dressing it

Even though most robots still walk around naked (see page 5), the Swedish Institute of Computer Science (SICS) in Stockholm is working to produce fashion conscious robots. The applied computer scientists there are looking for ways to make the robots of today easier for us to get along with. As part of the LIREC project to build the first robot friends for humans (see cs4fn issue 10) they are examining how our views of simple robots change when we can clothe and customise them. Does this make the robots more believable? Do people want to interact more with a fashionable robot?

How do you want it?

These days most electronic gadgets allow the human user to customise them. For example, on a phone you can change the background wallpaper or colour scheme, the ringtone or how the menus work. The ability of the owner to change the so-called 'look and feel' of software is called end-user programming. It's essentially up to you how your phone looks and what it does.

Dinosaurs waking and sleeping

The Swedish team began by taking current off-the-shelf robots and adding dress-up elements to them. Enter Pleo, a toy dinosaur 'pet' able to learn as you play with it. Now add in that fashion twist. What happens when you can play dress up with the dinosaur? Pleo's

costumes change its behaviour, kind of like what happens when you customise your phone. For example, if you give Pleo a special watchdog necklace the robot remains active and 'on guard'. Change the costume from necklace to pyjamas, and the robot slowly switches into 'sleep' mode. The costumes or accessories you choose communicate electronically with the robot's program, and its behaviour follows suit in a way you can decide. The team explored whether this changed the way people played with them.

Clean sweeps

In another experiment the researchers played dress up with a robot vacuum cleaner. The cleaner rolls around the house sweeping the floor, and has already proven a hit with many consumers. It bleeps happily as its on-board computer works out the best path to bust your carpet dust. The SICS team gave the vacuum a special series of stick-on patches, which could add to its basic programming. The right patch can change the way the humans perceive the robot's actions. Different patches can make humans think the robot is curious, aggressive or nervous. There's even a shyness patch that makes the robot hide under the sofa.

What's real?

If humans are to live in a world populated by robots there to help them, the robots

need to be able to play by our rules. Humans have whole parts of their brains given over to predicting how other humans will react. For example, we can empathise with others because we know that other beings have thoughts like us, and we can imagine what they think. This often spills over into anthropomorphism, where we give human characteristics to non-human animal or non-living things. Classic examples are where people believe their car has a particular personality, or think their computer's being deliberately annoying – they are just machines but our brains tend to attach motives to the behaviours we see.

Real-er robots?

Robots can produce very complex behaviours depending on the situations they are in and the ways we have interacted with them, which creates the illusion that they have some sort of 'personality' or motives in the way they are acting. This can help robots seem more natural and able to fit in with the social world around us. It can also improve the ways they provide us with assistance because they seem that bit more believable. SICS's 'actDresses' project will help us by providing new ways that the human users can customise the actions of their robots in a very natural way, by getting the robots to dress for the part.



up

Signals get shaken and stirred



A medical emergency can happen any time, especially if you're James Bond. That's just the reality when you spend your life falling out of planes, getting into car chases, and having lasers aimed at your netherparts. In *Casino Royale*, though, the inventive people in Q Division come up with a way to monitor 007's health remotely, using a radio device. Before too long, it comes in handy. During a high stakes poker game Bond's martini is poisoned, and under the watchful, bloody eye of the villain, Le Chiffre, Bond staggers out of the casino. Everyone back at MI6 knows Bond's in trouble thanks to the health monitor, and they're able to help him give himself the antidote to the poison. As the scene ends he's being accompanied back to the casino by a beautiful companion, and almost certainly not thinking how lucky he was that his radio monitor had good reception.

Which might be just as well. If Bond knew how tricky it is to get radio waves to work around the human body, it would have only added to his worries. Fortunately, though, electronic engineers are on the case – real ones too, not just the ones who work in James Bond's film universe. Real ones like Akram Alomainy and Yang Hao at Queen Mary, University of London, who are part of a project to develop wearable antennas so that doctors can monitor patients remotely.

Feeling electric

Here's the problem: it's really difficult to communicate around the human body. It sounds weird, but our bodies have electric properties that can change how radio waves behave around them. For example, a body can alter the frequency of a radio wave, or block it altogether. What's more, since bodies change position all the time, a radio wave is never going to be changed in a consistent way. It makes things very fiddly for engineers like Akram and Yang, who are trying to design a wireless network to be attached to the body.

That's a shame, because as James Bond's medical monitor shows, remote sensing can be pretty handy. It's likely to be more and more useful in the coming years, as the population gets older and needs more medical care. A good solution could be to monitor people with health problems as they go about their lives. Just like in *Casino Royale*, doctors would be alerted in case anyone took a turn for the worse – whether they had an asthma attack, or perhaps less likely, were poisoned by a megalomaniac.

Please repeat that

Let's say you're wearing a few sensors that monitor your health, all networked together to send reports back to a base. Making that network communicate over

various parts of your body is difficult. Akram and Yang's team are trying to help get around the problem of your own pesky, radio-blocking body by finding ways to boost the signal at various points around the body with 'repeaters'. Repeaters receive a weak signal from the monitor and add a bit of power to it before sending it on its way. The team use real-world experiments and mathematical simulations to try and figure out the best places to put the repeaters so that the whole network's signal works consistently. For example, it turns out that radio signals can become trapped between layers of the body, like between skin and fat. The signal will then find the easiest route to escape the body, which is often out the back. So you might want to put a repeater on a person's back to catch those signals and relay them.

You might be wondering why you don't normally hear about your body interfering with radio signals even though we use mobile phones all the time. The reason your mobile is able to get around the problem of your body interfering is because manufacturers just turn the power of the signal way up. This uses up the batteries quicker, but since people can always plug their phones in at the end of the day, battery life isn't such a problem. In the case of medical devices, though, you wouldn't want someone to have to take off their monitors every day to recharge them – it would defeat the whole purpose.

Let's get physical

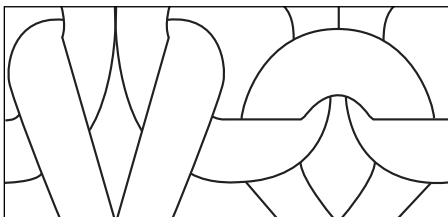
Medical devices aren't the only reason to put computer networks on your body. You might want a system for when you're jogging that chooses music with a beat that matches your heart rate. Or you might want your house to know how warm you are, so it can turn up the heat automatically when you're feeling chilly. Maybe you'd hook a bunch of personal networks together, so that everyone at a club would control the lights with their level of excitement.

Human bodies are pretty weird in lots of ways, including being able to mess around with radio waves. So it's kind of comforting to know that when those bodies go wrong, engineers like Akram have already thought about how to make sure doctors will find out about it. Leaving us to get back to any high-stakes poker games we might have left in a hurry.

Knitters and coders: separated at birth?

People often say that computers are all around us, but you could still escape your phone and iPod and go out to the park, far away from the nearest circuit board if you wanted to. It's a lot more difficult to get away from the clutches of computation itself though. For one thing, you'd have to leave your clothes at home. Queen Mary Electronic Engineer **Karen Shoop** tells us about the code hidden in knitting, and what might happen when computers learn to read it.

If you're wearing something knitted look closely at it (if it's a sunny day then put this article away till it gets colder). Notice how the two sides don't look the same: some parts look like a raised 'v' and others like a wave pattern. These are made by the two knitting stitches: knit and purl. With knit you stick the needle through and then behind the knitting; with purl you stick the needle in the other direction, starting behind the knitting and then pointing at the knitter [see picture]. Expert knitters know that there's more to knitting than just these two stitches, but we'll stick to knit and purl. As these stitches are combined, the wool is transformed from a series of waves or 'v's into a range of patterns: stretchy stripes (ribs), raised speckles (moss), knots and ropes (cable). It all depends on the number of purls and knits, how they are placed next to each other and how often things are repeated.



knit (k) and purl (p)

Knitters get very proficient at reading knitting patterns, which are just varying combinations of k (knits) and p (purls). So the simplest pattern of all, knitting a square, would look something like:

'30k (30 knit stitches), finish the line, then repeat this 20 times'.

A rib would look like:

'5k, 5p, then repeat this [a certain number of times], then repeat the line [another number of times]'

To a computer scientist or electronic engineer all this looks rather like computer code or, to be precise, like the way of describing a pattern as a computer program.

How your jumper is like coding

So look again at your knitted hat/jumper/cardi and follow the pattern, seeing how it changes horizontally and vertically. Just as knitters give instructions for this in their knitting pattern, coders do the same when writing computer programs. Specifically programmers use things called **regular expressions**. They are just a standard way to describe patterns. For example a regular expression might be used to describe what an email address should look like (specifying rules such as that it has one '@' character in the middle of other characters, no full-stops/periods immediately before the @ and so on), what a phone number looks like (digits/numbers, no letters, possibly brackets or hyphens) and now what a knitting pattern looks like (lots of ks and ps). Regular expressions use a special notation to precisely describe what must be included, what might possibly be included, what cannot be, and how many times things should be repeated. If you were going to teach a computer how to read knitting patterns, a regular expression would be just what you need.

Knitting a regular expression

Let's look at how to write a knitting pattern as a regular expression. Let's take moss or seed stitch as our example. It repeats a "knit one purl one" pattern for one line. The next line then repeats a "purl one knit one" pattern, so that every knit stitch has a purl beneath it and vice versa. These two lines are repeated for as long as is necessary. How might we write that both concisely and precisely so there is no room for doubt?

In knitting notation (assuming an even number of stitches) it looks like:

Row 1: *k1, p1; rep from *

Row 2: *p1, k1; rep from *

or

Row 1: (K1, P1) rep to end

Row 2: (P1, K1) rep to end

Repeat these 2 rows for length desired.

All this is fine ... if it's being read by a human, but to write experimental knitting software the knitting notation we have to use a notation a computer can easily follow: regular expressions fit the bill. Computers do not understand the words we used in our explanation above: words like 'row', 'repeat', 'rep', 'to', 'from', 'end', 'length' and 'desired', for example. We could either write a program that makes sense of what it all means for the computer, or we could just write knitting patterns for computers in a language they can already do something with: regular expressions. If we wanted to convert from human knitting patterns to regular expressions we would then write a program called a **compiler** to do the translation.

In a regular expression, to give a series of actions, we just name them. So *kp* is the regular expression for one knit stitch followed immediately by one purl. The knitting pattern would then say repeat or rep. In a regular expression we group actions that need to be repeated inside curved brackets, resulting in *(kp)*. To say how many times we need to repeat, curly brackets are used, so *kp* repeated 10 times looks like this: *(kp){10}*.

Since the word 'row' is not a standard coding word we then use a special character, written, *\n*, to indicate that a new line (=row) has to start. The full regular expression for the row is then *(kp){10}\n*. Since the first line was made of repetitions of *kp* the following line must be made of repetitions of *pk*, or *(pk){10}\n*

These two lines have to be repeated a certain number of times themselves, say 20, so they are in turn wrapped up in yet more brackets, producing:
((kp){10}\n(pk){10}\n){20}.

If we want to provide a more general pattern, not fixing the number of *kp* in a row or the number of rows, the 10 and 20 can be replaced with what are called variables - *x* and *y*. They can each stand for any number, so the final regular expression is:

((kp){x}\n(pk){x}\n){y}

How would you describe a rib as a regular expression (remember, that's the pattern that looks like stretchy stripes)? The regular expression would be *((kp){x}\n){y}*.

Regular expressions end up saying exactly the same thing as the standard knitting patterns, but more precisely so that they cannot be misunderstood. Describing knitting patterns in computer code is only the start, though. We can use this to write code that makes new patterns, to find established ones or to alter patterns, like you'd need to do if you were using thicker wool, for example. An undergraduate student at Queen Mary, Hailun Li, who likes knitting, used her knowledge to write an experimental knitting application that lets users enter their own combination of *ps* and *ks* and find out what their pattern looks like. She took her hobby and saw how it related to computing.



Look at your woolly jumper again...it's really made out of computation!



An eye for design

It's one thing to have good taste in clothes, but imagine being your own designer too. Wouldn't it be great to wear your own creations in real life? Imagine being able to buy a t-shirt made to match your own unique preferences. Or a product designed simply by observing the way you move your eyes while looking at a few alternatives. To understand how such designs might be created, says **Tim Holmes** of Royal Holloway, University of London, we need to go back 150 years to one of the most significant theories in scientific history.

A little bit of history

Charles Darwin's idea of "survival of the fittest" explains how highly specialised animals such as giraffes evolved. For example, those with the longest necks might be able to reach more food and so they survived to pass this trait onto the next generation through their genes. In the 1970s computer scientist John Holland devised a computer program which used this idea to solve complex mathematical problems, by representing possible solutions using artificial genes and then recombining the best solutions to give even better ones. Holland's idea became known as a 'genetic algorithm', and today they are used in everything from web-browsers to package design. Just as Darwin observed in nature, genetic algorithms are all driven by an ability to measure the fitness of a possible solution: how good something is at doing the job we need it for.

Mutant fashion

Some researchers at Yonsei University in South Korea have used exactly this strategy to help people design their own clothes. Let's pretend you're designing a shirt. The South Koreans' system would start by dividing the design into basic elements, like sleeves, cuffs and collar. To begin, the system chooses a few combinations and shows them to you. Your job is to rate the designs you like the best. That's when the genetic combination gets going. When organisms mate with one another, they mix their genetic material together and their children end up with a combination of their parents' traits. This program takes the shirt

designs you like best and...well, pairs them off just like parents. Your favourite designs get their genetic material mixed up and the system creates a new generation of shirts for you, from which to choose the ones you like best. After going through a few generations, you should have a group of designs that are all a little different from one another, but are all the kind of thing you would actually wear. Ta-da! You can then choose the one you like best, and get your newly-designed shirt made up for you.

There is an eye in "fitness"?

Designers aren't the only ones concerned with using fitness – marketing companies want to make sure their products will attract people, so they make sure to test how desirable they are. One of the techniques they use is to observe the eye movements we make while looking at their product, using an eye-tracker. Eye-trackers use reflected infrared light to measure the movements of your eyes. The ones marketers use can be attached to glasses that test subjects wear while shopping, but even the webcam built in to your computer could be used as a basic eye-tracker.

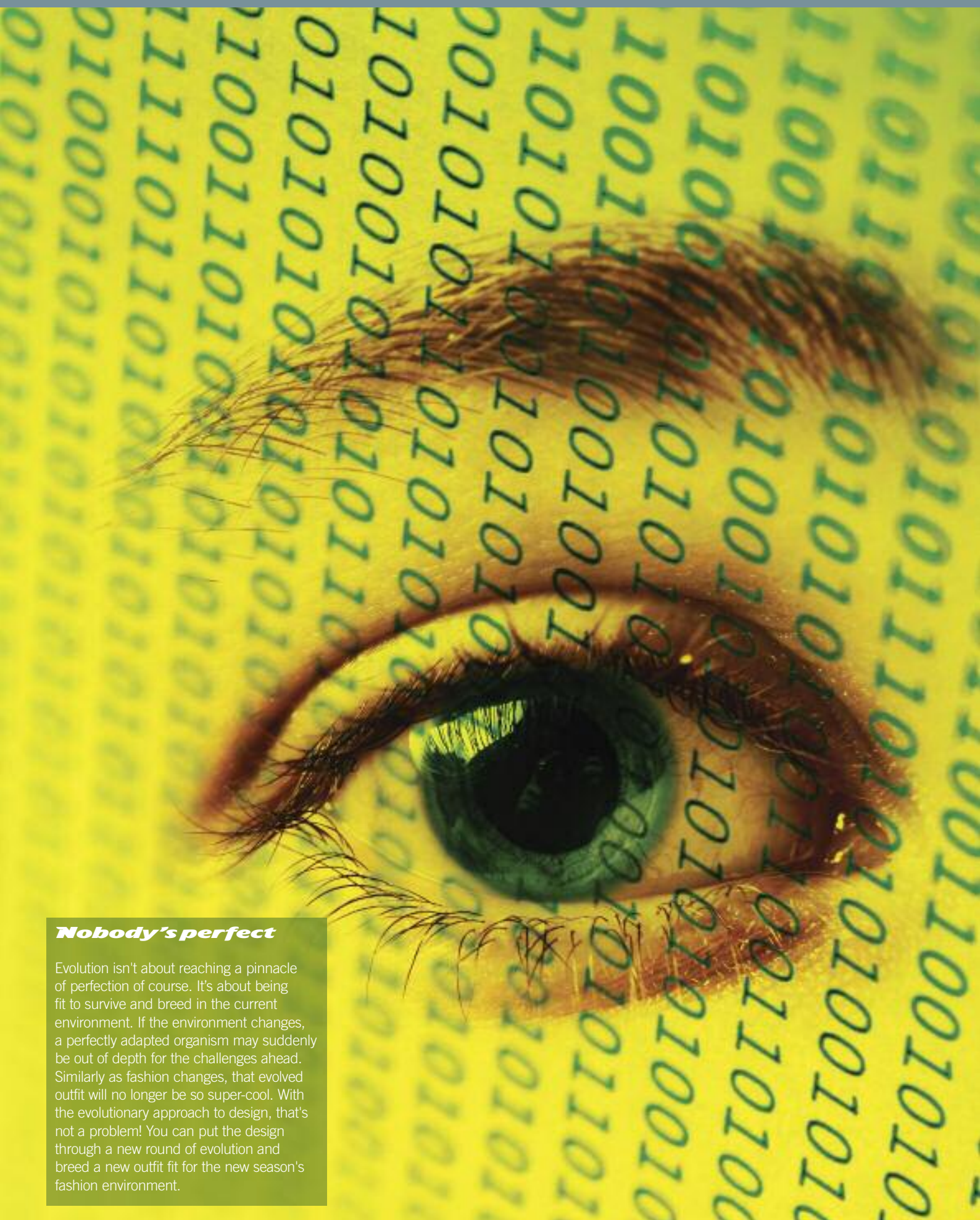
Snack time

In an experiment, researchers at Royal Holloway, University of London presented subjects with a variety of different images ranging from coloured shapes to mobile phones to find out exactly how eye movements correspond with their preferences. Once the eye-tracker could tell which images they liked, the

researchers developed an evolutionary algorithm to manipulate designs right before the subjects' eyes, so they gradually evolved to match each person's preferences. The researchers tested their new algorithm by, among other things, getting subjects to design packages for fictitious new flavours of Pringles. The subjects were not told to look for their favourite design, but to allow the computer to 'read their minds' through their eye movements.

Can you read my mind?

Gaze-driven design can join the growing family of 'neuromarketing' techniques, so called because their inputs come directly from the brain rather than interviewing customers. The idea that our unconscious responses to images might be used to sell us products might appear a little sinister, but there could be equally positive applications for such techniques. If we can identify the images that induce cravings for cigarettes, for example, then presumably we can also identify images for warning labels which will make cigarettes less appealing. Do you think such person-centred design for anything from clothing to wallpaper presents an opportunity for increased self-expression or simply facilitates consumer exploitation? Whatever your answer, the next time you are out shopping for something to wear, think about where you are looking, because the designs could soon be the results of your eye movements rather than the other way round.



Nobody's perfect

Evolution isn't about reaching a pinnacle of perfection of course. It's about being fit to survive and breed in the current environment. If the environment changes, a perfectly adapted organism may suddenly be out of depth for the challenges ahead. Similarly as fashion changes, that evolved outfit will no longer be so super-cool. With the evolutionary approach to design, that's not a problem! You can put the design through a new round of evolution and breed a new outfit fit for the new season's fashion environment.



The mirror with a vision for style

Imagine you're out shopping for clothes. Those moments in the fitting room, when you try to figure out whether an outfit looks right on you, can be tough. You've got to decide whether the clothes fit for a start, but you also have to judge whether they fit your personal style. You might like something on the rack, but is it really you? A team of researchers is designing a smart mirror that can help you make your decision, but teaching computers how to see with style is no easy task.

Online in real life

The team, based in the USA and Japan, began by noticing a difference between buying clothes in a shop and buying them online. While it's impossible to try on clothes you buy over the web, one advantage to online shopping is that it's a lot easier to find recommendations. Click on a pair of jeans, for example, and you're likely to see a few other pairs that are similar, plus some recommendations on what shirts might go with them. Plus, if you want, you can ask to see the most popular items – maybe you'd been looking at skinny jeans when everyone else was buying flares. The researchers wanted to find a way to combine the ability to try on your clothes with the recommendations a shopper can get online. And while we're at it, wouldn't it be nice to compare one outfit with another?

That's how they came up with the Responsive Mirror. Stand in front of it and in the middle you'll see a mirror like any other. But next to it are two display units. One shows you all the other clothes you've tried on, so you can compare the different looks. The other shows you alternative looks that people have put together, and allows you to choose between seeing similar outfits to yours, or something different if you think you're in a bit of a style rut. As a bonus, the Responsive Mirror doesn't just sense what clothes you're wearing. It can sense your pose when you look in it, and show you other outfits in the same position you're standing in.

Get the look

This means that the researchers have had to teach the mirror how to see. That's no easy task – we take vision for granted, but computers find it a lot harder. First, the

mirror needed some eyes, so they hooked a computer-controlled camera up to it. (We should probably point out that the mirror and camera setup isn't in the same room where you get changed, so you don't need to worry about your modesty.) Next, the mirror needed some vision programming. There were two big things the mirror needed to do: recognise the clothes a shopper is wearing, and work out how they are posed when they look in the mirror.

To realise just how tough it would be for a computer to match clothing items, think about how many characteristics a shirt might have. Is it a smart shirt, a casual t-shirt, or somewhere in between like a polo shirt? What colour is it? Does it have cuffs? A solid colour or stripes? And how thick are those stripes, by the way? With all those different possibilities, recognising the shirt and finding similar (or different) examples is a tall order. Oh, and not only that, but in order to detect the shirt in the first place the computer has to figure out where the person's torso is.

Fashionable dinosaurs

Here's how the computer decides where in its field of vision the person is: it detects motion. If you find the moving part of the image, that's where the person is. The computer draws a box around the whole person, and then uses the proportions of the human body to draw a reasonably accurate box around the torso, and that's where the shirt is. See how complicated this vision stuff can get?

Next the computer needs to find out the details about the shirt, so it knows what else to recommend. Colour is an easy one. The texture is a bit more difficult, but the computer can take a small area of the shirt and try to find similar patches in other shirts, so that's not too bad. How can it recognise whether a shirt is formal or casual, though? That's a very complex distinction, and one that you might think only a human could tell. Fortunately, the clue is mainly in the collar. Smart shirts have collars with lots of pointy corners, but casual shirts don't. So if you can train the computer to look for 'pointyness' around the top of the shirt, you've got a big clue. And it turns out you can! The maths of pointy corners has already been figured out, and it's been used to detect edges in computer images for more than 20 years. So by applying the pointy corner detector to a shirt, suddenly the computer can tell whether it's likely to go with a lounge suit, or just with lounging around.

Posing for the camera

On top of matching your outfit, the computer has to detect your pose in the mirror. This, too, is like putting together a puzzle. The first part, finding out which direction you're facing, isn't too tough. There's a second camera that takes an overhead view of your body. Since your shoulders give you a sort of oval shape from overhead, the computer assumes that you're facing the same way that the oval is facing. The second part, matching your exact pose, is more difficult. The camera in front of you, the same one that checks you for different colours and pointy collars, can see your outline. It would be easy for the computer to tell the difference between a normal pose and a really exaggerated one, but people usually do more subtle poses. There's not much difference in the outline of a person standing straight in front of the mirror, and another person, say, crossing their arms and twisting around a bit. But if you combine the views of the two cameras in front and above, so you know the person's outline and which direction they are facing, you can get it right. That way the Responsive Mirror can show you people wearing similar clothes in similar poses to you.

Standing in front of the Responsive Mirror, a shopper can see other outfits they've worn, and compare them to looks that other people have put together. That makes real-world shopping more like online shopping, and could help you walk out of the store a more satisfied customer. Upscale shops like Prada in New York already have similar systems, but as time goes on, who knows – you might be using it on your high street as well. You'll have an extra secret though: you'll know just how much complex computer vision goes into the mirror's magic.

This mirror never lies

An American mathematician has made a mirror that shows you your true image, without reversing it! Find out how he did it by going to the magazine+ section of our website, www.cs4fn.org.





The perfect fit

Having a one-of-a-kind garment tailored just for you is the height of fashion luxury. It fits you just right and you know that piece of clothing was made for you alone. It can feel like it's a part of you. But let's be honest: very few of us have custom-made clothes. Most of us make do with off-the-peg designs, made for the average dimensions of someone roughly the same size as us. Mass customisation could be coming your way though, thanks to research at the London College of Fashion.

Sandy Black and her colleague Penelope Watkins wanted to help make clothes more special. Their research was part of a project called Considerate Design, which was all about designing clothes in a way that paid more attention to the people wearing them, and to the Earth. They thought that if they could find a way to make an item of clothing more special to the person wearing it, they would take better care of it and wear it for longer. If clothing were less disposable we wouldn't have to buy so much of it to replace the stuff we'd chucked away. Ultimately, we'd consume less.

Scanning for lifeforms

How do you make it possible for more people to have custom clothes? With some impressive computer technology. Sandy and Penelope's process begins by scanning the customer's body with a 3D scanner. Then the body measurements and the customer's style preferences are translated into a 2D computer design which can be used in an industrial knitting machine. (For more about how knitting patterns are like computer programs, see page 12.) The machine can produce a knitted jumper that comes out in

one piece, practically ready to wear. If that jumper is yours, reflecting your own personal taste and fitting your own unique dimensions to a T, it's likely to help reduce the impact that fashion has on the planet.

Future to the back?

The 3D body scanning technology used to take people's measurements has other uses in fashion too. A different team on the Considerate Design project used the scans to design bags for people with back problems. After taking the scans and transferring them to real-life plaster moulds, designers shape the leather bags so that they conform exactly to the shape of the wearer's back. That way the weight of the bag is transferred evenly to the hips and the wearer doesn't suffer their usual pack pain.

If the researchers from the London College of Fashion have their way, in the future it will be much easier to get your clothes to fit you. Even better, though, our clothes will fit the Earth's resources much more comfortably as well.

Hollywood beckons

Why not kick-start your film career the computer science way by creating a computer animated short? There are several packages (even some free ones) that make it easy to create simple computer-animated cartoons. When Walt Disney started out, the animators had to draw every frame of a cartoon individually by hand. Now, if you are willing to teach yourself some simple programming skills, you can focus on the creative, fun parts rather than having to draw the same thing over and over, thousands of times for a few seconds of film.

Programmed animation skills are clearly thriving as shown by the annual University of Manchester Animation competition. Over 1,300 shorts were entered in the 2010 competition, which was funded by Electronic Arts and Google. Prizes were awarded to more than 50 students at The Lowry in Salford Quays.

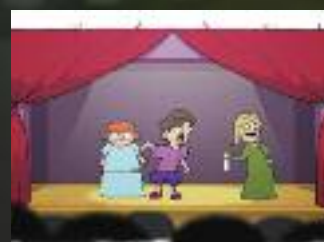
This year the overall EA "Hollywood beckons" Award went to KS4 entrant Hal Coley of Bosworth Community College, Leicester. All the judges agreed that his entry "Success" was the well-deserved winner and Hollywood really does beckon! His short impressed because he had a strong storyline, he used lots of different scenes and shots to tell the story and the detail in his drawings was stunning.

This year's cs4fn prize was for the cartoon that we thought was most inspirational. It was won by Ellen McLean from the High School of Dundee for her animation 'Life as a boring piece of paper' with its upbeat message that by thinking positively you can do well in life, even if things don't go exactly to plan.

Next year the Manchester audience could be watching your animated short as you go up to receive a prize. You need to come up with a good storyline, add a sense of humour or a serious message, then put in the time to flesh out all the detailed drawings and program the animation and you are there. What makes a good storyline? Well, one technique recommended by filmmakers is to think of it in a series of stages. You start by setting the scene. Things then start to develop, but a complication arises. Eventually everything starts getting sorted out until finally the story is resolved. Watch the winning entries from previous years and see which follow some, or all, of this pattern.

Most of all with filmmaking, once you've understood the basics, it's the amount of effort you put in refining your skills that matters. Given both filmmaking and programming are lots of fun you can have a great time taking part and learning some useful skills along the way, win or lose.

For more about the animation competition, how to enter and to see the videos go to www.cs.manchester.ac.uk/Animation



Above is a selection of stills from our favourite films in the competition.

Back (page) and sides

We've told you about dresses, sweaters and even basketball uniforms, but what about the finishing touches? Once you've got your outfit together, is there nothing more that computer science can do for you? Of course not! Here are some ways computing can help you top off your look.

Hair it is

Your hairstyle helps to express your character and personality, but what if you want to try something radically different? Will that new cut suit you? There is software available that lets you try out new hairstyles in the safety of your own room. Once you upload a head shot, the software uses image processing techniques to allow you to see how you would look with a mullet or a mohawk. You can even try radical new colours. It's your chance to find the style that's best for you before letting anyone near you with a pair of scissors.

The look: virtually hair-raising.

Nail that picture

Some salons can put art at the tips of your fingers. Fingernail designs, pictures that you can have glued onto your nails to enhance their glam factor often have a bit of computer science behind them. The images are created by designers using computer assisted packages or automatically generated by artificial intelligence. Then they're usually printed by computer on to special transfer sheets, which allow those stunning images to be attached to a well-manicured nail.

The look: digital digits

Tattoo you?

Perhaps the ultimate fashion statement of personal expression, the tattoo has a long and distinguished history. Using a vibrating needle, ink is driven under the skin to create a permanent image on the body. Despite new methods using laser light to reduce the visibility of this buried deep skin pigment, a tattoo remains a pretty serious decision with no easy way back. So how would you tell a tattoo was really really you? Graphic artist Loic Zimmerman has developed a computer program to help answer this pointed question. By creating a digital avatar, an exact computer graphic copy of his body, he is able to see exactly how the inked designs will look before the needle starts its work. While tattoos aren't everyone's idea of fashion, at least this software lets you draw your own conclusions about the ultimate result.

The look: software with a needle-sharp point.

Your shoes look good and do you good too

Trainers owe some of their sleekness to computer-aided design, but now some manufacturers are developing running shoes with the space to include tiny computer sensors that will be able to measure how far you have run, and calculate the number of calories you've burned in doing so. But the sensors won't keep this good news to themselves; they will be able to send this information wirelessly to your smartphone so you can keep a track as you run round the track, down the street or, if you're late, through the school corridor.

The look: fast and futuristic.



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