Thoughtful robot adapts to injury

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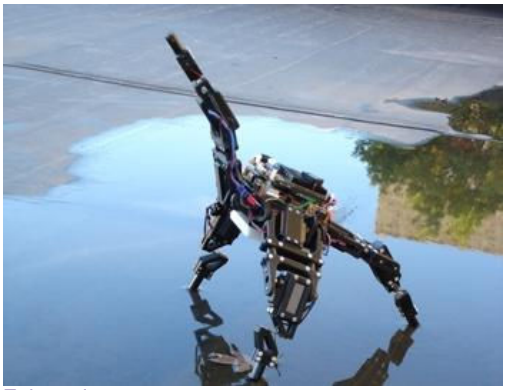
When an animal sprains its ankle, it starts to limp. And now, a robot with a similar adaptive ability has been created in the laboratory. If one the robot's legs is shortened, for instance, it works out how to carry on walking by modelling its movements in software.

"If a machine is damaged, that's usually it, the machine tends to fail completely," says creator Josh Bongard of the University of Vermont in Burlington, US. "The main implication here is that the robot can adapt and carry on despite damage."

The robot was built with the help of Hod Lipson and Victor Zykov, both at Cornell University in Ithaca, New York, US. A computer model of the robot is maintained on a connected computer, which constantly compares this to its real motion. If the behaviour ceases to match its model – perhaps due to an injury or a change in the terrain – the computer comes up with a new model designed to compensate.



Enlarge image
The robot creates simulations to work out how to walk using three legs (Image: Science)

This video (3MB, mov format) shows the simulations performed by the robot under various circumstances. After two of the robot's limbs are shortened, for example, these simulations, combined with real-world trial-and-error, let the robot find a new way to walk.

Thrashing about

Most robots are unable to adapt their movements to compensate for damage. Computer simulations show that control algorithms, "bred", through mutation and combining, can find an effective new way of walking.

However, in practice this would mean testing thousands of possibilities – a time-consuming process that would also risk damaging the robot. "You don't want it thrashing around randomly," says Bongard.

So he, Lipson and Zykov decided to tackle the challenge in a different way. Rather than blindly testing different algorithms, they created a bot that maintains a computer model of itself, which is adapted when its body or environment changes.

Once an existing model no longer fits its ability to move, the computer connected to the robot generates hundreds of new ones at random. It then tests these against the bot's last known physical movements, allowing some to be discarded.

To test further models, the computer calculates which new physical movements would most effectively show whether these new models are a good or a bad fit. It then carries out these "information rich" actions, discarding those models that do not closely match these movements.

Repeating the process enables the computer to come up with a model that neatly describes its new condition. The approach is crucial to the robots ability to adapt quickly to change, the researchers say. In testing, it came up with an accurate model about half of the time. Other approaches are typically less than 30% effective.

"The main result here is that it is better for the robot to be curious," Bongard explains.

Brittle bots

"The robot is able to adapt not only to its environment but to itself," says Owen Holland, a robotic expert at the University of Essex in the UK. He describes the new flexibility as a "sea change" for robotics: "It gets away from some of the brittleness that robotics has been plagued with."

More adaptable robots could be useful on planetary research, when fixing a failed robot is impossible, says Christoph Adami of the California Institute of Technology in Pasadena, who is working on Mars rovers with a team from NASA's Jet Propulsion Laboratory in Pasadena, California, US. "It does advance our ability to create these new types of robots," he says.

The same adaptive process could also help a robot grasp an unfamiliar object or adapt to other forms of damage, like stiffness in its joints, Holland suggests.

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