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Questing scientists go fishing for a better type of muscle

By Danny Bradbury
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As any aquarium owner will tell you, the problem with fish is that they tend to die if you don't feed them.

But not the electronic fish from Eamex of Japan. These primitive robots swim by flexing artificial muscles in their tails.

They may cost more than conventional fish, but you won't find them floating at the top of the tank – at least until their batteries run out.

Artificial muscles represent the holy grail for robotics researchers. Today's robots look blocky and are restricted by the size and flexibility of their motors.

Take the Asimo, Honda's flagship bipedal robot. It can run, recognise obstacles and even shake hands but it cannot flex its electronic motorised limbs as fluidly as people.

Modern robots use electric actuators for muscles. Mark Cutkosky, a professor at the Dextrous Manipulation Lab at Stanford University in California, describes their limitations: "What we're able to do is constrained by the actuators we're able to bring to bear.

"Look at the power density, the power-per-unit weight you can achieve with conventional electromagnetic actuators. It's quite limiting."

Instead of hydraulics and electric motors, researchers are looking into using more flexible materials, says Yoseph Bar-Cohen, a senior research scientist at the Nondestructive Evaluation and Advanced Actuators lab at Nasa's Jet Propulsion Laboratory. "We are at the dawn of a new era," he says. "We are developing plastic that responds as if it's a biological muscle. We are confident that we can make robots that will run like cheetahs."

Electroactive polymers (EAPs) are the most practical solution to date. These plastics can be made to flex in a muscle-like way, theoretically enabling a new class of robotic movement.

Eamex's fish are a primitive example, but in the future, we might see everything from androids with more human-like faces and limbs, to smaller robots with more strength than today's larger counterparts, which could assist them in tasks such as climbing.

But there are challenges. EAPs divide into two main categories, says Mr Bar-Cohen: those powered by electricity and those that use chemical processes involving the displacement of ions that are distributed through the material.

The problem is that neither delivers perfect performance.

Electrically charged EAPs have stronger, faster movements, but use high electric voltages. The ionic group is traditionally weaker and slower, 1,000 times slower than human muscle. On the other hand, these polymers require minimal voltages to work. Ideally, robotics researchers at companies such as Honda want muscles that deliver the best characteristics of both groups.

Honda's research and development lab is funding research at the Massachusetts Institute of Technology to help crack the problem. Professor Sidney Yip and postdoctoral associate Xi Lin believe that it will be possible to build polymers that move 1,000 times faster than human muscle. Polymers that work using ion displacement are slow-moving because the ions used to flex the material are heavy.

Instead, using mathematical models Prof Yip and Mr Lin have shown how polymers could be created that flex in response to light being shone on them at a single point. They re-evaluated the characteristics of the polymer from the ground up using quantum equations in order to arrive at their conclusion.

The difficulty now is actually building one, says Prof Yip: "It's a gap between concept and what's realistic. There could be a big hurdle there. At least we can say now, scientifically speaking, that we know of a way it could be done."

In the meantime, other researchers claim to have produced practical solutions to the problem, and have even launched companies to sell them.

Mohsen Shahinpoor, research professor of surgery in the neurological surgery division of the University of New Mexico school of medicine, is also the director of the Artificial Muscle Research Institute and chief scientist at Environmental Robots Incorporated.

He has developed ionic polymer metal composite (IPMC) muscles that he says offer the best of both worlds.

"Our muscles are actually 10 times faster than human muscles, with reaction times of milliseconds in actuation," he says, claiming power density greater than human muscle.

That, at least, is one thing that is easy to test. In March this year, at a conference held by the International Society for Optical Engineering, Mr Bar-Cohen organised an arm-wrestling competition with a difference. Three robotic arms – including one designed by Prof Shahinpoor – were pitted against 17-year-old San Diego school student Panna Felsen.

She felled two of them within three seconds, but Prof Shahninpoor's IPMC-based arm stood up to her for 26 seconds before throwing in the towel.

Clearly, we have some way to go before robots can flex bionic biceps with the same strength and freedom of movement as the rest of us, but researchers are making progress.

Perhaps one day, we will see a Mars rover that can bound across rocky plains on two or more legs, rather than inching slowly across the landscape on wheels. Until then, the labs will continue fishing for more positive results.