Robots learn to recover from damage in minutes: Machines with 'wounded limbs' adapt like animals to carry on walking

- Engineers made robots that adapt to injuries in less than two minutes
- Six-legged robots can work out a new way to walk with two broken legs
This is down to a new 'Trial and Error' learning algorithm
Discovery could lead to more autonomous search and rescue machines

By SARAH GRIFFITHS FOR MAILONLINE

Robots could one day replace firefighters and rescue workers in dangerous regions, but before they do they need to learn to keep working if they are damaged.

Now engineers have created robots that adapt and recover from injury in less than two minutes.

The hexapod - six-legged - machines can carry on walking even if two of their legs are broken thanks to a 'Trial and Error' algorithm that enables them to work out a new walking style.

Scroll down for video
Engineers have created robots that adapt and recover from injury in less than two minutes. The hexapod (pictured) - six-legged - machines can carry on walking even if two of their legs are broken.

Animals exhibit a similar amazing ability to adapt to injury. For example, three-legged dogs can catch frisbees in mid-air and humans quickly adapt to cope with a sprained ankle.

Researchers from Pierre and Marie Curie

**WHY DOES THE TECH MATTER?**

The ability of these robots to adapt and recover from injury is a significant advance in technology.
University in Paris and the University of Wyoming took inspiration from these biological strategies.

'When injured, animals do not start learning from scratch,' senior author Jean-Baptiste Mouret explained.

'Instead, they have intuitions about different ways to behave.

'These intuitions allow them to intelligently select a few, different behaviours to try out and, after these tests, they choose one that works in spite of the injury. We made robots that can do the same.'

Before being deployed, the type of robot uses a computer simulation of itself to create a detailed map of the space of 'high-performing behaviours'.

This map represents the robot's 'intuitions' about different behaviours it can perform and their predicted value.

See damage recovery in robots via intelligent trial and error
Here, a robot automatically learns to keep walking after breaking a leg, thanks to the Trial and Error algorithm. To keep walking, it uses a large map of the space of possible actions and their performance values. It selects a behavior it thinks will perform well based on the previous (simulated) experience stored in the map.
HOW DOES THE ROBOT LEARN TO WALK AGAIN?

Before being deployed, the robot uses a computer simulation of itself to create a detailed map that represents its 'intuitions' about different behaviours it can perform.

It uses a Trial and Error algorithm to enable the bot to learn a compensatory behaviour to cope with damage such as two legs being broken.

If the robot is damaged, it uses these 'intuitions' to guide a learning algorithm that conducts experiments to rapidly discover a compensatory behaviour that works despite the damage.

The new algorithm is called Intelligent Trial and Error.

Lead author Antoine Cully said: 'Once damaged, the robot becomes like a scientist.

'It has prior expectations about different behaviours that might work, and begins testing them.'
The algorithm tests behaviours to work out the most effective way of carrying on. If one behaviour doesn’t work, the robot’s smart enough to rule out the type of behaviour and try a new type instead.

The technology (pictured) could lead to the creation of robots that could help rescuers without needing their continuous attention, as well as robotic assistants that can continue to be helpful even when a part is broken.

'For example, if walking, mostly on its hind legs, does not work well, it will next try walking mostly on its front legs.

'What's surprising is how quickly it can learn a new way to walk.

'It's amazing to watch a robot go from crippled and flailing around to efficiently limping away in about two minutes.'

Jeff Clune, of the University of Wyoming, explained that the algorithm, which is described in the journal Nature, really has two steps –
The researchers said it was surprising how quickly the robot learned a new way to walk (pictured).

Creating the behaviour performance map and adapting to an unforeseen situation.

The map in the first step is created with a new type of evolutionary algorithm called MAP-Elites. Evolutionary algorithms simulate Darwinian evolution by hosting 'survival of the fittest' competitions in computer simulations to evolve artificially intelligent robots.

The adaptation in the second step involves a 'Bayesian optimisation' algorithm that takes advantage of the prior knowledge provided by the map to efficiently search for a behaviour that works despite the damage.

Dr Clune explained: 'We performed experiments that show that the most important component of Intelligent Trial and Error is creating and harnessing the prior knowledge contained in the map.'

It's hoped that the new technique will help develop more robust and effective, autonomous robots.

The technology could lead to the creation of robots that could help rescuers without needing their continuous attention, as well as creating personal robotic assistants that can continue to be helpful even when a part is broken.
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American woman, 22, dragged to her
Rows of pet dogs hanging on hooks
Air Force for one: Massive military
Surviving daughters lead
Floods bring the
Old West back to

UK Expat Hong Kong, Hong Kong, Hong Kong, 3 days ago
I have three legs and can walk with just two with no physical problem... (Well, Sometime had to say it! :-p

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Do you need professional PDFs for your application or on your website? Try the PDFmyURL API!
dchinom, Seattle, United States, 4 days ago
Genetic algorithms testing various simulated weakness. The developers then just save off a subset of the best results. The selection method itself is programmed explicitly and the robot simply runs through its options to find a reasonable solution. I wrote similar AI in undergrad program. I assure you, this isn't intelligence in the least.

Puppyfoot, My house, Jamaica, 4 days ago
All these people touting skynet... this is not as impressive as it sounds. It does not learn it just keeps going through different configurations by sensing data till it gets the result that it has as its goal.

LasvegasEd777, Las Vegas, United States, 4 days ago
Next: Self repairing robots...

SittingDuck, San Francisco, United States, 4 days ago
It would appear Agent Smith was right after all.

Ardleeworkin, New York, United States, 4 days ago
Project skynet is making progress sir

The Sarge, Perth, Australia, 4 days ago
The thin end of the wedge that we are building for our own ultimate destruction. It isn't too far away when robots will be able to build copies of themselves, with continuous upgrading. In short, I think we are digging our own graves.
Artificial Intelligence is one field that scientists will probably struggle with forever simply because common sense and what we think of as "gut" feeling has to come into play. Microcomputers can only go so far but then again, humans aren't doing such a fine job of it these days when it comes to applying Common Sense to their decision making either.

This is going to make them harder to kill when Skynet takes over.

They'll be telling us next that spell checkers work? Like the version they use at DM?
shape on 'old age'
Laughed off the rumours at the Hollywood Bowl

▶ Didn't get the memo? Robert Pattinson dresses way down in drab black and red outfit as his 'fiancée' FKA twigs looks chic in midriff-baring top

▶ Tom Cruise flashes his winning movie star smile before getting into character as an Eighties-era drug runner in the thriller Mena

▶ Johnny Depp and Amber Heard made to wait an hour on the tarmac as their private jet is searched upon landing back in Oz... a month after dog row

▶ SEBASTIAN SHAKESPEARE: Jemima bares her bedhead
The 41-year-old socialite decided to share her au naturel look

▶ She really CAN do it all! Pregnant Kristin Cavallari reveals she’s finished writing her first book Balancing In Heels. She is pregnant with her third child.

▶ 'You’re obsessed with me!' Irritated Kendall Jenner demands ‘momager’ Kris Jenner give her space at
New career path? Gisele Bundchen flashes midriff in white jumpsuit as she tries out the other side of the camera... after retiring from runway in April

'Most people thought I would end up in rehab, a psych ward or prison': Jersey Shore vet Snooki offers glimpse of her new tell-all book

'I love this... be true to you': Kim Zolciak supports Bruce Jenner's gender transformation with heartwarming tribute on Instagram

Khloe Kardashian and Lamar Odom caught flirting over the phone in teaser for KUWTK... and Kim is NOT happy
The two split in the summer of 2013

Kim Kardashian is pictured for the first time since revealing pregnancy as she flaunts her figure in a tight grey catsuit in NYC
Due in December

Bring your boyfriend to work day! Dakota Johnson holds hands with Matthew Hitt as he visits her on set of How To Be Single
<table>
<thead>
<tr>
<th>All loved up</th>
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<tr>
<td><strong>'I was thinking I should go back to Australia':</strong> Ruby Rose reveals she almost gave up on her US acting career before landing Orange Is The New Black gig</td>
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<td><strong>'Back at it':</strong> Ben Stiller returns to the Zoolander 2 set following the death of his mother Anne Meara. The 85-year-old died from natural causes</td>
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<td><strong>This wouldn't have happened at the Queen Vic!</strong> Leslie Grantham stuck outside pub waiting for it to open. Dirty Den looked less than impressed</td>
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<td><strong>Made In Mykonos:</strong> Lucy Watson shows off her pert derriere and hourglass figure as she goes topless on beach holiday. Doesn't want tanlines!</td>
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<td><strong>PICTURE EXCLUSIVE:</strong> Cristiano Ronaldo caught urinating in the street following night of partying in Saint Tropez. Spotted leaving exclusive Le Quai club</td>
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<td><strong>She’s a hit!</strong> Caitlyn Jenner becomes the fastest person ever to amass 1 million Twitter followers, smashing the record set by Barack Obama</td>
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<td>Enrique Iglesias</td>
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<td>Driving the Pork Chop Express! Dwayne Johnson</td>
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<td>On the white track! Model Lily Aldridge</td>
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<td>Britain's Got Talent champion dog Matisse</td>
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<td>Here comes the Enchantress: Cara Delevingne</td>
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<td>Like mother, like daughter! Tallulah Willis</td>
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Nice car, shame about the bald patch: Matthew Perry reveals thinning hair while spinning around in his $150k Audi convertible 45-year-old was in LA

The show must go on! Johnny Depp is seen in character as Jack Sparrow as he returns to Pirates Of The Caribbean set a day after returning to Oz

Not packing light then, Dannii? Miss Minogue pushes SIX suitcases through airport as she flies from Melbourne to Sydney in killer heels with son Ethan

'I had the worst time being a teenager' Cara Delevingne reveals she used to be a wild child... as unseen early modelling shot is unearthed

Georgia Kousoulou saves herself from a wardrobe malfunction as she shows off ample assets in plunging swimsuit while filming TOWIE in Marbella

Letting rip! Jessie J suffers embarrassing wardrobe malfunction as she splits her leather trousers during cinema trip

Whoopsie!
Robin Hood star Jonas Armstrong banned from driving after refusing breath test and saying he was only slurring his words because he’d drunk cough syrup.

Scruffy hair, don’t care! Ashley Tisdale has a dressed down day in denim overalls with her blonde tresses tied up

Star went make-up free

Daisy Lowe keeps it casual in leggings and trainers as she enjoys a stroll with her pet pooch Monty

The 26-year-old model took to streets of London

'We are so beyond excited': Kim Kardashian talks about 'rollercoaster' journey in first interview since announcing her second pregnancy

Is it all catching up to her? Tired-looking Kylie Minogue cuts a downcast figure as she reveals her makeup-free complexion following 47th celebrations

'She was an absolute joy!' Carl's Jr. CEO gushes over Kim Kardashian after saying she ‘wasn’t good at eating the burger’ for fast-food commercial
South, Kris or Beyonce? Bookies reveal odds for names for Kim and Kanye's second baby (and even Wild West is in the running)

As Kim announces she's pregnant again, a look back at her best (and worst) maternity style... including THAT floral dress and those perspex heels

She's been spoiled rotten and isn't afraid of throwing a public strop, so how WILL North West cope with being a big sister and sharing Kim and Kanye's affection?

'I'm not engaged': Kate Gosselin insists she's single despite sporting a sparkler on THAT finger this weekend... and after cozying up to millionaire Jeff Prescott

Making a splash! Pregnant Imogen Thomas shows off her growing baby bump as she flaunts impressive figure in red bikini

Looked blooming lovely

Another night, another brunette! 1D's Louis Tomlinson leaves club with Fifth Harmony's Lauren Jauregui as he and Niall Horan take girlband out on the town

Leggy Kimberley
<table>
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<tr>
<th>Title</th>
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<tr>
<td>Garner shows off her super-toned midriff in orange sports bra and</td>
<td><img src="https://example.com/garner.jpg" alt="Garner" /></td>
<td>She shares Instagram snaps of idyllic Ibiza getaway.</td>
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<td>We didn't expect to see pigs in the sea!': Animal HOGS the limelight</td>
<td><img src="https://example.com/pigs.jpg" alt="Pigs" /></td>
<td>From Wayne and Coleen Rooney as they share fun family portrait of Bahamas trip.</td>
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<td>'Everyone should dress up in drag once!' As RuPaul's hit cross-</td>
<td><img src="https://example.com/ru-paul.jpg" alt="RuPaul" /></td>
<td>As RuPaul's hit cross-dressing show airs in the UK, the star reveals there's a serious message behind all that lip gloss.</td>
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<td>Lucy Mecklenburgh looks chic in a peach blazer, lace top and</td>
<td><img src="https://example.com/lucy.jpg" alt="Lucy" /></td>
<td>She arrives back in London after LA break. Looked very tanned.</td>
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<td>It's a pretty dreamy cast!': Melissa McCarthy talks about working</td>
<td><img src="https://example.com/melissa.jpg" alt="Melissa" /></td>
<td>Alongside hunky co-stars Jude Law and Jason Statham in new comedy Spy.</td>
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<td>Hung Up on the past! Madonna goes back to the '80s posting vintage</td>
<td><img src="https://example.com/madonna.jpg" alt="Madonna" /></td>
<td>Madonna goes back to the '80s posting vintage snaps on Instagram, including one with Diana Ross.</td>
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<td>Britain's Got Talent</td>
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<td>final leaves bitter taste as viewers rumble magician Jamie Raven's lemon trick: But can YOU see how he did it?</td>
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<td>Stunned the judges</td>
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<td>Kylie Jenner legs it around LA in blue shorts and crop top... as she warms up her vocals amid rumours Kanye West will produce her debut single</td>
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<td>Red-dy for action! TOWIE's Chloe Sims enjoys a Baywatch moment as she showcases her cleavage in racy lace-up swimsuit in Marbella</td>
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<td>Shameless star Anne-Marie Duff spotted with blood streaming down her face while filming dramatic scenes for new BBC police drama</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
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<td>Let's take a selfie! Kate Moss cosies up to husband Jamie Hince as they stop for a picture in the streets of Rome Unlikely to see it on Instagram though...</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
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<td>Suits her! Victoria Beckham channels androgynous tailoring in red and white trousers with matching jacket as she arrives at JFK airport</td>
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<td>'I feel so blessed!' Marisa Miller welcomes</td>
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second son Grayson Lee Bazyl with husband Griffin Guess. Sports Illustrated model already has two-year-old Adele Silva is set to join the cast of Hollyoaks... as Danniella Westbrook goes platinum blonde to make her return as Trudy Ryan.

Is Top Gear set to have a different presenter every week? James May and Richard Hammond 'offered £1m deals to return to BBC show.

As Bradley Cooper contorts for the Elephant Man, the other actors who have undergone incredible transformations for a role (and bagged awards) revealed.

Bikini-clad Robin Wright and her lookalike daughter Dylan Penn soak up the sun and surf on Mexican holiday.

Too much exposure! Ex On The Beach star Jess Impiazzi goes braless in wet T-shirt as she takes a poolside dip during relaxing getaway in Cape Verde.
GADGET REVIEWS

The Mail's verdict on the Apple Watch
While it's not the first smartwatch on the market, the $349 (£299) Apple Watch is the first you'll actually want to use - and will change the way you communicate.

501 comments 5 videos

$99 'morphing' Phorm case adds physical keys to iPad
Californian-built Phorm (pictured) consists of a case and screen protector lined with microfluidics - small amounts of fluid that raises up from the screen when a button on the case is pressed.

4 comments 1 video

Apple iPhone 6 and 6 Plus
MailOnline has spent a week with Apple's new handsets - and found...
they could change the way we shop - and put clear water between Apple and its rivals.

The tiny $299 wireless headphones that could mean the end of tangled wires

The Dash headphones are wireless, and even contain their own MP3 player and fitness trackers, and won a best in show award at CES in Las Vegas.

The tiny $299 wireless headphones that could mean the end of tangled wires

Headphones: Musical Fidelity EB-33

The Musical Fidelity EB-33 in-ear headphones are impressive. They offer a strong performance which more than matches their value - and look good too.

Headphones: Musical Fidelity EB-33

Gadget of the week: Orbotix Sphero 2.0

The Sphero 2.0 is a modern Christmas present. In years past you would have had a remote-control racing car running on AA batteries.

Gadget of the week: Orbotix Sphero 2.0

Gadget review: Snugs fitted earphones

Sound quality is normally the purpose of a headphones review - but not in the case of Snugs, because they can be used on any earphones.

Gadget review: Snugs fitted earphones

Gadget of the week: Waka Waka solar powered lamp

The Waka Waka lamp and phone
charger is a useful camping tool and something that could be extremely useful in the developing world.

Gadget review: Tivoli Radio Silenz noise cancelling headphones

The Tivoli Audio Radio Silenz headphones are light, comfortable and portable, which makes them good for travel. They feature stylish wood panels.

Gadget review: Jawbone Mini Jambox

Fun. That's the first word that comes to mind when reviewing the Jawbone Mini Jambox. As you would expect from a product with mini in its name, it's small.

Gadget of the week: Philips Wake-up Light can make the mornings easier

Nobody likes getting up in the morning. That's a fact. So spending money on anything that makes it less painful is probably a sound investment.

Gadget review: Skullcandy Crusher Headphones

The Crusher does exactly what it says on the tin. Unleash an unrelenting torrent of deep bass through your eardrums. Be warned, these are not for the faint-hearted.

Gadget review: Klipsch Image X7i in-ear

Do you need professional PDFs for your application or on your website? Try the PDFmyURL API!
The Klipsch X7i headphones are nearly perfect. Nearly. The sound is excellent - and in headphones, that's 90 per cent of the battle won. Just some blips hold them back.

MailOnline reviews wireless speaker systems to find out which one should soundtrack your summer. Best on show was Jawbone's Big Jambox.

FROM THE MAKERS OF CANDY CRUSH
Farm Heroes Saga, the #4 Game on iTunes. Play it now!

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