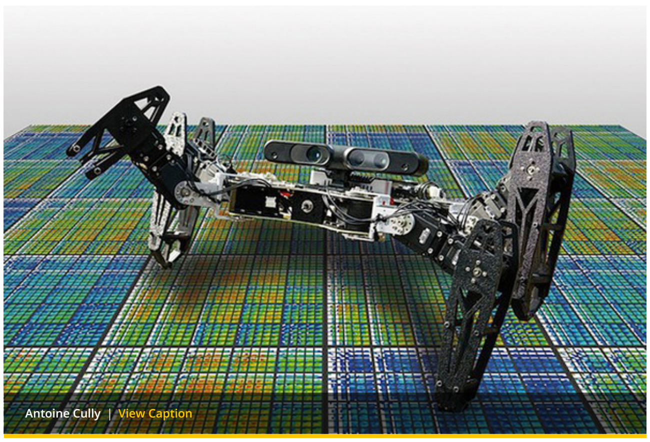
SCIENCE

'Healing' robot could keep chasing you even after you break its legs

Scientists have developed a six-legged robot the can adapt to keep walking after having two of its legs broken.

By Charles Q. Choi, LiveScience | MAY 28, 2015



Antoine Cully | View Caption

Robots that are damaged in action can now quickly "heal" themselves by tapping into experiences from simulated lives, according to a new study. It may sound like science fiction, but these abilities could lead to more robust, effective and autonomous robots, researchers say.

In experiments, a six-legged robot could adapt in little more than a minute to keep walking even if two of its legs were damaged, broken or missing. A robotic arm could also learn to place an object in the correct place even with several broken motors or joints.

"One thing we were surprised by was the extent of damage to which the robots could quickly adapt to," study co-author Jean-Baptiste Mouret, a roboticist at Pierre and Marie Curie University, in Paris, told Live Science. "We subjected these robots to all sorts of abuse, and they always found a way to keep working." [Super-Intelligent Machines: 7 Robotic Futures]

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Adaptable bots

Robots can survive extreme environments such as the deepest depths of the ocean or the harsh vacuum of outer space. However, a major obstacle that has kept robots from widespread adoption outside factories is their lack of adaptability — they typically cannot keep working if they become damaged.

In contrast, animals often can adapt rapidly from injuries. For instance, many three-legged dogs can catch Frisbees, and humans can often quickly figure out how to walk despite sprained ankles or other injuries.

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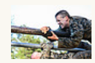

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"If we send in robots to find survivors after an earthquake, or to put our forest fires, or to shut down a nuclear plant in crisis like Fukushima, we need them to be able to keep working if they become damaged," Mouret said. "In such situations, every second counts, and robots are likely to become damaged because these environments are very unpredictable and hostile. Even in less extreme cases, such as in-home robot assistants that help the elderly or sick, we want robots to keep performing their important tasks even if some of their parts break."

Until now, robots typically recovered from damage by first diagnosing their problems and then choosing which contingency plan to follow. However, even if a robot possesses an expensive suite of sensors with which it can diagnose itself, it will be rendered helpless if its designer failed to foresee whatever problem the robot is facing.

In comparison, injured animals rely on trial and error to learn how to overcome adversity — for instance, learning that limping could minimize pain in the leg. Although scientists have experimented with trial-and-error programming for robots, it could take 15 minutes or more for such robots to overcome even relatively simple problems.

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Now scientists have developed a trial-and-error program that enables robots to adapt to damage in less than two minutes, all without a suite of sensors to diagnose itself or a host of contingency plans.

"The most important application of these findings is to have robots that can be useful for long periods of time without requiring humans to perform constant maintenance," Mouret said.

Learning from experience

The scientists reasoned that animals do not learn how to recover from injuries from scratch. "Instead, they have intuitions about different ways to behave," Mouret said in a statement. "These intuitions allow them to intelligently select a few, different behaviors 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."

In this new strategy, before a robot is deployed, the scientists develop a computer simulation to map out thousands of different motions it can take, and predict which patterns of actions are likely to work despite damage. This simulated lifetime of experiences serves as the collection of intuitions the robot can draw from. [The 6 Strangest Robots Ever Created]

"We do not pre-compute anything like 'find a gait that works if a leg is missing,'" Mouret said. "What we do with the simulator is simply to say 'find as many different ways to walk as you can.'"

When the robot faces a real injury, it can draw on these intuitions to guide trial-and error experiments intended to find a way to compensate for any damage.

"Once damaged, the robot becomes like a scientist," study lead author Antoine

Cully, a roboticist at Pierre and Marie Curie University, said in a statement. "It has prior expectations about different behaviors that might work, and begins testing them. However, these predictions come from the simulated, undamaged robot. It has to find out which of them work, not only in reality, but given the damage."

The robot can effectively experiment with different behaviors and rule out ones that don't work, Cully said.

"For example, if walking, mostly on its hind legs, does not work well, it will try walking mostly on its front legs," he added. "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."

Real-world uses

The researchers suggest this strategy could help robots adapt to unforeseen circumstances and new environments. "Our approach can work with any robot," Mouret said.

Some potential applications include "robots that can help rescuers without requiring their continuous attention," study co-author Danesh Tarapore, a roboticist at Pierre and Marie Curie University, said in a statement. "It also makes easier the creation of personal robotic assistants that can continue to be helpful even when a part is broken."

Although simulating a lifetime of potential robot experiences may seem expensive, "our approach is actually very cost-effective, because it does not require complex internal sensors," Mouret said. "The robot only needs to know how well it performs its task. It does not need to know the precise reason why it cannot perform the task as expected. That allows tremendous cost savings, because a robot does not need to have a suite of expensive self-diagnosing sensors woven throughout its body."

The researchers suggest their strategy for robots has implications far beyond damage recovery.

"They could in principle be applied to having robots learn almost anything," Mouret said. "Until now, nearly all approaches for having robots learn took many hours, which is why videos of robots doing anything are often extremely sped up. Watching them learn in real-time was excruciating, much like watching grass grow. Now we can see robots learning in real-time, much like you would watch a dog or child learn a new skill. Thus, for the first time, we have robots that learn something useful after trying a few different things, just like animals and humans."

The scientists now plan to test their strategy on more advanced robots in simulated real-world situations. The researchers are interested in investigating how these abilities could help robots designed for disaster-relief purposes, Mouret said, such as the bots that are scheduled to compete in the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge, being held next month in Pomona, California.

The scientists detailed their findings in the May 28 issue of the journal Nature.

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