Researchers develop hybrid fluid transmission enabling light and swift robotic arms

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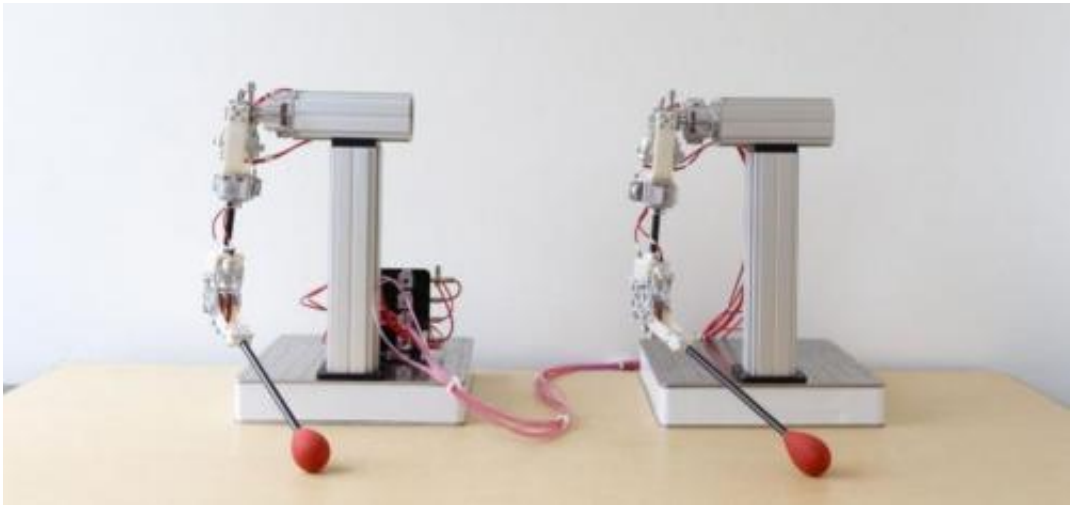

Engineers routinely face tradeoffs as they design robotic limbs – weight vs. speed, ease of control vs. fluidity. A new hybrid fluid transmission developed at Disney Research Pittsburgh promises to eliminate some of those tradeoffs, making possible robot arms that are light enough to move swiftly and gracefully, yet with precise control.

The transmission consists of antagonist pairs of rolling diaphragm cylinders – similar to traditional hydraulic cylinders, but sealed with a rubber diaphragm instead of sliding seals and valves. The result is a

system that can efficiently transmit power with little friction. Yet it is also "backdriveable," capable of absorbing energy, as well as transmitting it.

The latter characteristic allows engineers to design limbs with "give," an important feature as designers contemplate new applications in the home, at work, or in entertainment venues that enable soft interactions between people and robots.

"We've combined the best elements of a hydraulic system with the best elements of an electric motor system," said Peter Whitney, an associate research scientist at Disney Research Pittsburgh. The transmission allows robot limbs to be light, strong and graceful, he explained, while driving them with easily controlled, low-friction motors. The motors, which normally would add significant weight to the limbs, can be mounted on the robot body instead.

The system transmits force so efficiently that Whitney and a Disney Research Pittsburgh lab associate, Tianyao Chen, found they could build an entirely passive "puppet" system, moving one robot arm by manipulating a second robot arm linked to it with the transmission. The system is notably sensitive to tactile feedback from the puppet arm. One possible application of a system made of non-ferrous material would be as a surgical robot compatible with use in a magnetic resonance imaging (MRI) device, Whitney suggested.

Whitney, along with Jessica Hodgins, Disney Research Pittsburgh director and a professor of robotics at Carnegie Mellon University, and two Disney Research Pittsburgh colleagues, Matthew Glisson and Eric Brockmeyer. developed the transmission. They recently presented a research paper on the project at IROS 2014, the International Conference on Intelligent Robots and Systems, in Chicago.

Hydraulic systems often are used to actuate robots whose limbs need to be light and to move fluidly. But conventional hydraulics use a system of valves, which only transmit power and are unable to absorb power from the environment. Control also is not as precise or as easy as is possible with electrical motors, Whitney said. Electric motors meanwhile have their own problems, including heavy weight.

In contrast to the valves and sliding seals of conventional hydraulic systems, which are prone to leakage, the passive fluid transmission developed at Disney Research Pittsburgh uses pairs of rolling diaphragm cylinders – so named because the rubber diaphragm rolls back upon itself between the piston and the cylinder walls – connected by fluid-filled lines.

Each drive line is completely sealed, with a rolling diaphragm cylinder at each end, much like the master cylinder and slave cylinder of the brakes on a car. When one rolling diaphragm cylinder is compressed, the antagonist cylinder is decompressed. Balancing two of these drive lines against each other enables the transmission to exert force in two directions – pushing with one, pulling with the other.

The transmission is highly efficient, enabling it to be operated in a passive, "puppet" mode or to be driven by a heavy, low-friction electric motor located off of the robotic limbs, in the robot's body. Removing electric actuators from the limbs keep them light and makes it easier to move them rapidly and gracefully.

Provided by Disney Research