Cockroach inspires robotic hand to get a grip

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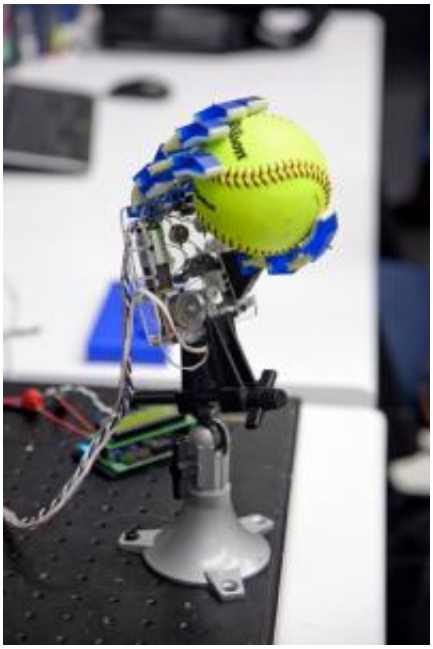

Credit: William Sacco, Yale University

No one thinks twice about picking up a cup of coffee, but this task has vexed robots for three decades. A new type of mechanical hand developed by researchers at Harvard and Yale promises to solve this problem.

In a makeover inspired by cockroach legs, the engineers chose not to make their robotic hand smarter, but to redesign its form to suit a dumb robot.

"People have been trying to build robotic hands for 20 or 30 years, but those hands have rarely been able to perform dexterous tasks," explained Robert D. Howe, who heads Harvard's BioRobotics Laboratory. Howe worked with Aaron Dollar, a former graduate student and now an assistant professor of engineering at Yale, to develop the new hand.

In the real world, Howe explained, both robots and humans have trouble estimating the relationship between their hand and the object they want to grasp. Humans compensate for errors by opening their hands and making their fingers soft and flexible, so they can glide along an object's edge before wrapping around it to pick it up.

"The traditional approach in robotics research is to deal with errors using elaborate sensors, motors, and controls," Howe explained. The resulting mechanical hands were very complex and expensive. They were also slow, since they required lots of computing power to perform even the simplest tasks.

Consider a robotic hand trying to pick up a wine glass. Unless it moved at glacially slow speeds, it might knock over the goblet before it could react to sensor signal that it had made contact.

"We took the opposite approach and tried to understand the fundamental mechanics using good mechanical design practices," Dollar said. Their goal was to reinvent the mechanical hand so that it automatically compensated for errors and adapted to grasp a variety of shapes.

Surprisingly, Howe said, their inspiration came from cockroach legs.

Starting in the late 1980's, University of California, Berkeley professor Robert Full began investigating how cockroaches could walk and run over uneven surfaces. Cockroaches have miniscule brains, so Full knew that they could not possibly be computing their movements so quickly.

Full analyzed the mechanics of cockroach legs to see how they worked. It turns out that their legs are flexible and springy. This lets them adjust to uneven surfaces automatically, without thinking. Full created robotic legs that duplicated these properties using springs and hinges and built an eight-legged robot that could run over uneven ground at breakneck speeds, something no robot had ever done before.

Full's demonstration startled roboticists, and Dollar and Howe decided to take a similar approach to building a hand. If they could get the springs and finger shapes and sizes just right, the hand would be flexible enough to glide along objects until it wrapped around them, just like a human hand lifting a coffee cup.

First, Dollar and Howe stripped the hand down to its essentials: a claw of two doubled-jointed plastic fingers with a single motor controlling them by cables and pulleys. Dollar then built a mathematical model to simulate how the hand would react to various shapes and sizes at different levels of springiness and flexibility.

Dollar eventually added another set of fingers for a surer grip. Despite its four-fingered form, the resulting hand has several human characteristics. At rest, its joints are opened from 25 to 45 degrees, and the joints at the base (our palm) are more flexible than the joints of the fingers. Dollar also added sensors to detect when a finger touches an object and the angle of the joints. While the hand automatically adjusts for many small errors, the sensors enable it to compensate for larger miscues.

The result is a very simple hand that can grasp a wide range of objects. It could become a platform for future household and service robots, where the ability to grasp different objects is important.

Dollar is also pursuing prosthetic hands. Each finger weighs under 1.5

ounces, which is an advantage because many amputees abandon mechanical devices because of their weight.

The hand cannot grasp and manipulate small objects, such as keys or forks. Such dexterity will require additional motors, which would increase the hand's weight and complexity. Dollar is also looking at a new configuration with an opposable thumb.

For three decades, researcher sought to make hands better by making them more complex. By embracing the simplicity of nature-based design, Dollar and Howe have given roboticists a new grip on building mechanical hands. There is still much work to do.

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